National Nuclear Security Administration

Facility Maintenance Management

Qualification Standard

DOE-STD-1181-2014

November 2014 | Reference Guide

The Functional Area Qualification Standard References Guides are developed to assist operators, maintenance personnel, and the technical staff in the acquisition of technical competence and qualification within the Technical Qualification Program (TQP).

Please direct your questions or comments related to this document to the Office of Leadership and Career Management, TQP Manager, NNSA Albuquerque Complex.

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Acronyms	
AC	administrative control
AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
BA	barrier analysis
CAIS	condition assessment information system
CAP	corrective action plan
CAS	condition assessment survey
CFA	causal factor analysis
CFR	Code of Federal Regulations
CM	configuration management
CMMS	computerized maintenance management system
CRD	contractor requirements document
CSE	cognizant system engineer
DID	defense-in-depth
DOE	U.S. Department of Energy
DSA	documented safety analysis
EPIX	equipment performance and information exchange
ES&H	environment, safety, and health
FAQS	functional area qualification standard
FRA	functions, responsibilities, and authorities
HQ	headquarters
IA	impact analysis
IAEA	International Atomic Energy Agency
IBEW	International Brotherhood of Electrical Workers
IG	Inspector General
ISM	integrated safety management
ISMS	integrated safety management system
JATC	Joint Apprenticeship and Training Committee
KSA	knowledge, skill, and ability
LCO	limiting condition for operation
MEL	master equipment list
MORT	management oversight and risk tree
MOU	memorandum of understanding
M&TE	measuring and test equipment
NMMP	nuclear maintenance management program
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
NSTS	national source tracking system
OJT	on-the-job training
OSHA	Occupational Safety and Health Administration
PdM	predictive maintenance
PISA	potentially inadequate safety analysis
PM	preventive maintenance
PMT	post maintenance test

PPE	personal protective equipment
PSA	probabilistic safety assessment
QA	quality assurance
QAP	quality assurance program
QC	quality control
RCA	radiologically controlled area
RCM	reliability-centered maintenance
RSRT	radiological source registry and tracking
SAC	specific administrative control
SC	safety-class
S/CI	suspect counterfeit item
SL	safety limit
S&M	surveillance and maintenance
SME	subject matter expert
SMS	safety management system
SO	secretarial officer
SS	safety-significant
SSC	structures, systems, and components
STD	DOE Standard
TES	training/evaluation standard
TF	testing frequency
TQP	Technical Qualification Program
TSR	technical safety requirement
USQ	unreviewed safety question
USQD	unreviewed safety question determination
WO	work orders
WP	work package
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 Facility Maintenance Management 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 has been developed to address the competency statements in the April 2014 edition of DOE-Standard (STD)-1181-2014, *Facility Maintenance Management Functional Area Qualification Standard*. The qualification standard for Facility Maintenance Management contains 20 competency statements.

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, abbreviations, and symbols is provided at the beginning of this document. It is recommended that the candidate review the list prior to proceeding with the competencies, as the acronyms, abbreviations, and symbols 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. 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. 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 2014. 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 TQP.

In the cases where information about an 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.

This reference guide includes streaming videos to help bring the learning experience alive. To activate the video, click on any hyperlink under the video title. Note: Hyperlinks to videos are shown in entirety, due to current limitations of eReaders.

TECHNICAL COMPETENCIES

1. **Facility maintenance management personnel must demonstrate a familiarity level knowledge of the following regulations, DOE Orders and manuals (and their CRDs), standards, and guides.**

   a. **Discuss the purpose, scope, and requirements of these directives and explain how they integrate with nuclear facility maintenance management:**
      - **DOE O 226.1B, *Implementation of Department of Energy Oversight Policy***
      - **DOE O 231.1B, *ES&H Reporting***
      - **DOE O 414.1D, *Quality Assurance***
      - **DOE O 420.1C, *Facility Safety***
      - **DOE O 430.1B, *Real Property Asset Management***
      - **DOE O 440.1B, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees***
      - **DOE O 422.1, *Conduct of Operations***
      - **DOE O 426.2, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities***
      - **DOE O 430.1-2, *Implementation Guide for Surveillance and Maintenance During Facility Transition and Disposition***
      - **DOE O 436.1, *Department Sustainability***
      - **DOE O 458.1, *Radiation Protection of the Public and the Environment***
      - **DOE O 450.2, *Integrated Safety Management***

      Code of Federal Regulations (CFRs):
      - **10 CFR 830, "Nuclear Safety Management"; Subpart A, "Quality Assurance Requirements"**
      - **Integrated Safety Management System (ISMS) provisions contained in 48 CFR 970.5223-1, "Integration of Environment, Safety, and Health into Work Planning and Execution"**
      - **10 CFR 835, "Occupational Radiation Protection"**
      - **10 CFR 850, "Chronic Beryllium Disease Prevention Program"**
      - **10 CFR 851, "Worker Safety and Health Program"**

DOE O 226.1B, Implementation of Department of Energy Oversight Policy

PURPOSE

DOE O 226.1B establishes requirements and provides direction for implementing DOE P 226.1B, *Department of Energy Oversight Policy.*

REQUIREMENTS

All applicable DOE organizations must

- establish and implement an effective oversight program consistent with DOE P 226.1B and the requirements of DOE O 226.1B; and
- maintain sufficient technical capability and knowledge of site and contractor activities to make informed decisions about hazards, risks, and resource allocation; provide direction to contractors; and evaluate contractor performance.

DOE line management must establish and communicate performance expectations to contractors through formal contract mechanisms. Such expectations must be established on an annual basis, or as otherwise required or determined appropriate by the field element.

DOE line management must have effective processes for communicating oversight results and other issues in a timely manner up the line management chain, and to the contractor as appropriate, sufficient to allow senior managers to make informed decisions.

For activities and programs at government-owned and government-operated facilities and sites that are not under the cognizance of a DOE field element, DOE headquarters (HQ) program offices must establish and implement comparably effective oversight processes consistent with requirements for the contractor assurance system and DOE line management oversight processes.

DOE O 231.1B, Environment, Safety, and Health Reporting

PURPOSE

The purpose of DOE O 231.1B is to ensure DOE, including NNSA, receives timely and accurate information about events that have affected or could affect the health, safety, and security of the public or workers, the environment, the operations of DOE facilities, or the credibility of the Department. This will be accomplished through timely collection, reporting, analysis, and dissemination of data pertaining to environment, safety, and health (ES&H) issues as required by law, or regulations, or in support of U.S. political commitments to the International Atomic Energy Agency (IAEA).

SCOPE

Except for the equivalencies/exemptions in DOE O 231.1B, paragraph 3.c., this directive applies to all departmental elements.

REQUIREMENTS

Reports that potentially contain classified or controlled unclassified information must be reviewed and marked in accordance with appropriate directives. If a report includes classified information, it must be contained in a separate classified addendum and an unclassified version of the report must be developed and annotated to indicate the existence, identification, and file location of the classified addendum. Reports must be submitted as follows:

- Reporting annual site environmental information. Annual site environmental information must be reported in accordance with DOE O 231.1B, Attachment 2, “Reporting Annual Site Environmental Information.”
- Reporting occupational safety and health information.
  - Injury and illness recordkeeping and reporting:
    - Work-related fatalities, injuries, and illnesses occurring to Federal employees must be recorded, reported, and maintained in accordance with the requirements contained in 29 CFR 1960, “Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters,” Subpart I, “Recordkeeping and Reporting Requirements,” and the requirements in DOE O 231.1B, Attachment 3, “Reporting Occupational Safety and Health Information.”
    - A work-related incident that involves a fatality or hospitalization of three or more Federal employees must be reported to the Chief, Health, Safety and Security Officer in accordance with 29 CFR 1960.70, “Reporting of Serious Accidents,” and 29 CFR 1904.39, “Reporting Fatalities and Multiple

Hospitalization Incidents to Occupational Safety and Health Administration (OSHA). The designated Federal Employees Occupational Safety and Health Program manager for each HQ element must report incidents involving their Federal employees and Federal employees of DOE field elements under their cognizance to the Chief Health, Safety and Security Officer.

  - Annual submission of fire protection information. Fire protection information must be reported in accordance with DOE O 231.1B, Attachment 3.

- Reporting ionizing radiation exposure information. Ionizing radiation exposure information must be reported in accordance with DOE O 231.1B, Attachment 4, "Reporting Ionizing Radiation Exposure Information."
- Reporting safety basis information. The status of the safety basis of hazard category 1, 2, and 3 nuclear facilities must be maintained up-to-date in the safety basis information system.
- Reporting of radioactive sealed sources information is as follows:
  - The radiological source registry and tracking (RSRT) database serves as DOE's centralized repository for inventory and transaction data to provide reports and information on radioactive sealed sources in support of the *IAEA Code of Conduct on the Safety and Security of Radioactive Sources* and *IAEA Guidance on the Import and Export of Radioactive Sources*, and the Nuclear Regulatory Commission (NRC) national source tracking system (NSTS) established in accordance with 10 CFR 20, "Standards for Protection Against Radiation," and 10 CFR 32, "Specific Domestic Licenses to Manufacture or Transfer Certain Items Containing Byproduct Material."
  - Transaction data must be reported from the DOE RSRT database to the NRC NSTS in a manner consistent with 10 CFR 20.1003, "Definitions," and 10 CFR 20.2207, "Reports of Transactions Involving Nationally Tracked Sources," for transactions involving IAEA category 1 and 2 radioactive sealed sources between DOE and the commercial sector, and DOE imports and exports of radioactive sealed sources.
  - IAEA category 1 and 2 transaction data as described above must be reconciled annually between the DOE RSRT and the NRC NSTS in a manner consistent with 10 CFR 20.2207.
  - Inventory and transaction information for radioactive sealed sources must be reported to the DOE RSRT in accordance with DOE O 231.1B, Attachment 5, "Reporting Radioactive Sealed Source Information."

DOE O 414.1D, Quality Assurance

PURPOSE

The objectives of DOE O 414-1D are

- to ensure that DOE products and services meet or exceed customers' requirements and expectations;
- to achieve quality for all work; and
- to establish additional process-specific quality requirements to be implemented under a quality assurance program (QAP) for the control of suspect/counterfeit items (S/CIs), and nuclear safety software.

REQUIREMENTS
Each departmental element and associated field element(s) must identify and assign a senior manager to have responsibility, authority, and accountability to ensure the development, implementation, assessment, maintenance, and improvement of the QAP. Using a graded approach, the organization must develop a QAP and implement the approved QAP.

Qualification for the quality assurance and safety software quality assurance functional areas are achieved as defined in the DOE O 426.1, *Federal Technical Capability*.

DOE O 420.1C, Facility Safety

PURPOSE
The purpose of DOE O 420.1C is to establish facility and programmatic safety requirements for the following:

- Nuclear safety design criteria
- Fire protection
- Criticality safety
- Natural phenomena hazards mitigation
- Cognizant system engineer (CSE) program

REQUIREMENTS
DOE must

- approve and oversee contractor programs;
- implement the requirements of DOE O 420.1C for government-owned government-operated facilities;
- provide oversight of the contractor CSE program and the operability of safety systems under the purview of the CSE program;
- document any operational responsibilities that are assigned to the contractor regarding the authority having jurisdiction for matters involving fire protection as defined by the National Fire Protection Association codes;
- document any authorities associated with the building code official, as defined in DOE-STD-1066-2012, *Fire Protection*, that are assigned to the contractor; and
- establish an integrated site-wide wildland fire management plan, consistent with the Federal Wildland Fire Management Policy.

DOE O 430.1B, Real Property and Asset Management

PURPOSE
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, DOE O 430.1B identifies requirements and establishes reporting mechanisms and responsibilities for real property asset management.

REQUIREMENTS
The management of real property assets must take 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. Acquisitions, sustainment, recapitalization, and disposal must be

balanced to ensure real property assets are available, used, and in a suitable condition to accomplish DOE missions.

DOE O 440.1B, Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees

PURPOSE

To establish the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE Federal workers with a safe and healthful workplace.

REQUIREMENTS

DOE elements must

- establish and implement a written worker protection program appropriate for the facility hazards;
- establish written policy, goals, and objectives for the worker protection program;
- use qualified worker protection staff to direct and manage the worker protection program;
- assign worker protection responsibilities, evaluate personnel performance, and hold personnel accountable for worker protection performance;
- encourage the involvement of employees in the development of program goals, objectives, and performance measures and in the identification and control of hazards in the workplace;
- provide workers the right, without reprisal, to
  - accompany DOE worker protection personnel during workplace inspections;
  - participate in activities provided for in DOE O 440.1B on official time;
  - express concerns related to worker protection;
  - decline to perform an assigned task because of a reasonable belief that, under the circumstances, the task poses an imminent risk of death or serious bodily harm to that individual;
  - have access to DOE worker protection publications, DOE-prescribed standards, and the organization's own worker protection standards or procedures applicable to the workplace;
  - observe monitoring or measuring of hazardous agents and have access to the results of exposure monitoring;
  - be notified when monitoring results indicate they were overexposed to hazardous materials;
  - receive results of inspections and accident investigations upon request;
  - have limited information on any recordkeeping log (OSHA Form 300). Access is subject to Freedom of Information Act requirements and restrictions; and
  - review the DOE Form 5484.3 (the DOE equivalent to OSHA Form 301) that contains the employee's name as the injured or ill worker.

- implement procedures to allow workers to stop work when they discover employee exposures to imminent danger conditions or other serious hazards. The procedure must ensure that any stop work authority is exercised in a justifiable and responsible manner;

- inform workers of their rights and responsibilities by appropriate means, including posting the Occupational Safety and Health Protection for DOE Employees poster in the workplace where it is accessible to all workers;
- identify existing and potential workplace hazards and evaluate the risk of associated worker injury or illness;
- implement a hazard prevention/abatement process to ensure that all identified hazards are managed through final abatement or control;
- provide workers, supervisors, managers, visitors, and worker protection professionals with worker protection training;
- develop and implement occupant emergency plans and procedures, conduct training, and emergency drills according to directives and guidance issued by DOE; and
- comply with worker protection requirements that are applicable to the hazards at the facility.

DOE O 422.1, Conduct of Operations

PURPOSE

The objective of DOE O 422.1 is to define the requirements for establishing and implementing conduct of operations programs at DOE facilities and projects. A conduct of operations program consists of formal documentation, practices, and actions implementing disciplined and structured operations that support mission success and promote worker, public, and environmental protection. The goal is to minimize the likelihood and consequences of human fallibility or technical and organizational system failures. Conduct of operations is one of the safety management programs recognized in the Nuclear Safety Rule, but it also supports safety and mission success for a wide range of hazardous, complex, or mission-critical operations, and some conduct of operations attributes can enhance even routine operations. It supports the ISMS by providing concrete techniques and practices to implement the ISM core functions or develop and implement hazard controls and perform work within controls. It may be implemented through facility policies, directives, plans, and safety management systems (SMSs) and need not be a stand-alone program.

REQUIREMENTS

To implement DOE O 422.1, contractors develop, for DOE line management approval, documentation demonstrating implementation of the requirements in the contractor requirements document (CRD). DOE line management means the Federal officials such as secretarial officers (SOs) and heads of field elements responsible for DOE facilities and operations. It is not necessary to develop new documents to demonstrate implementation, but at a minimum to provide a conduct of operations matrix, which is a list of CRD requirements, citing the specific documentation that implements each item, or providing justification for each item that is not implemented.

DOE O 426.2, Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities

PURPOSE

To establish selection, training, qualification, and certification requirements for contractor personnel who can impact the safety basis through their involvement in the operation, maintenance, and technical support of hazard category 1, 2, and 3 nuclear facilities. The systematic approach to training as defined in the CRD of DOE O 426.2 is designed to ensure that these personnel have the requisite knowledge, skills, and abilities to properly perform work in accordance with the safety basis. The Nuclear Safety Management rule, 10 CFR 830, requires QAPs and documented safety analyses (DSAs) to address training. The training programs established to comply with DOE O 426.2 support those requirements.

DOE O 426.2 updates and consolidates DOE training requirements consistent with applicable aspects of current industry standards, based on years of DOE experience. Implementation of the requirements of DOE O 426.2 will address 10 CFR 830.122, "Quality Assurance Criteria," Criteria 2—Management/Personnel Training and Qualification.

REQUIREMENTS

A selection, training, qualification, and certification program must be implemented at new and existing hazard category 1, 2, and 3 DOE nuclear facilities, including activities and programs at government-owned and government-operated facilities.

Heads of field organizations/field element manager for NNSA operations, or designee, must evaluate and approve 1) the contractor training implementation matrix or succeeding training program description or plan and 2) contractor procedures that are established to release an individual from portions of a training program through prior education, experience, training, and/or qualification/certification.

Heads of field organizations/field element manager for NNSA operations or designee must evaluate contractor training and qualification programs using the methodology described in DOE-STD-1070-94, *Guidelines for Evaluation of Nuclear Facility Training Programs.*

DOE G 430.1-2, Implementation Guide for Surveillance and Maintenance During Facility Transition and Disposition

PURPOSE

The purpose of DOE G 430.1-2 is to provide guidance on surveillance and maintenance (S&M) activities conducted as part of facility transition and disposition activities, for DOE facilities that have been declared or are forecast to be excess to any current or future mission requirements. It is one of four guides developed to provide guidance for facility transition and disposition activities.

SCOPE

DOE G 430.1-2 may be applied to S&M activities and processes at contaminated DOE facilities. "Contaminated refers to radioactive contamination and to hazardous-substance contamination. Nuclear and non-nuclear contaminated facilities are included in the scope of DOE G 430.1-2. Project personnel are expected to apply a graded approach in planning and

conducting S&M activities at different types of facilities and with different hazard conditions.

REQUIREMENTS

S&M activities are performed throughout the facility transition and disposition phases and are adjusted during the facility life cycle as transition, deactivation, and decommissioning activities are completed. The objectives for S&M programs for contaminated, excess facilities are to

- ensure adequate containment of contamination;
- provide physical safety and security;
- inspect and maintain facilities in a manner that will eliminate or mitigate hazards to workers, the public, and the environment;
- inspection an maintain selected systems and equipment essential for transition and disposition activities, the safety and health of individuals performing these activities, and/or potential future alternative use;
- provide a mechanism for identifying and complying with applicable environmental, safety and health, and safeguards and security requirements; and
- incorporate safety management in all levels of S&M activities to ensure the protection of workers, the public, and the environment.

DOE O 436.1, Department Sustainability

PURPOSE

Provide requirements and responsibilities for managing sustainability within DOE to 1) ensure the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient, and reliable energy for the future, 2) institute wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions, and 3) ensure DOE achieves the sustainability goals established in its strategic sustainability performance plan pursuant to applicable laws, regulations and Executive Orders, related performance scorecards, and sustainability initiatives.

REQUIREMENTS

Comply with the sustainability requirements contained in EO 13423, “Strengthening Federal Environmental, Energy, and Transportation Management,” EO 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” the National Energy Conservation Policy Act, the Energy Policy Acts of 1992 and 2005, the Energy Independence and Security Act of 2007, and continue to adhere to the inventory and reporting requirements of Sections 301 through 313 of the Emergency Planning and Community Right-to-Know Act, the Pollution Prevention Act of 1990 at DOE facilities, related statutory and administrative requirements.

Prepare and submit any required reports supporting and related data as requested pursuant to the EOs, including Federal agency scorecards.

Each site must develop and commit to implementing an annual site sustainability plan that identifies its respective contribution toward meeting the Department’s sustainability goals.

Use, to the maximum extent practicable, alternative financing for energy saving projects, which include renewable energy, energy efficiency, water-efficiency, high performance sustainable building, pollution prevention, and other sustainability projects.

DOE O 458.1, Radiation Protection of the Public and the Environment

PURPOSE

To establish requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the DOE pursuant to the Atomic Energy Act of 1954.

The objectives of DOE O 458.1 are

- to conduct DOE radiological activities so that exposure to members of the public is maintained within the established dose limits established;
- to control the radiological clearance of DOE real and personal property;
- to ensure that potential radiation exposures to members of the public are as low as is reasonably achievable (ALARA);
- to ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public; and
- to provide protection of the environment from the effects of radiation and radioactive material.

REQUIREMENTS

DOE O 458.1 includes specific, detailed requirements in the following areas—refer to the Order for details:

- Environmental radiological protection program
- Public dose limit
- Temporary dose limit
- ALARA
- Demonstrating compliance with public dose limit
- Airborne radioactive effluents
- Control and management of radionuclides from DOE activities in liquid discharges
- Radioactive waste and spent nuclear fuel
- Protection of drinking water and ground water
- Protection of biota
- Release and clearance of property
- Records, retention, and reporting requirements
- Implementation

DOE O 450.2, Integrated Safety Management

PURPOSE

To ensure that DOE systematically integrates safety into management and work practices at all levels so that missions are accomplished efficiently while protecting the workers, the public, and the environment.

REQUIREMENTS

DOE line management organizations must document their approach for ensuring that their DOE offices and their contractors establish ISMSs, including the implementing mechanisms, processes, and methods to be used in an ISM.

The ISMS description document must be consistent with the hazards and complexity of the facilities and work performed. Furthermore, this document must clearly describe how ISM guiding principles and core functions have been applied and how relevant safety goals and objectives are established, documented, and implemented.

DOE line managers must determine the adequacy for approval and frequency of updates of their DOE offices' and their contractors' ISMS.

DOE line managers must determine the need for, and frequency of, DOE ISM declarations for facilities and activities based on hazards, risks, and contractor performance history and document their decisions concerning high consequence activities, such as high-hazard nuclear operations.

DOE line managers responsible for program and site offices' overall ISMS implementation must designate a representative to serve on the ISM champion's council.

ISM champions council, functioning in accordance with its charter, must support line management in developing and sustaining vital, mature ISMSs throughout the Department so that work is reliably accomplished in a safe manner.

To ensure adequate safety in contractor management of DOE facilities while meeting mission goals, DOE line management must ensure that appropriate requirements are incorporated into contracts, oversee compliance, assess contractor performance against established performance measures, analyze relevant trends, and obtain relevant operational information for use as feedback to improve safety.

Line management and support organizations, with safety management responsibility, must develop, issue, and maintain, separately or as part of the ISMS description document, an organizational functions, responsibilities, and authorities (FRA) document.

FRA documents for program offices that direct operations at locations where more than one DOE program offices have work conducted must contain applicable memoranda of understanding (MOU) that define the allocation of safety management functions and responsibilities among the program offices.

Each Department's line management organization must develop, issue, and maintain a documented process for delegation of authorities to perform safety management functions consistent with the hazards and complexity of the work. DOE's safety management responsibilities for ensuring adequate protection and safe operations must be met by DOE line management and cannot be delegated to contractors.

10 CFR 830, Nuclear Safety Management, Subpart A, "Quality Assurance Requirements"

PURPOSE

Subpart A, "Quality Assurance Requirements," establishes quality assurance requirements for contractors conducting activities, including providing items or services that affect, or may affect, nuclear safety of DOE nuclear facilities.

REQUIREMENTS

Contractors conducting activities, including providing items or services, that affect, or may affect, the nuclear safety of DOE nuclear facilities must conduct work in accordance with the Quality Assurance criteria in 10 CFR 830.122.

The contractor responsible for a DOE nuclear facility must

- submit a QAP to DOE for approval and regard the QAP as approved 90 days after submittal, unless it is approved or rejected by DOE at an earlier date
- modify the QAP as directed by DOE
- submit annually any changes to the DOE-approved QAP to DOE for approval. Justify in the submittal why the changes continue to satisfy the quality assurance requirements
- conduct work in accordance with the QAP

The QAP must address the criteria described in 10 CFR 830.122.

48 CFR 970.5223-1, "Integration of Environment, Safety, and Health into Work Planning and Execution"

PURPOSE

The purpose of 48 CFR 970.5223.1 is to provide the requirements for integrating ES&H into work planning and execution.

REQUIREMENTS

In performing work under this contract, the contractor shall perform work safely, in a manner that ensures adequate protection for employees, the public, and the environment, and shall be accountable for the safe performance of work. The contractor shall exercise a degree of care commensurate with the work and the associated hazards. The contractor shall ensure that management of ES&H functions and activities becomes an integral but visible part of the contractor's work planning and execution processes.

The contractor shall manage and perform work in accordance with a documented SMS that fulfills all conditions in 48 CFR 970.5223-1.

The SMS shall describe how the contractor will establish, document, and implement safety performance objectives, performance measures, and commitments in response to DOE program and budget execution guidance while maintaining the integrity of the system. The SMS shall also describe how the contractor will measure system effectiveness.

The contractor shall submit to the contracting officer documentation of its SMS for review and approval. Dates for submittal, discussions, and revisions to the SMS will be established

by the contracting officer. Guidance on the preparation, content, review, and approval of the SMS will be provided by the contracting officer. On an annual basis, the contractor shall review and update, for DOE approval, its safety performance objectives, performance measures, and commitments consistent with and in response to DOE's program and budget execution guidance and direction. Resources shall be identified and allocated to meet the safety objectives and performance commitments as well as maintain the integrity of the entire SMS. Accordingly, the SMS shall be integrated with the contractor's business processes for work planning, budgeting, authorization, execution, and change control.

The contractor shall comply with, and assist DOE in complying with, ES&H requirements of all applicable laws and regulations, and applicable directives identified in the clause of the contract entitled "Laws, Regulations, and DOE Directives." The contractor shall cooperate with Federal and non-Federal agencies having jurisdiction over ES&H matters under the contract.

The contractor shall promptly evaluate and resolve any noncompliance with applicable ES&H requirements and the SMS. If the contractor fails to provide resolution or if, at any time, the contractor's acts or failure to act causes substantial harm or an imminent danger to the environment or health and safety of employees or the public, the contracting officer may issue an order stopping work in whole or in part. Any stop work order issued by a contracting officer under this clause shall be without prejudice to any other legal or contractual rights of the government. In the event that the contracting officer issues a stop work order, an order authorizing the resumption of the work may be issued at the discretion of the contracting officer. The contractor shall not be entitled to an extension of time or additional fee or damages by reason of, or in connection with, any work stoppage ordered in accordance with this clause.

Regardless of the performer of the work, the contractor is responsible for compliance with the ES&H requirements applicable to this contract. The contractor is responsible for flowing down the ES&H requirements applicable to this contract to subcontracts at any tier to the extent necessary to ensure the contractor's compliance with the requirements.

The contractor shall include a clause substantially the same as this clause in subcontracts involving complex or hazardous work on site at a DOE-owned or -leased facility. Such subcontracts shall provide for the right to stop work under the conditions described in 48 CFR 970.5223-1. Depending on the complexity and hazards associated with the work, the contractor may choose not to require the subcontractor to submit an SMS for the contractor's review and approval.

10 CFR 835, "Occupational Radiation Protection"

PURPOSE

The rules in 10 CFR 835 establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities.

REQUIREMENTS

No person or DOE personnel shall take or cause to be taken any action inconsistent with the requirements of

- 10 CFR 835; or
- any program, plan, schedule, or other process established by 10 CFR 835.

With respect to a particular DOE activity, contractor management shall be responsible for compliance with the requirements of 10 CFR 835.

Where there is no contractor for a DOE activity, DOE shall ensure implementation of and compliance with the requirements of 10 CFR 835.

10 CFR 850, "Chronic Beryllium Disease Prevention Program"

PURPOSE

10 CFR 850 provides for establishment of a chronic beryllium disease prevention program that supplements and is deemed an integral part of the worker safety and health program under 10 CFR 851.

REQUIREMENTS

Enforcement

DOE may take appropriate steps pursuant to 10 CFR 851 to enforce compliance by contractors with 10 CFR 850 and any DOE-approved chronic beryllium disease prevention program.

Dispute Resolution

Any worker who is adversely affected by an action taken, or failure to act under 10 CFR 850 may petition the Office of Hearings and Appeals for relief in accordance with 10 CFR 1003, Subpart G, "Private Grievances and Redress."

The Office of Hearings and Appeals may not accept a petition from a worker unless the worker requested the responsible employer to correct the violation, and the responsible employer refused or failed to take corrective action within a reasonable time.

If the dispute relates to a term or condition of employment that is covered by a grievance-arbitration provision in a collective bargaining agreement, the worker must exhaust all applicable grievance-arbitration procedures before filing a petition for relief with the Office of Hearings and Appeals. A worker is deemed to have exhausted all applicable grievance-arbitration procedures if 150 days have passed since the filing of a grievance and a final decision on it has not been issued.

10 CFR 851, "Worker Safety and Health Program"

PURPOSE

10 CFR 851 establishes

- requirements for a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites; and

- procedures for investigating whether a violation of a requirement of this part has occurred, for determining the nature and extent of any such violation, and for imposing an appropriate remedy.

REQUIREMENTS

Compliance Order

The Secretary may issue to any contractor a compliance order that

- identifies a situation that violates, potentially violates, or otherwise is inconsistent with a requirement;
- mandates a remedy, work stoppage, or other action; and
- states the reasons for the remedy, work stoppage, or other action.

Enforcement

A contractor that is indemnified under Section 170d of the Atomic Energy Act (AEA) and that violates any requirement of 10 CFR 851 shall be subject to a civil penalty of up to $75,000 for each such violation. If any violation under this subsection is a continuing violation, each day of the violation shall constitute a separate violation for the purpose of computing the civil penalty.

A contractor that violates any requirement of 10 CFR 851 may be subject to a reduction in fees or other payments under a contract with DOE, pursuant to the contract's conditional payment of fee clause, or other contract clause providing for such reductions.

DOE may not penalize a contractor under both paragraphs (a) and (b) of 10 CFR 851.5 for the same violation of a requirement of 10 CFR 851.

For contractors listed in subsection d. of Section 234A of the AEA, 42 U.S.C. 2282a(d), the total amount of civil penalties under paragraph (a) and contract penalties under paragraph (b) of 10 CFR 851.5 may not exceed the total amount of fees paid by DOE to the contractor in that fiscal year.

DOE shall not penalize a contractor under both sections 234A and 234C of the AEA for the same violation.

b. Discuss each of the following nuclear safety Orders, Standards, and Guides:

- **DOE G 421.1-2A, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830***
- **DOE G 424.1-1B, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements***
- **DOE O 425.1D, *Verification of Readiness to Start Up or Restart Nuclear Facilities***
- **DOE O 460.1C, *Packaging and Transportation Safety***
- **DOE-STD-1083-2009, P*rocessing Exemptions To Nuclear Safety Rules and Approval of Alternative Methods for Documented Safety Analyses***
- **DOE-STD-1186-2004, *Specific Administrative Controls***
- **DOE-STD-3009-94 (Change Notice 3), *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analysis***
- **10 CFR 830, Subpart B, 'Safety Basis Requirements**

DOE G 421.1-2A, Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830

PURPOSE

DOE G 421.1-2A was developed in support of 10 CFR 830, Subpart B, and provides guidance in meeting the provisions for DSAs defined in that subpart.

INTRODUCTION

10 CFR 830, Subpart B requires the contractor responsible for a DOE nuclear facility to analyze the facility, the work to be performed, and the associated hazards and to identify the conditions, safe boundaries, and hazard controls necessary to protect workers, the public, and the environment from adverse consequences. These analyses and hazard controls constitute the safety basis on which the contractor and DOE rely to conclude that the facility can be operated safely. Performing work consistent with the safety basis provides reasonable assurance of adequate protection of workers, the public, and the environment.

DOE G 424.1-1B, Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements

PURPOSE

DOE G 424.1-1B provides information to assist in the implementation of 10 CFR 830.203, "Unreviewed Safety Question Process," of the nuclear safety management rules for applicable nuclear facilities owned or operated by DOE, including the NNSA.

10 CFR 830.203 allows contractors to make physical and procedural changes and to conduct tests and experiments without prior DOE approval if the proposed change can be accommodated within the existing safety basis. The contractor must evaluate any proposed change to ensure that it will not explicitly or implicitly affect the safety basis of the facility. The unreviewed safety question (USQ) process is primarily applicable to the DSA. The rule references only the DSA, and includes conditions of approval in safety evaluation reports and facility-specific commitments made in compliance with DOE rules, Orders, or policies. Because application of the USQ process depends on facility-specific information, results of a USQ determination (USQD) in one facility generally cannot be extrapolated to other

facilities. DOE approves procedures to implement the USQ process as required by 10 CFR 830.203.

DOE O 425.1D, Verification of Readiness to Start Up or Restart Nuclear Facilities

OBJECTIVE

The objective of DOE O 425.1D is to establish the requirements for the DOE, including the NNSA, for verifying readiness for startup of new hazard category 1, 2, and 3 nuclear facilities, activities, and operations, and for the restart of existing hazard category 1, 2, and 3 nuclear facilities, activities, and operations that have been shut down.

The readiness reviews provide an independent verification of readiness to start or restart operations.

INTRODUCTION

DOE and NNSA line management must establish procedures as necessary to manage the verification of readiness to start up or restart nuclear facilities, activities, or operations according to the requirements of DOE O 425.1D and forward those procedures to the appropriate program secretarial officer and central technical authority as well as HSS for information; and exercise delegation of authority and document all delegations of authority made under the provisions granted by DOE O 425.1D.

DOE O 460.1C, Packaging and Transportation Safety

PURPOSE

The purpose of DOE O 460.1C is to establish safety requirements for the proper packaging and transportation of DOE/NNSA offsite shipments and onsite transfers of hazardous materials and for modal transport.

INTRODUCTION

Each entity subject to DOE O 460.1C must perform packaging and transportation activities according to the U.S. Department of Transportation (DOT) requirements of the hazardous materials regulations.

Heads of operations offices or field offices/site office managers are responsible to implement the requirements of DOE O 460.1C and ensure that contractors under their purview fully implement and comply with the requirements of DOE O 460.1C.

DOE-STD-1083-2009, PROCESSING EXEMPTIONS TO NUCLEAR SAFETY RULES AND APPROVAL OF ALTERNATIVE METHODS FOR DOCUMENTED SAFETY ANALYSES

DOE may grant temporary or permanent exemptions from its nuclear safety requirements in rules provided the provisions of 10 CFR 820, Subpart E, "Exemption Relief," are met. The provisions of 10 CFR 820 state that the SO shall use any procedures deemed necessary and appropriate to comply with the exemption responsibilities. DOE-STD-1083-2009 establishes acceptable procedures that may be used to request and grant exemptions to DOE nuclear safety rules in accordance with 10 CFR 820.

DOE-STD-1083-2009 provides a procedure to be used to request and approve a methodology to develop a DSA other than the methodologies explicitly included in table 2 of Appendix A to 10 CFR 830.

DOE-STD-1186-2004, Specific Administrative Controls

DOE-STD-1186-2004 provides guidance applicable to administrative controls (AC) that are selected to provide preventive and/or mitigative functions for specific potential accident scenarios, and which, also have safety importance equivalent to engineered controls that would be classified as safety-class (SC) or safety-significant (SS) if the engineered controls were available and selected. This class of AC is designated as specific administrative controls (SACs).

Similar to the classification of structures, systems, and components (SSC) as safety SSCs, not all ACs requiring specific actions related to individual accident scenarios rise to the level of importance of SACs. Similar to SSCs of lower importance, which are sometimes referred to as "important to safety" or defense-in-depth (DID) SSCs, SACs of lesser importance can be addressed under the implementation of related safety management programs. However, when a specific action AC is elevated to the class of SAC, then the guidance of DOE-STD-1186-2004 should be used to enhance assurance of the effectiveness and dependability of these important ACs beyond that which might be experienced if the specific action AC were simply to be implemented under the auspices of a safety management program.

DOE-STD-3009-94, (Change Notice 3) Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analysis

PURPOSE

DOE-STD-3009-94 describes a DSA preparation method that is acceptable to the DOE, and was developed to assist hazard category 2 and 3 facilities in preparing DSAs that will satisfy the requirements of 10 CFR 830. Hazard category 1 facilities are typically expected to be category A reactors for which extensive precedents for DSAs already exist.

Guidance provided by DOE-STD-3009-94 is generally applicable to any facility that is required to document its safety basis according to 10 CFR 830. For new facilities in which conceptual design or construction activities are in progress, elements of this guidance may be more appropriately handled as an integral part of the overall design requirements. The methodology provided by DOE-STD-3009-94 focuses more on characterizing facility safety with or without well-documented information than on the determination of facility design. Accordingly, contractors for facilities that are documenting conceptual designs for preliminary DSA should apply the process and format of DOE-STD-3009-94 to the extent it is judged to be of benefit.

Beyond conceptual design and construction, the methodology in DOE-STD-3009-94 is applicable to the spectrum of missions expected to occur over the lifetime of a facility. As the phases of facility life change, suitable methodology is provided for use in updating an existing DSA and in developing a new DSA if the new mission is no longer adequately encompassed by the existing DSA. This integration of the DSA with changes in facility mission and associated updates should be controlled as part of an overall safety management plan.

INTRODUCTION

DOE-STD-3009-94 addresses the following tasks related to implementing the requirements of 10 CFR 830:

- Ensures consistent and appropriate treatment of all DSA requirements for the variety of DOE nonreactor nuclear facilities.
- Provides final facility hazard categorization and considers and incorporates the categorization into programmatic requirement measures to protect workers, the public, and the environment from hazardous and accident conditions. Technical safety requirements (TSRs) and SS SSCs that are major contributors to worker safety and DID are identified in the hazard analysis.
- Designates SC SSCs and safety controls as a function of the evaluation guideline.
- Provides a consistent and measured treatment of the application of the graded approach, including guidance on the minimum acceptable DSA content.

10 CFR 830, Subpart B, "Safety Basis Requirements"

PURPOSE

10 CFR 830, Subpart B, establishes safety basis requirements for hazard category 1, 2, and 3 DOE nuclear facilities.

INTRODUCTION

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, CN 1;
- prepare a DSA for the facility; and
- establish the hazard controls on which the contractor will rely to ensure adequate protection of workers, the public, and the environment.

2. Facility maintenance management personnel must demonstrate a working level knowledge of nuclear facility maintenance organization and administration.

a. Discuss maintenance organizational structure, including roles and responsibilities of key positions in the organization.

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 433.1B, the nuclear maintenance management program (NMMP) must clearly address the management structure that applies sufficient resources necessary to support the requirements described in DOE G 433.1-1A and ensures integration with other programs.

The NMMP should address the following:

- The organizational structure, including roles and responsibilities of key positions in the organization.
- Staffing levels and resources, including a description of how these levels and resources were determined to be adequate to accomplish assigned tasks.

- Interfaces with supporting groups, such as quality assurance, materials management, and radiological controls.
- Processes in place to actively encourage personnel to provide feedback and develop methods to improve safety, reliability, quality, and productivity.
- Performance objectives and indicators that are used to improve maintenance performance.
- How management and supervisory personnel will monitor and assess facility maintenance activities to improve all aspects of maintenance performance. This should include a description of how
  - line managers and supervisors will personally take part in monitoring and assessing maintenance activities;
  - frequently tours of the plant and observations of ongoing work are expected;
  - observations are documented and effective corrective actions are taken for noted problems;
  - senior managers will monitor the assessment activities of their subordinate managers and supervisors;
  - management and supervisory assessments, and improvement efforts will be performance-oriented;
  - assessments by other independent groups, such as quality assurance (QA), will be used by line managers and supervisors as a management tool to assist them in assessing maintenance performance; and
  - selected maintenance data reflecting facility performance are analyzed and trended, and the results are forwarded to appropriate levels of management.

- The process for determining root causes for problems identified during monitoring of maintenance activities and by analysis of trends, and how corrective actions are initiated and tracked to completion.

The maintenance management structure should ensure sufficient resources to support the NMMP meeting the requirements of DOE O 433.1B and the expectations described in DOE G 433.1-1A. The maintenance management structure should provide for integration with other programs.

To achieve a high level of performance in facility maintenance senior management should establish high standards; communicate these standards to personnel who perform maintenance; select and train high-quality personnel; provide sufficient resources to the maintenance organization; set goals and objectives; closely observe and assess performance; effectively coordinate maintenance activities with operations and other facility organizations; and hold workers and their supervisors accountable for their performance. In addition, senior management should provide time for and emphasize long-range planning.

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. These responsible managers should visit the facility, assess selected activities and portions of the facility; and leave a written record of their observations.

Additionally, these managers should periodically review the maintenance programs to verify that they are effectively accomplishing their intended objectives and are upgraded as needed.

Maintenance management has the primary responsibility to ensure implementation of contractor management and facility policies that affect the maintenance organization. Maintenance organization procedures should support these policies and clearly identify the responsibilities for their implementation. Maintenance personnel should clearly understand their authority, responsibility, accountability, and interfaces with other groups. Based on these policies and procedures, definitive documentation should be developed to guide maintenance organization activities. These documents should specify the types of controls necessary to implement maintenance policies.

b. Discuss maintenance staffing levels and resources, including indicators of inadequate staffing or resource levels.
[Note: Indicators of inadequate staffing or resource levels is covered in competency statement 2d.]

The following is taken from DOE G 433.1-1A.

The maintenance manager is responsible for selecting high-quality personnel, for effectively using available resources, for assessing resource adequacy, and for making recommendations to the appropriate manager regarding needed change. The manager should be involved in defining entry-level criteria and in screening new personnel. Entry-level criteria should ensure that maintenance personnel have the requisite background and experience to be trainable for work in nuclear facilities. High quality personnel should be selected to establish a staff of supervisory, subject matter experts (SMEs), engineering, planning, technical warehousing, and other personnel needed to support the maintenance program. Adequate engineering support should be available.

The maintenance staff should have sufficient personnel and time to conduct training activities. A training and qualification program should be developed for maintenance supervisors, planners, craft workers, and warehouse personnel, to ensure that high-quality performance is achieved and maintained.

c. Discuss maintenance organization interfaces with facility operations, quality assurance, procurement, nuclear safety, engineering, industrial hygiene and safety, and radiological safety.

Facility Operations

The following is taken from DOE G 420.1-1A.

Surveillance equipment should be located and sufficient space provided for relative ease of routine testing and maintenance activities.

The facility design should include features that provide for ease of routine maintenance without a subsequent mission reduction. Examples include providing sufficient clearance around equipment to accommodate the change out of large components and providing permanent ladder(s) and platform(s) to access lubrication and equipment areas.

The facility design should use a reliability, maintainability, and availability program to achieve operational needs for the design life of the desired end product, expected normal and worst-case operating conditions, and expected downtime for either corrective or preventive maintenance (PM) actions.

Appropriate human factors engineering principles and criteria should be integrated into the design, operation, and maintenance of DOE facilities.

Quality Assurance (QA)

The following is taken from DOE G 414.1-1B.

Program level assessments are used to determine whether the overall organizational programs are properly established and implemented, and are used to evaluate complex organizations from several perspectives. They usually examine the integration of the systems designed to achieve organizational goals and customer expectations.

At the program level for example, a maintenance management program, which relies on the work control system, would use results from the process and system level assessments to determine the effectiveness of the entire maintenance program. This program level assessment could be performed as either a management assessment or an independent assessment.

Procurement

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 433.1B, the NMMP must include appropriate integration of the procurement process with the NMMP to ensure the availability of parts, materials and services for maintenance activities. Overall, procurement normally falls under the responsibility of the materials management/supply/procurement organization. However, as a customer of the procurement process, maintenance should be involved in the aspects of procurement, which impact the parts, materials, and services received; and how they effectively integrate into those processes. Additionally, 10 CFR 830.120, DOE O 414.1D, *Quality Assurance*, and its associated guide provide the requirements and implementing guidance for the quality aspects of materials management.

The NMMP should address the following:

- The process to identify, order, receive, store, and install proper parts and materials for work activities while meeting all quality requirements
- Mechanisms to provide for the expeditious procurement of parts and material on a high priority basis when needed
- How materials are stored and identified in ways that result in timely retrieval
- How safety-related parts and components are properly controlled, segregated, and identified in all material storage areas
- Identifying, segregating, and properly controlling flammable, contaminated, radioactive, and other hazardous materials
- How parts and materials issued for installation are properly controlled, and appropriate unused parts and materials are promptly returned to inventory

- Providing input to stock level adjustments, as necessary, to meet facility needs
- How lessons learned from experience, such as lead times, parts usage, and supplier reliability, are factored into materials management

To maintain the validity of the safety basis, replacement parts and materials should meet the equipment design criteria. A graded approach is used to verify the critical attributes of these items based on the importance of each item. Not every piece/part of a safety system is integral to the system's safety function and may not require the degree of rigor to verify its capabilities as those items that are critical to the safety function. The QAP should specify the processes used to approve suppliers; upgrade commercially obtained materials; perform receipt inspections; and document, track, and disposition identified deficiencies. Additionally, the terms "like-for-like" or "like-in-kind" should be applied to assure the correct component or part is used.

A process for providing the data that forms the basis for procurement of items, which support all SSCs that are part of the safety basis, and other major purchases should exist, typically within the engineering organization. This data should include the following:

- Critical parameters and their acceptance criteria
- Unique or special testing requirements/methods
- Reorder instructions
- Suspect/counterfeit parts information

Procurement controls should be developed and maintained to help maintenance obtain parts, materials, and services promptly. Consideration should be given to the following:

- The ability to track procurement status from receiving through delivery to issue-for-use.
- Ability of the procurement organization to track procurement progress and take necessary measures to meet maintenance and outage schedules.
- Emergency procurement policies and an expediting process to obtain parts, materials, and services that are needed immediately to support safe and reliable facility operation.
- Control and maintenance of QA records to provide documentation for qualified parts and materials, and to ensure traceability of parts and materials.
- Assurance that procurement documents and controls prevent the delivery or use of suspect/counterfeit parts.
- 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.
- Retaining special receipt inspection documentation to support future procurement.
- Provisions for qualifying nonqualified material (i.e., commercial grade dedication). An effective upgrade process will result in improved availability of quality parts and materials.
- Verification of the reliability of supplier performance. This can be accomplished by audits, inspections, or surveillances of supplier facilities.

Nuclear Safety

The following is taken from DOE G 433.1-1A.

10 CFR 830 Subpart B, "Nuclear Safety Management," and DOE O 420.1C, *Facility Safety*, require formal definition of minimum acceptable performance of SSCs in the DSA. This is accomplished by first defining a safety function, then describing the SSCs, placing functional requirements on those portions of the SSCs required for the safety function, and identifying performance criteria that will ensure functional requirements are met.

A product of initial safety basis development and updates should be a listing of these SSCs, which is then used to develop and maintain the master equipment list (MEL). The MEL clearly identifies all SSCs that are part of the safety basis, thus requiring controls that are more rigorous. The organization may include in the MEL and the nuclear maintenance program those non-safety SSCs to which they chose to apply rigorous controls.

Management should establish and reinforce clear expectations and requirements for the use of procedures to perform maintenance activities. Management should ensure procedure use requirements are understood and met by the workers. Normally, three levels of procedure use are defined:

- Continuous use of procedures for activities having direct impact on nuclear safety and reliability or difficult, complex tasks independent of the frequency performed
- Reference use for tasks easily accomplished from memory or for tasks for which improper actions pose no immediate consequences to workers or equipment
- Information use for tasks that can be performed without referring to the procedure

Engineering

The following is taken from DOE G 433.1-1A.

Generally, the engineering group has cognizance of the configuration management (CM) program. The maintenance process should address installation and verification of facility modifications based on the complexity of the task, the extent of the modification, and the importance of the equipment, just as is done for normal maintenance activities. Typically, maintenance packages, which implement a design change, have additional commissioning and/or post-installation testing requirements specified by the design change package to validate the operability of the installation.

Normal maintenance practices are intended to close out work with the affected equipment in its original baseline configuration. Replacement parts should be identical to the installed parts unless item equivalency has been reviewed and approved by engineering. The modification process addresses control of activities, which can change SSC configuration.

Engineering and maintenance personnel may be needed to assist in the receipt inspection of more complicated parts, materials, and equipment. Recurring or special test/inspection packages may be required for maintenance personnel to conduct and document these checks on received material prior to being released for issue. In some situations, outside facilities/organizations may be used to conduct specialized testing beyond the facility‘s capability.

Special inspections and/or tests should be considered for products that have histories of being counterfeited, such as high strength fasteners, molded case breakers, valves, UL listed items and semi-conductors.

Engineering personnel should approve any deviation from design specifications of material or equipment received before the item is considered for issue. They should also approve any upgrade of material or equipment from a non-safety to a safety category. Nonconforming items should be clearly identified; segregated from normal items to prevent inadvertent use; documented on a nonconformance report and/or a defective or substandard material report; and tracked and resolved as soon as practical by the applicable authority.

Experience gained through the NRC has demonstrated that effective S/CI processes have these common characteristics:

- Engineering staff involvement in procurement and product acceptance
- Effective supplier evaluation, source inspection, receipt inspection, and testing programs
- Thorough, engineering-based processes for review, testing, and dedication of commercial-grade items for suitability in safety systems and mission critical facilities
- Engineering staff should receive training in S/CI awareness and design, prevention, and detection methods

The NMMP should address how system engineering is involved in the following activities:

- Remaining apprised of operational status and ongoing modification activities
- Assisting in review of key system parameters and evaluate system performance
- Identifying trends from operations and maintenance, and providing assistance in determining operability, correcting out-of-specification conditions, and evaluating questionable data
- Remaining cognizant of system-specific maintenance and operations history and industry operating experience, as well as manufacturer and vendor recommendations and any product warnings regarding safety SSCs in their assigned systems in order to advise the maintenance organization
- Initiating actions to correct problems
- Reviewing and concurring with design changes and maintenance modifications
- Providing input to the development of special maintenance and test procedures
- Ensuring that system configuration is being managed effectively, including reviewing and concurring with post-maintenance/post-modification testing and acceptance criteria for assigned systems

In accordance with DOE O 420.1C, the CSE is required to maintain the integrity of a facility‘s safety basis as well as maintain overall cognizance of the system and the CSE is responsible for system engineering support for operations and maintenance. In accordance with DOE O 420.1C, the CSE is required to provide technical assistance in support of line management safety responsibilities and ensure continued system operational readiness. The CSE supports the planning and performance of maintenance activities by

- ensuring that system configuration is being managed effectively, including reviewing and concurring with post-maintenance/post-modification testing and acceptance criteria for assigned systems;

- remaining apprised of operational status and ongoing modification activities;
- assisting in review of key system parameters and evaluate system performance;
- initiating actions to correct problems;
- remaining cognizant of system-specific maintenance and operations history and industry operating experience, as well as manufacturer and vendor recommendations and any product warnings regarding safety SSCs in their assigned systems in order to advise the maintenance organization;
- identifying trends from operations and maintenance;
- providing assistance in determining operability, correcting out-of-specification conditions, and evaluating questionable data;
- providing or supporting analysis when the system is suspected of inoperability or degradation;
- reviewing and concurring with design changes and maintenance modifications; and
- providing input to the development of special maintenance and test procedures.

Industrial Hygiene

The following is taken from DOE-STD-6005-2001.

DOE and contractor line management are required to coordinate industrial hygiene efforts with cognizant occupational medical, environmental protection, health physics, and work planning professionals.

Coordination must be established, maintained, and documented between the industrial hygiene staff and other worker protection and organizational functions in the facility to ensure the successful implementation and efficacy of the worker protection program. These functions include, but are not limited to occupational medicine, epidemiology, industrial safety, environmental protection, fire protection, health physics, purchasing, maintenance, engineering, operations, contracting, QA, and employee groups and recognized bargaining units. For example, the senior industrial hygienist may recommend employees to be included in medical surveillance and should participate in the review of occupational exposure and medical surveillance data.

Radiological Safety

The following is taken from DOE G 433.1-1A.

When ALARA work planning is performed, special consideration should be given to providing adequate detail to assist the craft worker in performing the task and reducing radiation exposure. Examples of items that should be considered include the following:

- Reviewing previous work packages (WPs) for lessons learned and effective methods of performing the task
- Reviewing area photographs, if available, to identify problems that may delay work
- Providing detailed tool lists
- Providing rigging and handling sketches
- Performing mockups or practice runs in non-radiation areas
- Using portable shielding to reduce radiation levels
- Dividing work into distinct tasks to be performed by different individuals

- Holding an in-depth pre-job briefing to ensure craft workers have a clear understanding of the tasks to be performed
- Improving access to the work through portable scaffolding or work platforms;
- Posting work areas to control access
- Including ALARA personnel in the planning process
- Designing special tools that may reduce time to complete repair

Work with the operations manager and the system engineer/engineering to determine the following:

- Operational impacts such as alarms, possible actuation, special system alignment, or operator actions
- Post-maintenance tests that should be performed to check the maintenance performed and to return the component to operation

d. Discuss how management and supervisory personnel can monitor and assess facility maintenance activities to improve all aspects of maintenance performance.

Identifying Performance Indicators

The following is taken from DOE G 433.1-1A.

Performance monitoring is a valuable management tool to track the reliability of SSCs important to safety and the conduct of maintenance. However, the identification of performance indicators, which accurately predict future performance, is challenging. Metrics tend to count results like lost time accidents and PM accomplishment rate. Typically, a goal is set for each metric and possibly a grade or color associated with various performance results. Unfortunately, past performance is not always a reliable indicator of what is to come. Future performance tends to be more a result of behaviors, how workers follow safety rules or provide feedback on inefficient work practices; how management personnel interact with the staff and receive bad news.

Measuring behavior can be more subjective than objective, but standards should be as well defined as possible.

The selection of core performance indicators should reflect the most important elements of mission and safety performance. The selection of these metrics is itself a message to the organization of what management considers important.

For maintenance, typical indicators include the following:

- Safety
  - Safety system availability
  - Limiting condition for operation (LCO) due to equipment failure
  - Total recordable case and days away/restricted time
  - Contamination events

- Quality
  - Equipment availability
  - maintenance rework

- Production
  - Corrective maintenance backlog
  - Overdue PMs

Other examples worthy of consideration include the following:

- Close-calls may identify weak work practices, equipment, or procedures
- First aid cases may be an indication of safe work practices
- Overtime hours—are resources adequate for the work, will backlogs rise?
- Personal protective equipment (PPE) infractions may be an indication of safety awareness.
- Sick days may indicate the commitment of the workforce (this should not be associated with specific individuals).
- Self-assessment compliance—are supervisors/managers getting into the field; are their observations meaningful (reinforces good practices, discourages bad practices)?
- Training attendance—is training the right priority, are supervisors managing their work to permit attendance?

The initial selection of performance indicators should be a thoughtful process involving all the levels of the organization. The selected metrics should be reviewed periodically and modified as necessary to ensure they provide useful data. The metrics and their purpose need to be understood by all.

In 2002, the Energy Facility Contractors Group published WSRC-RP-2002-00252, *Performance Metric Manual*, which explains a performance measurement process piloted at the Savannah River Site. This manual provides a process for metrics, which flow from top to bottom in an organization. Even if not used exactly as described, the manual provides numerous ideas to consider in any maintenance program.

Measuring Performance Indicators

Performance Indicators should be sufficiently defined so that their measurement is a simple matter of counting or transcribing from an organization record or log. Even assessment results that may be somewhat subjective can be given a grade useful for comparison. The periodicity of the data should be thoughtful—typically monthly or quarterly is sufficient. The data should be recorded, retained, and trended over multiple data periods—typically a year or more.

The data should be true and accurate to be of real value in assessing organizational conditions. Established goals should be challenging, but realistic. It would be laudable if an organization never had an occurrence or even a close call, but significant management pressure to achieve that goal may discourage reporting. A close call, properly handled, could fix an organizational deficiency that if left unreported could lead to a significant event. That is clearly not the desired result.

Analyzing Performance Indicators

What is done with performance indicator data is the most important aspect of performance measures. How are changes in data evaluated to be significant or a trend? Some organizations have employed statistical process control techniques to establish data normal

and standard deviations—this may be a reasonable approach if there is access to the specialized expertise required to make this meaningful. However, most organizations simply look for changes and the apparent causes, and if other related indicators are consistent. If this condition is considered important by the responsible manager or their boss, they are further analyzed.

The purpose of analyzing changes in performance indicators is to identify the factors causing the indicator to change. There will be obvious factors, however, these are typically superficial—fixing them is not a long-term solution and may hide an error producing condition. There will likely be human performance factors, but the vast majority of these factors are influenced by organizational conditions that affect more than a single individual. Data gathering and analysis, using the event analysis techniques described in the references above, should go beyond faultfinding and determine the underlying organizational conditions or processes that should be addressed.

The following factors should be considered in these analyses:

- Availability of physical resources including
  - tools, equipment;
  - spare parts, materials;
  - workers, support personnel;
  - workspace, light, ventilation;
  - sufficient labels, gauges, annunciators, and control devices;
  - availability of tools, materials, technology, equipment, improved lighting, adequate budget, spare parts, etc.; and
  - adequate predictive/PM.

- Organization/Facility structure including
  - clear responsibilities, policies, goals;
  - logical reporting structure;
  - effective CM—drawings, procedures, training up-to-date;
  - available support personnel;
  - consistent scheduling and adequate work planning; and
  - effective oversight, self-assessment, and supervision.

- Information including
  - adequate pre-job brief, turnover;
  - clear and accurate maintenance, operating, or special test procedures/instructions;
  - accurate and available drawings, equipment manuals, technical specifications;
  - adequate time to review work procedure and prepare for task;
  - lessons Learned appropriately applied/shared; and
  - post-maintenance testing verifies equipment operability.

- Knowledge/Skills/Abilities including
  - effective qualification program;
  - appropriate worker and supervisor training programs and materials;
  - effective on-the-job training (OJT) and skills training;
  - proper use of self-check and peer-check; and

- adequate QA/QC.

- Motivation including
  - reasonable work schedule, overtime not excessive;
  - appropriate recognition, bonuses; and
  - fair pay, benefits, job security, advancement opportunity, etc.

3. Facility maintenance management personnel must demonstrate a working level knowledge of the master equipment list.

a. Discuss the development and maintenance of an up-to-date and comprehensive listing of SSCs that are a part of the safety basis.

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 433.1B, the NMMP must include a process for developing, implementing, managing, and maintaining the MEL at a level that clearly identifies the SSCs that are part of the safety basis. The NMMP should address the following:

- Development and maintenance of up-to-date of a comprehensive listing of SSCs that are a part of the safety basis
- How the MEL will be used by maintenance and support personnel to identify and apply appropriate controls to maintenance

The maintenance history program should clearly identify the SSCs for which a history is to be maintained, the data to be collected, methods for recording data, and uses for the data. Typically, maintenance history is provided for all SSCs for which periodic maintenance is performed. The program should include the type of equipment, model, serial and identification numbers, location information, and other information listed below.

At a minimum, each SSC included in the safety basis should have a separate maintenance history file. An essential element of the history files is a chronological record (beginning with the date of installation) of the completion data of each work order (WO) (for all types of work orders and service calls) including the date of completion, worker notes on completed WOs, labor hours expended, etc. The history file should include data on each review of the history including results of the review, date of review, and names of personnel who performed the review.

b. Discuss the different uses of the MEL, including identification of appropriate controls of maintenance, maintenance history, minimum spares, vendor information, and safety category.

The following is taken from DOE G 433.1-1A

In accordance with DOE O 433.1B, the NMMP must include a process for developing, implementing, managing, and maintaining the MEL at a level that clearly identifies the SSCs that are part of the safety basis. The NMMP should address the following:

- Development and maintenance of up-to-date of a comprehensive listings of SSCs that are a part of the safety basis
- How the MEL will be used by maintenance and support personnel to identify and apply appropriate controls to maintenance

10 CFR 830 and DOE O 420.1C, require formal definition of minimum acceptable performance of SSCs in the DSA. This is accomplished by first defining a safety function, then describing the SSCs, placing functional requirements on those portions of the SSCs required for the safety function, and identifying performance criteria that will ensure functional requirements are met.

A product of initial safety basis development and updates should be a listing of these SSCs, which is then used to develop and maintain the MEL. The MEL clearly identifies all SSCs that are part of the safety basis, thus requiring controls that are more rigorous. The organization may include in the MEL and the nuclear maintenance program those non-safety SSCs to which they chose to apply rigorous controls.

Within the design change and/or CM process, the facility should evaluate changes/modifications to identify any necessary updates to the MEL. The work planning process should include checking equipment that will be affected in the MEL to determine if special controls are required in the maintenance package.

While an approved hard-copy list of all SSCs that are part of the safety basis is acceptable, typically the MEL is maintained electronically in the facility‘s computerized maintenance management system (CMMS) and includes all facility equipment, with the safety basis items coded for identification. Thus, the MEL can be an index with many uses, including periodic maintenance, spare parts inventories, and equipment history. Each MEL item should be identified uniquely. An engineering group typically develops and maintains the MEL. Additional information, such as the following, may be included or linked/referenced to the MEL items:

- Equipment name/type
- Equipment tag in field
- Safety category
- Reference to safety basis source
- Any applicable TSRs/LCOs
- Installed make and model
- Spare parts
- Status (active, retired, inactive)

Spare Parts

Establishing the master catalog of spare parts and appropriate stocking levels requires a significant effort initially and ongoing effort over the life of the facility. The starting point should be MEL, which at a minimum contains a list of all SSCs that are part of the safety basis. This equipment is expanded into its respective subassemblies, components, and piece parts to identify potential spare parts using drawings, manuals, and vendor information. With this list, vendor recommendations, operations and maintenance experience, and engineering judgment, as well as duplicate equipment and common parts used in multiple units, should be balanced to determine the items and amount to stock on hand. Consideration is also required of the lead-time, cost, shelf life, size, and storage requirements for selecting stock levels, as warehouse facilities, their contents, and maintenance compete with other funding priorities.

A catalog of parts, materials, and equipment normally used at the facility should exist with an up-to-date indication of what is available for issue. This catalog should provide a cross-reference listing that contains such information as manufacturer part number, local part number, name, and component or system for which a part is used. This catalog assists in more efficient planning and execution of maintenance activities.

Spare parts and stocking levels should be reviewed over the life of the facility to ensure they are effectively supporting maintenance and operations. Usage data should be kept and reviewed to identify unnecessary materials kept in stock. Updates should occur when facility modifications add, remove, or change equipment; or periodic maintenance activities are changed. Maintenance should provide input to this process and recommendations when stocking levels are considered inappropriate for maintenance support.

4. Facility maintenance management personnel must demonstrate a working level knowledge of planning, scheduling, and coordination of maintenance.

a. Discuss the process for ensuring the appropriate level of detailed maintenance work instruction so that workers, schedulers, and other affected organizations can carry out the activities as planned.

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 433.1B, the NMMP must include the process for developing and implementing documented and approved work instructions for work on safety SSCs.

In meeting this requirement, maintenance procedures should be prepared and used to provide appropriate work direction and to ensure that maintenance is performed in a safe, efficient, and consistent manner. Maintenance procedures should be technically accurate, complete, up to date, and presented in a clear, concise, and consistent manner to minimize human error.

Guidance should be provided for the development, writing, verification, validation, approval, and use of maintenance procedures as required. The guidance should also include such factors as procedure: issuance, periodic review, revision, reference material control, identification, and storage.

The NMMP should address the following:

- A process governing the development of procedures which includes
  - ensuring procedures are clear, concise, and contain adequate information for users to understand and perform their activities effectively;
  - verifying technical details such as set points, control logic, and equipment numbers are consistent among procedures, drawings, valve lineup sheets, and system descriptions;
  - including hold-points such as quality and radiological protection checks in procedures, as needed;
  - incorporating human performance factors into procedures to promote error-free performance;
  - documenting post-maintenance/modification testing requirements and acceptance criteria, follow-on steps, and restoration instructions, where appropriate; and

- checking new, changed, or revised procedures to ensure usability before or during initial use.

- Control of the review, approval, and revision of procedures and other work-related documents
- How documents used in lieu of or in support of procedures (such as excerpts from vendor manuals) receive the same review and approval as procedures, and are maintained technically accurate and up-to-date
- How effective procedures are clearly identified and maintained readily available for workers
- Management‘s expectations for procedure use
- Identifying actions to be taken when procedures conflict, are inadequate for the intended tasks, or when unexpected results occur
- Periodic procedure reviews for technical accuracy, human performance factors, and the inclusion of in-house and industry operating experience

b. Discuss the process for coordination of integrated discipline of maintenance work packages to ensure involvement of the appropriate persons and the proper sequence of carrying out the work.

The following is taken from *MYCMMS, Maintenance Manual*, “Work Package Processing.”

The following outlines the process and responsibilities associated with the initiation, planning, scheduling, and execution and close-out of a WP. The discussion will address the following sections:

- WP planning
- WP scheduling
- WP execution
- WP close-out

The WP is a document outlining the scope/extent of work activities necessary to correct/resolve an identified problem or requested work activity. A WP is a manageable unit of work consisting of at least one (and possibly more) WP task. There are three basic events that lead to the generation of a WP:

1. Presence of an approved work request (WR)
2. Scheduled preventive or predictive maintenance (PdM)
3. Specific requirement not requiring a WR

Upon completion of the associated work activities, the WP is used to document the trouble found, the work actually performed and the resources necessary to complete the work. The WP is intended to document all work performed associated with the correction/resolution of the identified problem. WPs may be initiated for administrative activities or other activities that required planning, scheduling and/or tracking of work performed. A WP task represents a logical breakdown of the required work activities necessary to resolve an identified problem and/or work scope description. The work scope associated with a WP should be broken into work activities that can be effectively planned and scheduled. The scope or

complexity of a WP task is dependent upon the planner and the amount of work desired to be accomplished.

A WP task could consist of

- one craft
- one equipment ID
- bill of materials
- required technical references
- required tools
- necessary work permits

Work Package Planning

RESPONSIBILITIES

PLANNERS & CRAFT SUPERVISORS

The primary responsibility for ensuring that WPs are appropriately planned is retained by the planners. However, in the performance of the individual tasks, the craft supervisor(s) plays a significant role in the development and execution of the individual WP tasks. Participation of the craft supervisor(s) is especially critical in supporting the development of initial plans for work not previously documented/available and in the database. The planner and craft supervisor should work closely together as a team to accurately assess the work to be performed, including the following:

- Review of component history for lessons learned
- Site verification and assessment of work environment
- Definition of work task requirements
- Detailed estimate of work required
- Assessment of craft support, including cross discipline and technical support required
- Determination of materials and tools required
- Determination of technical references
- Assessment of work permits and clearance requirements
- Assessment of post maintenance requirements

PLANNING SUPERVISOR

The planning supervisor will oversee the planning process to assure that WPs are properly planned and efficiently use existing resources. The planning supervisor will also assure that coordination with other departments is streamlined and effective.

Procedure

Individuals assigned planning responsibilities will plan the WP tasks. Information provided by the craft supervisors will play an important role in the development of WP task work instructions. Until valid work history information becomes available, communication with the craft supervisors may be necessary to assist in the identification of material requirements and labor resource estimates. Once a WP is selected to begin the planning process, the planner will be able to perform any of the following actions:

- Review all WR information, including comments
- Review past work history for the affected item
- Review nameplate information

- Review bill of materials information
- Access the applicable module and review all information associated with the affected item.

At any time in the planning process the planner can change the assigned planner of the WP. As a minimum, the planner should enter/review the following general information for a WP:

- Work scope description—A short description (40 to 60 characters) of the work to be accomplished. This description will be used when the WP is printed.
- Work package status—A code associated with the status of the WP.
- Date work package initiated—The date that the WR received final approval or the date the WP was initiated.
- Work priority—The work priority code assigned/ calculated during the WR process. The WP (and all associated tasks) will be planned, scheduled and worked in accordance with this priority. The planner will coordinate any work priority change with the shift foreman and planning supervisor.
- Outage type and outage ID (if necessary)—If any work task requires a unit outage to accomplish the work, the WP level will reflect the need for a unit outage.
- Project number—If the WP is associated with a project, all work tasks will be associated with the project.
- Date required by—The required date entered during the WR process.
- Required by reason—The required by reason entered during the WR process.
- Work package category—An overall work category code associated with the work scope of the WP.

The planner will be allowed to initiate WPs without using a WR. Each WP initiated must have at least one WP task assigned. WP tasks allow the planner to breakdown complex work activities such as a pulverizer overhaul into manageable, logical work steps that can be scheduled and worked more efficiently. Each WP task will possess the following information:

- Task description—For each WP task the planner will identify the scope or description of the task. Other guidelines discuss the general strategy for development of work plans. Each task will be provided with a task description (or summary). This will be a short description of the WP task.
- Each task will be assigned a single equipment ID.
- Lockout/Tagout (LOTO)—A LOTO tag to indicate whether the WP task requires an LOTO prior to the commencement of work.
- Confined space check sheet required flag—A Y/N flag to indicate whether the WP task requires a confined space check sheet to be printed with the WP task.
- Cutting and welding permit sheet required flag—A Y IN flag to indicate whether the WP task requires a cutting & welding permit sheet to be printed with the WP task.

Each task will be assigned a single CRAFT.

- Each task will designate the number of workers and work duration estimated. When the number of workers and work duration are entered, the process will calculate the estimated labor costs.
- Each task will be assigned a CREW, the crew assignment is not mandatory in the work planning process; however, it must be assigned at time of scheduling

- Each task will be assigned the appropriate account code.
  - For an equipment ID, the account code will be taken from the database.
  - For a tool ID, the account code will be taken from the Tool Control process or assigned as a general maintenance account number.
  - For a stock item, the account code will be taken from the MMS or assigned as a warehouse overhead account number.

- Each task will provide for the entry of detailed work task instructions (if necessary). A method of capturing unlimited textual information will be provided; data entry for these items will be supported with word processing capability, including spell checking.

In addition, the planner will have the ability to cancel a WR/WP if the planner feels an existing WP addresses the identified problem. If the WR/WP is canceled, the planner will change the work status code to CANCELED and record the reason in the comments section. The planner will be able to completely plan each work task in detail.

Tools Planning

The planner will be provided a method of recording the required tools and measuring and test equipment (M&TE) for a particular work task. The planner will be provided access to the tools list for the equipment ID from the tool crib and have the capability of identifying tools from the list. The planner will confirm the availability of critical tools required for each WP task with the tool room attendant. Tools will be issued concurrent with the decision to schedule work. Search capabilities of the tool control will be provided to the planner with the ability to select tools and M&TE required for a WP task. At a minimum, the planner will be capable of searching by any combination of the following criteria:

- Tool ID
- Tool serial number
- Tool description
- Manufacturer/supplier code/name
- Manufacturer model number/part number
- Requisition/purchase order number

Once the planner has identified a tool required for the WP, the planner will be provided a method of identifying (selecting) the tool and entering the quantity of that tool ID required from a specific tool room. The planner will be provided the ability to assign or identify tools and other equipment that are not controlled by the tool control process.

Technical References

The planner will be provided the ability to identify all relevant technical references for a specific WP task. The planner will be provided access to document management. At a minimum, the planner will be capable of searching by any combination of the following criteria:

- Plan’s document type and number
- Vendor document type and number / vendor code/ name
- Document title
- Equipment ID

- Original contract number
- Project number

Once a document is determined appropriate for a WP task, the system will allow the planner to select the document or otherwise list the document as a technical reference for the WP task. The planner will be provided the ability to flag those technical references that should be printed with the WP task.

Required Work Permits

The planner will be provided a method of associating the required work permit types required for each WP task. The system will display the available permit types and allow the planner to select those permits applicable to the work task.

In addition, the planner will be provided the flexibility to route a WP at any point in the planning process for review, craft input, management review/approval, etc. or approval of the planned WP tasks by the facility manager, Engineering or other personnel may be required depending on the estimated funds required, contractual liabilities and operability impact of the identified deficiency on the facility.

c. Discuss how feedback and history from previous maintenance evolutions is recorded and used in the planning process.

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 433.1B, the NMMP must include the process for developing and maintaining documented and retrievable maintenance history to support work planning, performance trending, analysis of problems to determine root causes of unplanned occurrences related to maintenance, and continuous program improvement.

The NMMP should address the following:

- Maintaining maintenance history records for SSCs that are part of the safety basis.
- Considering maintenance history records in planning for CM, periodic maintenance, and modifications.
- The availability of maintenance history records for use by appropriate personnel and departments.
- Effectively documenting maintenance work and inspection/test results.
- Periodic reviews of maintenance history to identify equipment trends and persistent maintenance problems to determine root causes and to assess the impact on facility safety and reliability. Maintenance program adjustments are made or other corrective actions are taken as needed.

A maintenance history and trending program should be implemented to document maintenance performed, to provide historical information for maintenance planning, to support maintenance and performance trending of facility systems and components, and to improve facility reliability. The documentation of complete, detailed, and usable history will be increasingly important as plant-life extension becomes an issue. Maintenance history enables trending to identify improvements for the maintenance program and needed

equipment replacements or modifications. This history should assist in ensuring that root causes of failures are determined, corrected, and used in future work planning.

The maintenance history program should clearly identify the SSCs for which a history is to be maintained, the data to be collected, methods for recording data, and uses for the data. Typically, maintenance history is provided for all SSCs for which periodic maintenance is performed. The program should include the type of equipment, model, serial and identification numbers, location information, and other information listed below.

At a minimum, each SSC included in the safety basis should have a separate maintenance history file. An essential element of the history files is a chronological record of the completion data of each work order, including the date of completion, worker notes on completed WOs, labor hours expended, etc. The history file should include data on each review of the history including results of the review, date of review, and names of personnel who performed the review.

Equipment failures and abnormal trends should be analyzed and corrective action recommended in a timely manner. In addition, periodic engineering reviews of the maintenance history file should be conducted in accordance with a schedule recommended by the engineering support supervisor and approved by the responsible manager. The purpose of the reviews is to determine whether recurring maintenance problems or other performance trends indicate a need for corrective maintenance, replacements or modifications. The assigned engineer should determine the probable cause and recommend a course of action. This may result in CM, component modification or replacement, a change in the preventive or PdM schedule, or a change in a procedure. The assigned engineer should track performance after corrective action has been performed to ensure deficiencies have been corrected.

Regular users should be trained to access and search the history databases and files.

Maintenance coordinators, supervisors, experienced workers, and work planners should review the maintenance history file on defective and similar components. Their review should consider information on similar deficiencies and performance trends when preparing WRs and/or WP repair instructions. They should also consider the performance of similar components at other DOE and non-DOE facilities.

The following uses of maintenance history data should be considered:

- Failure analysis
- Maintenance assessments
- Preventive maintenance
- Outage planning
- ALARA program
- Plant life extension

d. Discuss work planning considerations such as material, tool, and manpower requirements; interdepartmental coordination; safety considerations; radiological protection requirements; and quality control requirements are included; and maintenance history records are considered where appropriate.

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 433.1B, the NMMP must include the process for planning, scheduling, coordination, and control of maintenance activities, and properly emphasizing equipment availability. The process must include the application of a CSE program in accordance with DOE O 420.1C in the planning and execution of maintenance activities.

The NMMP should address the following:

- Planning group organization and responsibilities
- Expectations for management commitment, overview, and support of the program
- The process for ensuring the appropriate level of detailed work instruction so that workers, schedulers, and other affected organizations can carry out the activities as planned
- The process for coordination of integrated discipline of WPs to ensure involvement of the appropriate persons and the proper sequence of carrying out the work
- Expectations for experience or qualification of individuals performing work planning
- How feedback from maintenance personnel is used to facilitate improved future planning activities
- The use of job history for establishing standard job duration, parts, and consumables for repetitive jobs
- The manner in which the planning system addresses the following:
    - Identification and control of the hazards associated with the work activity and area
    - Reduction of the impact of planned outages by planning, coordinating, and completing maintenance activities in a timely manner
    - Reducing facility and equipment downtime
    - Reducing human errors
    - Reducing radiological and toxicological exposure to workers
    - Controlling and reducing the number of contaminated areas
    - Completing scheduled surveillances and PM activities in a timely manner
    - Establishing appropriate post-maintenance/post-modification testing and acceptance criteria
    - Managing the CM backlog to minimize the backlog and completion time of outstanding deficiencies
    - Controlling overtime
    - Completing outage and non-outage work on schedule
    - The process for reviewing completed WPs for proper documentation, post-maintenance testing, safety hazards encountered, feedback, possible changes to the PM program, and equipment history update

In accordance with DOE O 420.1C, the CSE must maintain integrity of a facility's safety basis as well as maintain overall cognizance of the system and be responsible for system

engineering support for operations and maintenance. The CSE must provide technical assistance in support of line management safety responsibilities and ensure continued system operational readiness. In accordance with DOE O 433.1B, the NMMP must describe the application of a CSE to the maintenance activities.

Effective work planning is necessary to identify the required support and detailed scoping to successfully schedule, coordinate, and control maintenance activities. Accurately defining the work to be performed and providing qualified workers and appropriate procedures or instructions can reduce maintenance errors and the risk of injury to personnel. Planning also reduces work delays and improves efficiency by ensuring required support items such as special tools, PPE, other equipment, repair parts, and materials are available when needed.

Coordinating maintenance activities is necessary to help ensure work can be effectively accomplished. Coordination should ensure the availability of necessary safe work permits; equipment lockouts/tagouts; and quality control (QC) verifications. Coordination should include the CSE when the maintenance activities involve SC and SS SSCs as defined in the facility's DOE approved safety basis, as well as to other systems that perform important DID functions, as designated by facility line management. Coordination is needed where various groups are involved in a work activity or are concurrently working in the same area. A knowledgeable individual responsible for the major portion of the work activity should be assigned the lead in identifying and coordinating needed support.

The primary objective of work planning is to identify all technical and administrative requirements to complete a work activity and to provide the materials, tools, and support activities needed to perform the work safely and correctly. Effective planning, scheduling, and coordination will help minimize delays.

Work planning should be periodically assessed through field observation of work being performed and direct feedback from maintenance personnel to maintenance planners. An effective planning program should contain the following:

- Management commitment, overview, and support of the program
- The appropriate level of detailed work instruction so that workers, schedulers, and other affected organizations can carry out the activities as planned
- Proper coordination of integrated discipline review to ensure involvement of the appropriate persons and the proper sequence of carrying out the work
- Involvement of experienced individuals in work planning
- Feedback from maintenance personnel to facilitate improved future planning activities
- Use of job history for establishing standard job duration, parts, and consumables for repetitive jobs

The planning system should address the following:

- Identifying and controlling the hazards associated with the work activity and area
- Reducing the impact of planned outages by planning, coordinating, and completing maintenance activities in a timely manner
- Reducing the number of forced outages
- Minimizing challenges to SSCs that are a part of the safety basis

- Reducing worker lost-time accident rate
- Reducing facility and equipment downtime
- Reducing human errors
- Reducing radiological and toxicological exposure to workers
- Controlling and reducing the number of contaminated areas
- Completing scheduled surveillances and PM activities in a timely manner
- Establishing appropriate post-maintenance/post-modification testing and acceptance criteria
- Reducing repeat maintenance WRs (rework)
- Managing the CM backlog to minimize the backlog and completion time of outstanding deficiencies
- Controlling overtime
- Staffing and training the maintenance organization
- Completing outage and non-outage work on schedule

When developing controls for a maintenance work activity, consideration should be given to the probability and significance of negative consequences due to the identified hazards associated with the work activity and area. The complexity of the work activity will also impact the probability of an undesirable outcome. A simple matrix such as the one illustrated in figure 1 would show hazard consequence measured on one axis and probability measured on the other. The worse the potential consequence and the greater the probability of an undesirable outcome, the more robust the controls or the DID should be.

The purpose of the matrix (figure 1) is to gage the appropriate effort to expend on control development and implementation, graded from the least to the most hazardous work activities. The level of hazards analysis and controls is graded based upon the likelihood and severity of the consequences to the worker, the public, and the environment.

HAZARD RANKING MATRIX			
	CONSEQUENCE		
PROBABILITY	H	M	L
H	HH	HM	HL
M	MH	MM	ML
L	LH	LM	LL

Source: DOE G 433.1-1A

Figure 1. Hazard ranking matrix

Depending on the particular maintenance work activity, the individual planning the work should use a team approach in evaluating the hazard(s). The team may include environmental, health, and safety professionals, the CSE, the facility owner, and worker representation in determining whether the consequence and the probability of the hazard(s) are at the high, medium, or low level.

The information gained from the matrix should be used in planning the work to determine the proper degree of rigor needed to ensure the safe and effective performance of the work activity. Controls to be considered include the following:

- Mix of worker skills and qualifications (apprentice, master, special qualifications)
- Degree of worker preparations (pre-Job briefing, mockup training)
- Detail of work instructions (minor maintenance, comprehensive WP)
- Level of supervisory oversight (routine, frequent, continuous)

e. Discuss how prioritization, scheduling, and coordination of maintenance activities avoids unnecessary removal of equipment and systems from service, and uses manpower and outage time effectively, and controls backlog.

The following is taken from DOE G 433.1-1A.

The NMMP should further address how

- the work-control system provides management with an accurate status of maintenance planning and outstanding maintenance work;
- control of work is accomplished through the effective use of a priority system and the backlog of work is effectively managed;
- work planning considerations such as material, tool, and manpower requirements; interdepartmental coordination; safety considerations; radiological protection requirements; and QC requirements are included; and maintenance history records are considered where appropriate;
- the work to be accomplished is clearly defined by a work document that identifies or includes applicable procedures and/or instructions. Troubleshooting activities are controlled by applicable work documents;
- advance planning is performed and routinely updated for scheduled and unscheduled outages. Considerations such as work priority, work procedures and instructions, facility/system conditions, length of outage required, pre-staging of documents and materials, and coordination of support activities are included;
- ALARA concepts are used in work planning to minimize man-rem exposure;
- scheduling and coordination of maintenance activities avoids unnecessary removal of equipment and systems from service and uses manpower effectively;
- post-maintenance testing requirements are clearly defined and include the following:
  - Clearly written test instructions
  - Test scope sufficient to verify the adequacy of work accomplished
  - Test acceptance criteria

- post-maintenance testing results are documented and reviewed to ensure proper system/equipment performance before returning the system to service; and

- completed work-control documents are reviewed in a timely manner to check proper completion of maintenance work and to verify that corrective action resolved the problem.

f. Discuss how system engineering is involved in the following activities:

- **Remaining appraised of operational status and ongoing modification activities**
- **Assisting in review of key system parameters and evaluates system performance**
- **Identifying trends from operations and maintenance, and providing assistance in determining operability, correcting out-of-specification conditions, and evaluating questionable data**
- **Remaining cognizant of system-specific maintenance and operations history and industry operating experience, as well as manufacturer and vendor recommendations and any product warnings regarding safety SSCs in their assigned systems in order to advise the maintenance organization**
- **Initiating actions to correct problems**
- **Reviewing and concurring with design changes and maintenance modifications**
- **Providing input to the development of special maintenance and test procedures**

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 420.1C, the CSE is required to maintain integrity of a facility's safety basis as well as maintain overall cognizance of the system and the CSE is responsible for system engineering support for operations and maintenance. In accordance with DOE O 420.1C, the CSE is required to provide technical assistance in support of line management safety responsibilities and ensure continued system operational readiness.

The CSE supports the planning and performance of maintenance activities by performing the following:

- Ensuring that system configuration is being managed effectively, including reviewing and concurring with post-maintenance/post-modification testing and acceptance criteria for assigned systems
- Remaining apprised of operational status and ongoing modification activities
- Assisting in review of key system parameters and evaluating system performance
- Initiating actions to correct problems
- Remaining cognizant of system-specific maintenance and operations history and industry operating experience, as well as manufacturer and vendor recommendations and any product warnings regarding safety SSCs in their assigned systems to advise the maintenance organization
- Identifying trends from operations and maintenance
- Providing assistance in determining operability, correcting out-of-specification conditions, and evaluating questionable data
- Providing or supporting analysis when the system is suspected of inoperability or degradation
- Reviewing and concurring with design changes and maintenance modifications
- Providing input to the development of special maintenance and test procedures

The following is taken from DOE O 420.1C.

The protocols for implementing the site or facility CSE program must be documented, must include the FRAs of CSEs, and must address the following elements:

- Identification of systems covered by the CSE program and identification of systems assigned for coverage
- CM
- Support for operations and maintenance
- Training and qualifications of CSEs

The CSE program must be applied to active SC and SS systems, as defined in the facility's DOE-approved safety basis, as well as to other active systems that perform important DID functions, as designated by facility line management. The designated systems and the rationale for assignment of CSEs in a graded approach must be documented.

A qualified CSE must be assigned to each active system within the scope of the program. Consistent with the graded approach, large, complex, or very important systems may require assignment of more than one CSE. Conversely, a single individual may be assigned to be the CSE for more than one system.

5. Facility maintenance management personnel must demonstrate a working level knowledge of types of maintenance.

a. Describe types of maintenance that can be used by nuclear facilities, their definitions, and applicability.

The following is taken from DOE G 433.1-1A.

Types of maintenance generally fall into two categories: periodic (or proactive)—scheduled by calendar period, operating hours, or other situational event (e.g., prior to startup) and corrective (or reactive) – repairs, alignments, etc. needed when equipment fails or does not perform its intended purpose. Periodic maintenance includes PM, surveillances, and PdM.

Preventive Maintenance

PMs consist of all those systematically planned and scheduled actions performed to prevent equipment failure. The PM program should define the required activities and the frequency with which they should be performed. Surveillance is the term normally used to denote PM, inspections, or tests on safety SSCs required by the facility safety basis. These surveillances are important as they help to maintain the safety basis valid and maintain compliance with the TSR, where applicable. Normally, operations track the scheduling and performance of surveillances, in addition to the general work control process, because of their safety basis relationship.

Predictive Maintenance

PdM consists of measurements or tests performed to detect equipment or system conditions. These activities should be less invasive, time consuming, and costly than PM or CM. The results of PdM can be analyzed to determine what degree of maintenance is required and when it is needed. This provides benefits similar to PM without performing unneeded

maintenance with its cost and potential for human error. CM efficiency may be improved by directing repair efforts (manpower, tooling, parts) at problems detected using PdM techniques. Industry studies have shown significant savings and improved reliability using PdM. PdM should be integrated into the overall maintenance program so that proactive repair planned maintenance may be performed before equipment failure.

Not all equipment conditions and failure modes can be reliably monitored; therefore, PdM should be selectively applied. It is normally limited to components and systems that are important to the safe and reliable operation of the facility. The effectiveness of the program is dependent on the accuracy of equipment degradation rate and time to failure assessment.

Video 1. Predictive maintenance
http://wn.com/Predictive_maintenance#/videos

Corrective Maintenance

Corrective Maintenance is performed in response to failed or malfunctioning equipment, systems, or facilities to restore their intended function and design capabilities. Analysis should be performed to determine the causes of unexpected failure and the corrective action that should be taken, including feedback into the preventive and PdM programs, and training and qualification programs. The establishment of priorities for CM should be based on plant objectives and the relative importance of the equipment scheduling. Emergency management procedures should manage equipment failures leading to emergency conditions. This is not to be confused with urgent maintenance (failure of equipment important to safety and/or mission performance). Urgent maintenance may have accelerated processes, but should continue to follow the ISM model for work scope definition, hazard identification and control, and work authorization.

A program for identification and timely repair of deficient SSCs should be established. There should be established criteria and responsibilities established for timely review and approval of deficiency reports and work requests. A reliable method should be in place to confirm that all material deficiencies are identified and entered into the work-control system. Inspection criteria, including a process to measure the degradation of standby and passive safety-related systems should be in place, and inspection tours should be periodically conducted to identify any exceptions or deviations. The criteria should include the following:

- Mechanical systems and equipment are in good working order.
- Good equipment lubrication practices are being followed.
- Fluid system leaks are minimized, monitored, appropriately corrected or controlled, and assessed for impact on safe operations.
- Instrumentation, controls, and associated indicators are operable and calibrated as required.
- Electrical and electronic equipment are operable and appropriately protected from adverse environmental conditions.
- Mechanical operators, fasteners, and supports are in place and operable.
- Components, systems, and structures are preserved and insulated.
- Housekeeping is adequate to support reliable system operations.

b. Discuss how maintenance strategies are balanced with respect to safety basis, high production, reliability, quality, and worker safety.

The following is taken from DOE G 433.1-1A.

An effective maintenance program provides a high degree of equipment and facility predictability, reliability, and cost-effectiveness. Individual equipment maintenance plans may vary, but should be optimized for the equipment. This maintenance approach may range from "run-to-failure"—for non-safety related, low-cost, easily replaceable equipment; to a very proactive plan of ongoing maintenance—for equipment whose failure can impact safe operation, product quality, and facility mission. Many factors should be considered in establishing an effective and efficient balance of the various types of maintenance. For safety related systems and equipment, a thorough technical analysis using a method such as reliability-centered maintenance (RCM) should be used to establish this balance. RCM provides a systematic method for analyzing functions, failure modes, and periodic maintenance to monitor and maintain equipment to ensure it continues to meet its functional requirements. For other equipment, the amount of periodic maintenance may be determined through industry experience, consensus standards, and good engineering judgment; then adjusted based upon results during the operating cycle.

Elements needed to implement this maintenance program successfully include the following:

- The MEL, which includes a listing of all SSCs that are part of the safety basis. The MEL may also include other SSCs that are not part of the safety basis. The MEL should be used as the listing for development of system and component maintenance plans.
- A system engineering program per DOE O 420.1C, which should take the lead in developing, monitoring, and revising maintenance plans in conjunction with maintenance and operations. The effectiveness of these maintenance plans should be periodically reviewed.
- Work control planners should develop standard work procedures for this periodic maintenance and ensure it is scheduled at its required periodicity.
- Maintenance management should monitor compliance with periodic maintenance schedules and provide input to improve the efficiency of the program. Performance of this maintenance should be evaluated in their self-assessment program.

Video 2. Reliability-centered maintenance
http://wn.com/Reliability_centered_maintenance

c. Discuss when a corrective or reactive maintenance strategy could be used as an alternative to proactive maintenance.

The following is taken from ReliabilityWeb.com, *Preventive vs. Corrective Maintenance: Clearing the Confusion.*

Historically, some confusion exists on how to classify maintenance tasks as PM or CM. In its simplest form, PM tasks are inspection and servicing actions that are performed on a scheduled basis, and CM tasks are unexpected actions that require an unscheduled response. However, the confusion arises primarily in two commonly encountered areas.

The first deals with predictive and condition directed PM tasks, which measure and trend equipment "health" parameters for signs of incipient failure modes. Such measurements are accomplished on a scheduled basis—and preplanned actions are also scheduled to occur when the incipient failure condition progresses to a critical stage, thus preventing outright failure. Notice that this form of PM is preplanned and scheduled in its entirety, including the final action to preclude outright failure. This scenario is PM from start to finish, that is, the maintenance actions to preclude an outright failure are part of the preventive—not corrective—scenario.

A second issue deals with RCM-based decisions to deliberately run-to-failure. The scheduled strategy here is to do nothing until actual failure occurs if safety, uptime, and economics of restoration are not compromised. Even though the actual restoration tasks cannot be scheduled, it is nevertheless preplanned. From the outset, restoration of the failed item is preplanned to occur and, as above, this scenario is likewise PM from start to finish.

In both of the above issues many people tend to categorize the restoration action as corrective. Not so—it is preventive. When these two issues are not properly treated and recorded as preventive (not corrective) actions, the metrics that are measured and reported become distorted and management is apt to have a distorted view about the overall effectiveness of their PM program.

d. Discuss how preventive maintenance (PM) and predictive maintenance (PdM) are selected and assigned appropriate periodicity.

The following is taken from DOE G 433.1-1A.

Preventive Maintenance

Selection of required PM actions should be based on manufacturers' recommendations, plant experience, and good engineering practice. PM frequency should be based on adequately implementing the entire program, considering such elements as regulatory requirements, consensus standards, vendor recommendations, ALARA considerations, and performance monitoring. A documented basis for the planned actions should be provided. Further, any deferral of planned tasks should have a technical basis. An SME should lead or be directly involved in the establishment of the PM program and individual PM activities. Effectiveness should be monitored and the program revised if necessary.

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 fails. Unfortunately, maintenance actions sometimes introduce new failures because of factors such as human error. Therefore, there is a need to establish an effective interval (or frequency of maintenance) that yields the maximum achievable availability.

Optimization of maintenance intervals involves the following general activities:

- Ranking PM tasks
- Monitoring PM activities, plans, and schedules
- Accessing PM and other maintenance data
- Listing recurring failure modes/parts

- Calculating and monitoring SSC availability
- Keeping track of PM cost
- Calculating the PM interval by balancing availability, reliability, and cost

The management of PM scheduling should incorporate the following concepts:

- A master resource-loaded schedule should be prepared for all PMs.
- PM work-control documents should be prepared for each task. Since they are recurring and may be used on more than one piece of equipment, they should be designed for easy replication.
- PM tasks are capable of being quickly sorted and listed by system and required operational condition. This can aid in planning work items during forced outages or unplanned changes in operating conditions.
- PMs should be scheduled at their nominal intervals and, where practical, with corrective and other related maintenance or testing on the same equipment.
- PMs that might affect the results of surveillance testing such as lubrication, venting, and equipment exercising should be scheduled to occur following the completion of surveillance testing to avoid pre-conditioning the equipment and affecting the results.
- PMs are intended to be performed at their nominal periodicity using a graded approach. To allow some flexibility for workload and other unforeseeable conditions, the maintenance program documents should define what is meant by each technically based nominal period. Generally, this allowance should not be more than 25 percent of the PM interval (e.g., monthly equals three to five weeks) not to exceed one quarter regardless of the interval, and should be approved as part of the interval determination. PMs should be scheduled at their nominal intervals under normal circumstances.
- Delays in the performance of scheduled PMs beyond their defined period should require escalating approval. For example, approval should be obtained from system engineers, maintenance supervisors, operations managers, maintenance managers, and the facility manager, depending on the length of time that the task is to be delayed and the potential risk involved.
- Maintenance and operations personnel should be encouraged to recommend changes in PM intervals based on real-time observations and conditions. System engineers should evaluate and the operations and maintenance management should approve these proposals.
- The maintenance manager should report periodically to the operations manager any associated problems with performing PM tasks, including the number overdue.

Predictive Maintenance

Many different PdM techniques are used throughout industry. The following paragraphs describe some of the common PdM techniques. Although the key elements of the program are applicable to all facilities, some of the details may need to be modified to reflect individual facility conditions and needs.

Bearing temperature monitoring is a technique used to measure and trend temperatures of critical machinery bearings to predict failure. Changes in bearing temperature may indicate wear due to loss of lubrication, excessive vibration, or intrusion of foreign material into the

rotating assemblies. Bearing temperature analysis is often performed in conjunction with the vibration monitoring and lubricating oil analysis/ferrography programs.

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

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

- Lubricating oil analysis monitors the actual condition of the oil itself. Parameters measured include viscosity, moisture, additive package, and the presence of other contaminants.
- Ferrography is a technique used to analyze oil for metal wear products and other particulates. Trending and analyzing the amount and type of wear particles in a machine's lubrication system may pinpoint where degradation is occurring.
- Grease analyses are techniques used to detect changes in the lubricating properties of grease. Sensory tests such as color, odor, and consistency are most often applied to grease. A penetration test is sometimes used to quantify grease consistency. Grease analyses are often performed on samples obtained from motor-operated valves.

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

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

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

Acoustic testing is in many cases one of the few techniques that can locate leaks in buried lines. Acoustic testing uses various devices that amplify the sound produced by leaking fluids to aid in the detection and location of leaks in buried pipelines. Acoustic testing can be used for leak detection in water, steam, gas and air lines.

e. Discuss how PMs are waived or deferred.

The following is taken from DOE G 433.1-1A.

PMs are waived or deferred only with appropriate approval related to SSC significance and amount of delay.

f. Discuss how PdM can be used to limit unnecessary PMs.

The following is taken from Ezine Articles, *Preventive vs Predictive Maintenance*.

There are 3 types of maintenance: corrective, preventive, and PdM. All differ considerably, and are used in different situations. Corrective maintenance involves doing nothing until something fails. For example, a new car is purchased and driven until something breaks. It is common sense that doing some minor maintenance at scheduled intervals is going to increase the lifespan of the vehicle, which is why cars are serviced regularly.

Preventive maintenance is exactly this; pre-determined schedules of maintenance that happen regardless of the equipment's condition. Preventive maintenance includes regular inspections of fluids, safety checks, and draining the necessary oils and filling them back up with new oil. By doing this, problems are identified before they worsen, and the fixes are minor. This usually translates to less cost, and the vehicle life is significantly extended. In the industrial world, everything from pumps through to conveyors, mills and crushers have PM scheduled. This ensures that problems are picked up early and maintenance can be arranged to replace any worn parts before failure occurs.

Preventive maintenance is not cheap, but over the lifetime of equipment it certainly pays off. In most applications, downtime is extremely expensive. By having the right PM schedule in place, downtime is limited, and therefore the cost of doing the maintenance in the first place is negligible. Maintenance has changed and evolved significantly over the last 10 years. Today, the most preferred way to do maintenance is predictive.

As the name suggests, PdM involves predicting when a machine is going to fail. There are many different ways in which a machine's condition can be monitored. These are known as condition monitoring, and include vibration analysis, oil analysis, thermal imaging, and ultrasonic measurements. All of these are nondestructive, fast, and highly effective.

A lot of equipment in the industrial world has maintenance applied to it when it does not need it. For example, pumps may be stripped down as part of a PM schedule. If the pump was in pristine condition, the maintenance was almost a waste of time. What if it was possible to tell that the pump is in perfect condition without pulling it apart? By using vibration analysis, vibrations can be trended indicating the condition of the equipment. As rotational equipment wears, it vibrates more, and this is easily identified. It is possible to trend the vibration and watch it get worse, and plan maintenance when the equipment really needs it.

Each of the condition monitoring types mentioned above are specialized fields in themselves. Two methods to improve the way maintenance is done. The first is to ensure that a quality CMMS is in place and the second is to implement PdM policies. These two methods will help point maintenance in the right direction and ensure increased efficiency, morale, and enjoyment in the maintenance departments.

Video 3. Proactive maintenance

http://www.bing.com/videos/search?q=Proactive+Maintenance&view=detail&mid=87BD8C5FCC0D2FA6119287BD8C5FCC0D2FA61192&first=0&FORM=NVPFVR

6. **Facility maintenance management personnel must demonstrate a working level knowledge of maintenance procedures.**

   a. **Discuss the development, review, approval, and revision of maintenance procedures including:**
      - **Ensuring procedures are clear, concise, and contain adequate information for users to understand and perform their activities effectively**
      - **Verifying technical details such as set points, control logic, and equipment numbers are consistent among procedures, drawings, valve lineup sheets, and system descriptions**
      - **Including hold-points such as quality and radiological protection checks in procedures, as needed**
      - **Incorporating human performance factors into procedures to promote error-free performance**
      - **Documenting post-maintenance/modification testing requirements and acceptance criteria, follow-on steps, and restoration instructions, where appropriate**
      - **Checking new, changed, or revised procedures to ensure usability before or during initial use**
      - **Applying the USQ process**

The following is taken from DOE G 433.1-1A.

As addressed in DOE O 433.1B, the term “maintenance procedures” is a generic term for documents providing maintenance directions. Maintenance procedures should be prepared and used to provide appropriate work direction and to ensure that maintenance is performed in a safe, efficient, and consistent manner. Maintenance procedures should be technically accurate, complete, up to date, and presented in a clear, concise, and consistent manner to minimize human error.

Guidance should be provided for the development, writing, verification, validation, approval, and use of maintenance procedures as required. The guidance should also include such factors as procedure: issuance, periodic review, revision, reference material control, identification, and storage.

A balanced combination of written direction, skilled workers, and work-site supervision is required to achieve the quality work essential to safe and reliable facility operation.

Maintenance procedures should be written for and used in all maintenance of SSCs that are part of the safety basis in hazard category 1, 2, and 3 nuclear facilities. Maintenance procedures should be developed following ISM and the five core functions: define the scope of work, analyze the hazards, establish the controls, perform the work safely, and obtain feedback. Maintenance procedures should extend the five core functions into the planning and performance of work. Using the graded approach, the procedures may include information such as special skill levels required, materials and special tools needed, facility or system conditions and permits needed, and other safety requirements and precautions needed to perform the maintenance. Workers should be involved in procedure development and verification whenever possible. In addition, the procedures should identify system

interactions and interconnectivities that could result in equipment/systems undergoing maintenance adversely affecting other SSCs.

The maintenance procedures should be clear and concise with the user in mind, to ensure accurate understanding. Experienced workers and engineers can be trained to write maintenance procedures, or procedure writers can be used, with experienced workers or engineers providing technical input. Maintenance procedures should include the following:

- Procedure identification and approval status
- Procedure purpose and scope
- Consistent organization, presentation and format
- Clearly understandable text, using correct grammar and punctuation; appropriate level of detail; concise instruction steps in logical sequence; flags to identify instructions steps that need to be performed in a prescribed sequence; specific nomenclature; quantitative and compatible values; referencing methods; coordination of multiple actions; effective formatting; and clear table, graph, and data sheet layout
- Clear indication of hold points, warnings, caution statements, independent verification requirements, or data to be recorded
- Nuclear facility and system prerequisites, precautions and limitations, required special tools and materials, and required personnel
- Clear indication of post-maintenance/post-modification testing and acceptance criteria, follow-on steps, and restoration instructions where appropriate
- Applicable operating experience information
- Direction to workers to stop work and notify management of maintenance that cannot be completed as originally planned
- Reference to source information

Procedure Verification

Verification is review of a new or revised procedure to determine whether it is technically accurate and in the proper format. The review should ensure the work activity is adequately described, all hazards are analyzed and controls are established, and that human factors principles and appropriate administrative policies are incorporated. The technical accuracy review should review 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 procedure.

Verification should be conducted by one or more reviewers who were not involved in writing the procedure but are representative of the intended users. Reviewers from other disciplines, such as health physics, engineering, and operations, should be considered for involvement in the process.

Procedure Validation

Validation is review of a procedure to determine its usability and correctness. This review evaluates whether the procedure provides sufficient and understandable direction to the worker and is compatible with the equipment or system being maintained. Validation may be conducted in a shop, in a training environment, on a mockup or simulator, or by the worker and supervisor walking through the procedure prior to its approval. In general, the walk through of the procedure should be done at the location where the work will be performed to

identify any issues with equipment, the procedure, access, unanticipated hazards, controls, etc. In certain hazardous circumstances, such as a high radiation area, it may be necessary to identify any issues without performing the walk through at the work location.

Procedure Approval

Proposed procedures and changes to procedures, which could affect the performance of safety SSCs, should be reviewed as part of the USQ process. In accordance with administrative procedures, management should approve maintenance procedures.

Procedure Change Control, Periodic Review, and Revision

Responsibilities for procedure program administration should be clearly defined. Procedure changes and revisions should be controlled in accordance with facility administrative requirements. All procedures should be periodically reviewed to ensure their continued applicability and accuracy. Redline changes and revisions of procedures should receive the same review, approval, and distribution as new procedures with the extent of these reviews varying depending on the extent of the revision. The implementation impacts need to be evaluated and communicated to affected parties.

Vendor manuals or the portions of a vendor manual and other reference materials used in support of maintenance should be technically accurate, up to date, and controlled. Reference material used in lieu of facility-prepared maintenance procedures should receive the same review and approval as facility maintenance procedures.

b. Discuss management's expectations for procedure availability and use.

The following is taken from DOE G 433.1-1A.

A process should be in place to ensure the worker has the most current procedure prior to performing work.

Management should establish and reinforce clear expectations and requirements for the use of procedures to perform maintenance activities. Management should ensure procedure use requirements are understood and met by the workers. Normally, three levels of procedure use are defined:

1. Continuous use of procedures for activities having direct impact on nuclear safety and reliability or difficult, complex tasks independent of the frequency performed
2. Reference use for tasks easily accomplished from memory or for tasks for which improper actions pose no immediate consequences to workers or equipment
3. Information use for tasks that can be performed without referring to the procedure

Procedures should clearly identify and distinguish between steps or groups of steps that may be performed out of sequence and those that need to be performed in a prescribed sequence. Procedure users should understand the need to use procedures with forethought and good judgment, even when step-by-step compliance is not required. Workers should not proceed with work and should seek supervisory assistance with any situation that is unclear or unexpected. (See definition of stop work and time out/safety pause.) Supervisors or managers should resolve such inquiries promptly.

c. Discuss actions to be taken when procedures conflict, are inadequate for the intended tasks, or when unexpected results occur.

When there is a conflict between the various code requirements, the most stringent/ conservative standard should always apply.

7. Facility maintenance management personnel must demonstrate a working level knowledge of training and qualification.

a. Discuss the systematic approach to training as required by DOE O 426.2.

The following is taken from *Instructional Design: Using the ADDIE Model*.

The acronym ADDIE stands for analyze, design, develop, implement, and evaluate. It is a systematic approach to training model that has withstood the test of time and use. It is simply a device to help us think through a course's design. Though the model appears linear, it does not have to be followed rigidly or in a linear approach, especially if course materials are already developed. Figure 2 gives an abbreviated overview of some of the components of ADDIE.

Analyze	Design	Develop	Implement	Evaluate
Pre-planning; Thinking about the course	Design your course on paper	Develop course materials and assemble the course	Begin teaching	Look at the course outcomes with a critical eye
• Design of course • Audience • Goal • Objectives • Identify content • Identify environment and delivery • Instructional strategies • Assessment strategies • Formative evaluation • Constraints	• Name the learning units of instruction • Identify content and strategies for an individual unit of instruction • Write instructions for the learning unit • Name the menu items for a learning module	• Based on design phase • Build content, assignments, assessments • Build course structure • Upload content	• Overview of course • Expectations • Initiate instruction • Interaction • Ask for feedback early on (formative evaluation)	• Did the students achieve expected learning outcomes? • What have you learned • How can you make the course better?

Source: Instructional Design: Using the ADDIE Model

Figure 2. Using the ADDIE model

The following is taken from DOE-HDBK-1078-94.

Analysis

The process descriptions contained in DOE-HDBK-1078-94 describe a systematic approach to identifying and documenting performance-based training requirements. The types of analysis used for identifying training requirements include needs analysis, job analysis, and task analysis. These analyses will provide assurance that training is the appropriate solution

to performance problems and identify requirements that serve as the basis for the design and development of performance-based training programs.

DETERMINE TRAINING NEEDS

Training needs are initially identified by reviewing regulatory requirements and existing training programs, and/or conducting a needs analysis. These activities enable facilities/sites/offices to determine training needs originating from performance problems, regulatory requirements, and in some cases, requests for additional training or changes to existing training.

A needs analysis can identify solutions to job performance discrepancies. Substandard performance may be related to faulty equipment, inadequate procedures, attitude of the workforce, etc. Prior to developing new courses or modifying existing training programs, a needs analysis should be conducted to determine that training is the appropriate solution. Proper conduct of the analysis identifies the root cause(s) and serves as a basis for future plans to correct identified performance discrepancies.

DEVELOP A VALID TASK LIST

A job analysis is conducted to develop a detailed list of duty areas and tasks for a specific job or position. It can also supply information to develop a job/position description, if desired. Job analyses also allow comparison of existing training programs to established requirements and identify deficiencies in the adequacy of program content. For existing programs, the job analysis provides reasonable assurance that all tasks essential to safe and efficient operation are addressed by the training program. It also identifies parts of the training program that are unnecessary, thus resulting in a more effective training program and more efficient utilization of resources. For facilities/sites/offices developing new programs, the job analysis provides the information necessary to identify tasks associated with the job. Training design and development activities can then be based on actual needs, as opposed to perceived needs.

All pertinent information regarding position-specific job analyses should be documented in a job analysis report, which becomes part of the training program file for each specified position. This report describes the process/methodology used to conduct the job analysis, the names and positions of individuals conducting the analysis, and the results of the analysis.

The first step in job analysis is a review of available job information. This review provides input to an initial list of tasks and duty areas, and serves as the starting point for further analysis. In addition to the information obtained from the review, SMEs from the prospective user group are consulted for compilation of task lists.

Questionnaires are prepared for distribution to job incumbents. They are used to verify the accuracy and validity of the initial task list and identify which tasks will be selected for training. The job incumbent is asked during the survey to assign ratings in the following categories: task importance, task difficulty, and task frequency.

Survey results are compiled and analyzed by the training organization. At a minimum, the reported results should contain the following:

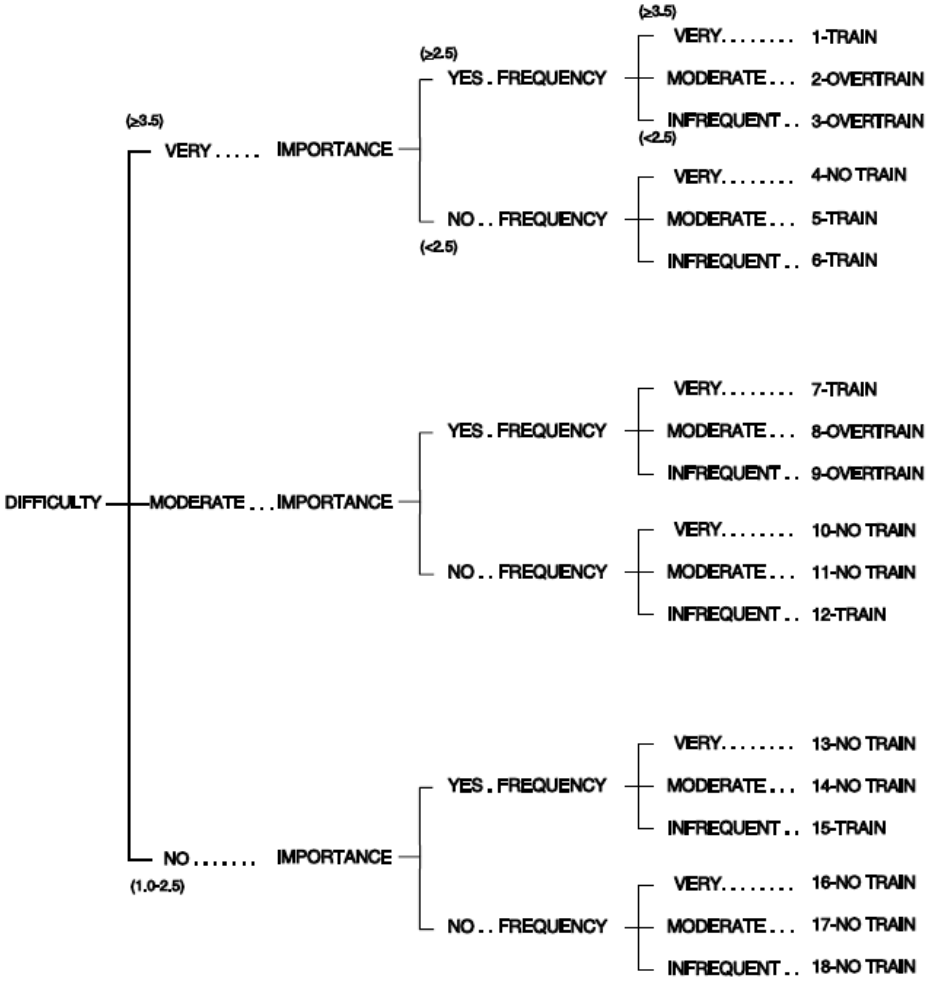
- Frequency of task performance
- Importance (consequences of inadequate performance)

- Difficulty of task performance
- All additional tasks, identified by survey respondents, which were not included in the initial survey

SELECT TASKS FOR TRAINING

After analyzing the survey results, the numerical averages of the responses are used to identify which tasks will be selected for training. Tasks are selected or deselected for training using a systematic process similar to the one illustrated in figure 3.

After the criteria have been established, the numerical average of each of the tasks is inserted into the decision tree and the proper path is chosen. Tasks should then be sorted into groups according to similar combinations of average difficulty, importance, and frequency ratings. The decisions arrived at using this procedure result in a grouping of tasks along a scale so that one end of the scale contains difficult, important, and frequently performed tasks; the other end of the scale contains the easy, less important, and infrequently performed tasks. Tasks that are identified as "No Train" should be reviewed by SMEs and supervisors to ensure that no formal training is needed.



Source: DOE-HDBK-1078-94

Figure 3. Criteria for selecting tasks for training

PREPARE A TASK-TO-TRAINING MATRIX

The purpose of a task-to-training matrix is to provide one document that can be used to guide the maintenance of a training program. It provides a ready reference for evaluating the impact of procedure changes, criteria for selecting tasks for training, updated technical information, revised learning objectives, etc.

CONDUCT AN ANALYSIS OF EXISTING TRAINING MATERIAL

At this point in the analysis phase, a comparison of existing training materials should be conducted. This is best accomplished using a committee made up of at least three SMEs and one or two knowledgeable people from the training organization.

CONDUCT A TASK ANALYSIS

Although included in this process for consistency, in actual practice, task analyses, design, and development activities normally occur concurrently for most tasks. As training is designed and developed for the tasks selected for training, each task should be analyzed to determine the knowledge, skills, and abilities required for satisfactory accomplishment of the task. Task analysts should be selected and further trained in the process.

APPLICATION OF JOB OR TASK ANALYSIS INFORMATION

Information collected during the analysis is translated into training program requirements. Analysis data are also used to validate training program content and ensure that training reflects actual job requirements for both existing and newly developed material.

TRAINING DEVELOPMENT/CHANGES

As additional training requirements are identified by user groups, requests for the development of new training materials and/or modifications of existing materials should be made.

ANALYSIS CHECKLIST

For ease in tracking activities during the analysis phase, use of a checklist is encouraged. This will allow individuals involved in the process to better plan and coordinate their activities.

Design

The approach described in this section outlines the basic processes used to design training programs that are based on the job-related/performance-based information collected during analysis. This section is organized into the major headings of the design process.

WRITE TERMINAL OBJECTIVES

Terminal learning objectives are learning objectives that clearly state the measurable performance the trainee will be able to demonstrate at the conclusion of training, including conditions and standards of performance. They are translated directly from the task statement, and provide the framework for the development of training/evaluation standards (TESs), enabling objectives, and lesson plans. Care must be taken when developing and writing learning objectives. Trainees must clearly understand them, or they are of limited use. Related terminal objectives must be written for each task statement before any other design work is begun.

DEVELOP TRAINING/EVALUATION STANDARDS

After the terminal objectives have been written, it is necessary to ensure that when training materials are developed they are directly linked to the objectives. The development of a TES can help to ensure that this vital link is maintained. The purpose of the TES is to provide the basis for the development of objective-based training materials and to maintain consistency in the evaluation of student performance. Each TES is directly related to a specific job task (or group of very similar tasks) identified during job analysis.

DEVELOP TEST ITEMS

Test items are developed to be consistent with the learning objectives. The purpose of the test item is to measure trainee performance against the criteria stated in the learning objective.

CONSTRUCT TESTS

The construction of tests at this time is optional. However, tests must be constructed prior to implementing the training program. Tests are a form of evaluation that instructors can use to measure the results or effectiveness of their stated objectives. Test items should be constructed and scored in an objective, rather than subjective, manner. An objective test can be scored without the exercise of personal opinion. The length of a test should not exceed the number of test items which could be answered in two hours by the average trainee. This may require assembling several tests for a given instructional area.

WRITE TRAINING DEVELOPMENT AND ADMINISTRATIVE GUIDE

A training development and administrative guide should not be confused with the facility's training management manual, which outlines the facility training policies and procedures that guide the development of all training. A training development and administrative guide is a management tool for the administration of an individual training program. It is used to gain management approval of the program and guide development and implementation efforts. Though not part of this guide, additional specifications may be developed to clarify and detail the required characteristics of individual courses or lessons. Approval should include training management and the management of the organization for which the training is being developed.

Development

This section describes the processes used to develop training programs that are based on job-related, performance-based information collected during the analysis phase and the work accomplished during the design phase. The development process includes the following.

SELECT TRAINING METHODS

Training methods selected should be based on the objectives and settings for the course. Training methods are techniques of communicating instructional material to trainees. They include lecture, demonstration/practice, discussion/facilitation, oral questioning, role playing, walk-through, and self-pacing.

DEVELOP LESSON PLANS

Lesson plans are detailed expansions of the curriculum outline that ensure consistency in the delivery of training from instructor to instructor and from student to student. They are used by the instructor as the primary training tool to guide the learning process and utilization of training materials. Lesson plans identify the learning objectives, content, learning activities,

training equipment, and training materials needed for training and provide guidance for their use.

DEVELOP TRAINING SUPPORT MATERIAL

Training support materials refer to training equipment, audiovisual media, and printed material. When selecting or developing training support materials, the type of material is influenced by the learning objectives and method of instruction. Materials should support the learning objectives and emphasize job-related information and situations. The lesson specifies what training materials are required and when.

CONDUCT TRAINING TRYOUTS

During a training program tryout, data is compiled and evaluated to correct faults and improve the effectiveness of the lesson plan and training materials. A training program tryout includes evaluation of training material for technical accuracy as well as instructional effectiveness.

Implementation

The implementation activities described in this section should be applied based on the status of an existing program. Some activities are performed only once during implementation of a training program while others are repeated each time the program is conducted. Activities of implementation are as follows:

CONDUCT TRAINING

If specified in the training development and administrative guide, trainees should be pretested to ensure that they are adequately prepared. Trainee performance should be monitored and evaluated during training. This evaluation should provide for recognizing successful performance and areas in need of improvement.

CONDUCT IN-TRAINING EVALUATION

During training, data should be collected for subsequent use in evaluating and improving training program effectiveness. Evaluation information is collected from test performance data, instructor critiques and trainee critiques. Evaluation of the training program is addressed in the process.

DOCUMENT TRAINING

The documentation of training includes preparing, distributing, storing, controlling, and retrieving records and reports that address the training program and trainee participation. These records and reports assist management in monitoring the effectiveness of the training program. They also provide a historical reference of changes that have occurred within a program due to evaluations.

Evaluation

The evaluation phase of performance-based training takes place to determine the effectiveness of the training program. Evaluation is the QA component of the performance-based training model. There are three major activities involved in evaluation: monitoring of indicators, analyzing information, and initiating corrective actions.

MONITOR INDICATORS
Data should be collected for each indicator that provides the best indication of training effectiveness. While this data collection should be continuous, in many cases it is a batch process. In these cases, the frequency for which these items are reviewed should be determined based on the frequency management feels is necessary to ensure the currency of the training program.

ANALYZE INFORMATION
Program evaluation information must be analyzed before it can be used to make changes in training. The simplest method of analysis that will yield the information required should be used. Analysis methods include exception analysis and content analysis. Some types of data should be organized and tabulated using frequency distributions prior to analysis. Apparent performance discrepancies must also be verified through discussions with appropriate personnel.

INITIATE CORRECTIVE ACTIONS
If a performance discrepancy or potential problem is discovered and analysis confirms that training can contribute to a solution, action should be initiated to correct the existing or potential problem. Training modifications initiated due to existing deficiencies in personnel performance and those resulting from changing needs should be processed in a similar manner. Improvements and changes to training should be initiated and tracked systematically. Analysis results should be retained to document evaluation activities and indicators should continue to be monitored.

Because of the amount of work and cost involved, any decision to modify training should be carefully considered. Each facility should establish a procedure for deciding whether or not training should be changed, how it should be changed, and to whom the new or modified training should be provided.

Improvements or revisions involving any phase of the training process (analysis, design, development, implementation, or evaluation) should be completed in a timely manner. Since some performance deficiencies can be eliminated by better implementation of an existing program, with no changes in the program itself, this should be considered.

b. Discuss how maintenance personnel are qualified and/or certified.

The following is taken from DOE-G 433.1-1A.

Maintenance management should review an individual's training accomplishments before qualifying them for a given task. Similarly, qualifications of contractor personnel should be reviewed. This review should include the following:

- Verifying completion of all required prerequisite training
- Conducting or evaluating the results of a final written, oral, or practical examination, if required
- Evaluating the recommendations of the individual's supervisors
- Formally approving and documenting qualification

The following is taken from DOE O 426.2.

The program leading to qualification must be governed by written procedures that include requirements for documented assessment of the person's qualifications through examinations and performance demonstrations. The contractor must define qualification requirements for personnel in each functional level or area based on the criteria contained in this CRD. The contractor must have a method for formally indicating that a person is qualified and when the qualifications expire.

Qualification may be granted only after assuring that all requirements and other specified requirements have been satisfactorily completed. Qualification of operators and their immediate supervisors is valid for a period not to exceed two years unless revoked for cause.

Technician and maintenance personnel qualification must include demonstrated performance capabilities to ascertain their ability to adequately perform assigned tasks. Written examinations should be administered to personnel in these positions as applicable. However, a comprehensive final examination need not be administered to ascertain formal qualification of technicians and maintenance personnel. Satisfactory completion of the continuing training program, performance of their assigned duties, and assessment of individual performance such as that which is typically included in personal performance appraisals may be used to document continued satisfactory performance.

Certification is the process by which contractor management endorses and documents, in writing, the satisfactory achievement of qualification of a person for a position. Certification follows the completion of the qualification program for those positions identified as requiring certification. The notable difference between certification and qualification is that certification requires official contractor management endorsement of an individual's qualification to ensure senior management involvement in the qualification of key operations positions. Other significant differences between qualification and certification are the requirements associated with continuing training, examination, and reexamination for recertification.

c. Discuss how trade unions implement the apprentice and journeyman system and how it integrates into an M&O contractor T&Q program.

The following is taken from Lawrence Berkeley National Laboratory, *Berkeley Lab Launches Apprenticeship Program for Electrical Workers*.

Apprentice electricians will now have the chance to hone their skills at the U.S. Department of Energy's Lawrence Berkeley National Laboratory, thanks to a new MOU signed October 27, 2009, by representatives of Berkeley Lab and the Alameda County Electrical Joint Apprenticeship and Training Committee (JATC). The agreement will bring the apprentices to the lab's facilities division as part of their five-year-long program to become certified in the electrical trade.

"This MOU is an example of a new partnership between Berkeley Lab and the Building Trades Council of Alameda, and provides important training opportunities for a skilled craft whose performance is critical to the safe and efficient maintenance and renewal of Berkeley

Lab's infrastructure," says Jim Krupnick, the Lab's Chief Operating Officer and Associate Laboratory Director for Operations.

The MOU is the culmination of discussions begun in the spring of 2009 between Krupnick and Victor Uno, the business manager of Local 595 of the International Brotherhood of Electrical Workers (IBEW). IBEW jointly sponsors the JATC training facility with the Northern California chapter of the National Electrical Contractors Association.

"The idea of a partnership between Berkeley Lab and the JATC emerged from the recognition of the growing importance of green technology and science, and the need to train the future workforce and contribute to the local community with employment," says Uno, who previously worked at Berkeley Lab for 10 years as an electrician in the facilities division.

"In the past, the Lab has tried to create its own training programs," says facilities division director Jennifer Ridgeway, "but every major craft has their own requirements, which made it hard to cover everything in-house." The partnership with the JATC is an important step forward. "They are in the business to train, and they train 'em well," says Ridgeway.

In the spring, Krupnick, Ridgeway, and Ken Fletcher of Facilities toured the JATC's training facility in San Leandro, which is under the direction of Byron Benton. The $3-million state-of-the-art facility has instruction in almost two dozen areas of residential, commercial, and industrial electrical construction and installation, from basic residential wiring to photovoltaics and direct digital controls for energy management.

The five-year apprenticeship program combines JATC instruction with 900 hours of courses at Chabot College in Hayward and 8,000 hours of hands-on, OJT. The Berkeley Lab partnership is the first with a Federal agency in the Bay Area. Ridgeway says she came away with an increased appreciation of the trade itself. "I was impressed by what our electricians do. For their part, our people have a sense of pride in helping to train the next generation."

d. Discuss how worker qualification relates to work authorization.

The following is taken from DOE G 433.1-1A.

In accordance with DOE O 433.1B and using a graded approach as applicable, the NMMP must include a training and qualification program for maintenance positions specified in DOE O 426.2.

The NMMP should address the following:

- That a maintenance training and qualification program should establish and maintain the knowledge and skills needed by maintenance personnel to perform maintenance on all SSCs that are part of the safety basis for hazard category 1, 2, and 3 nuclear facilities.
- Maintenance is performed by or under the direct supervision of personnel who are qualified on the tasks to be performed.
- Maintenance personnel, including temporary and non-facility personnel, are knowledgeable of the following:

- General plant layout
- Purpose and importance of facility/systems and equipment
- Maintenance policies, processes, and procedures
- Effect of work on facility systems
- Industrial safety, including hazards associated with work on specific; equipment/systems
- Radiological protection and ALARA principles
- Job-specific work practices
- Principles to be used in the identification of potential suspect/counterfeit items
- Cleanliness and housekeeping practices

- OJT activities being evaluated for qualification sign-off are evaluated by personnel qualified as OJT instructors/evaluators.
- Maintenance personnel are knowledgeable of appropriate lessons learned from industry and in-house operating experiences (including actual events) applicable to their craft.
- Maintenance personnel are capable of troubleshooting equipment problems in a safe and efficient manner.
- Continuing Training is performed to maintain and enhance worker proficiencies and qualifications.
- Maintenance training is reviewed as part of the facility‘s self-assessment program.
- Periodic systematic evaluations of maintenance training and qualification in accordance with DOE-STD-1070-94 are performed.

Maintenance management should review an individual’s training accomplishments before qualifying them for a given task. Similarly, qualifications of contractor personnel should be reviewed. This review should include the following:

- Verifying completion of all required prerequisite training
- Conducting or evaluating the results of a final written, oral, or practical examination, if required
- Evaluating the recommendations of the individual’s supervisors
- Formally approving and documenting qualification

e. Discuss how on-the-job training activities being evaluated for qualification sign-off are evaluated by personnel qualified as OJT instructors/evaluators.

The following is taken from DOE G 433.1-1A.

OJT is practical, hands-on training by which employees learn skills through training conducted within the job environment. OJT is a formal part of maintenance training. This aspect of an individual’s training is normally conducted in the facility as part of their day-to-day work activities. Accordingly, maintenance department supervisors and selected experienced workers should be directly involved in OJT. Key elements of OJT include the following.

- Program adherence—OJT should be conducted in accordance with formally defined training programs that specifically identify items the trainee needs to accomplish. Knowledge requirements for each item, as well as the action a trainee is required to

do should be defined. The trainer and the trainee should understand what is required for each training item.

- Trainer qualification—OJT evaluations should be performed by personnel who are qualified as OJT instructors/evaluators. Personnel in the training department who have maintenance experience, as well as personnel in the maintenance department itself, may be used as OJT instructors/evaluators. 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—Non-qualified personnel should work under the direct supervision of personnel qualified to perform the activity or task. The trainee should understand how to avoid errors that could affect personnel safety or adversely impact the station. Before performing maintenance on equipment, trainees should discuss the procedure with the qualified worker 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. When trainees perform maintenance for qualification purposes, a qualified OJT instructor should observe the work so that the trainee properly accomplishes the activity in accordance with OJT evaluation guidance.
- Logs and reports—The qualified worker 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, they should discuss with the trainee out-of-specification values and their consequences, and the required reporting of such issues.
- Number of trainees—Consideration should be given to the training effectiveness and the effect on the equipment being maintained when a number of trainees are involved in an activity. Limiting the number will help each trainee receive the most effective instruction and will help ensure that the qualified worker is not overwhelmed by having too many trainees at once. An individual may be able to handle several trainees for disassembly and assembly of a pump. However, it may be prudent to have only one trainee at a time for work involving a live, high voltage circuit or for conducting safety system surveillances.
- Qualified to conduct maintenance—The maintenance manager should establish a process that only allows individuals to perform independent maintenance on equipment for which they are qualified. This process should specify how supervisors determine that an individual is qualified before they are independently assigned to perform a task.

f. Discuss how continuing training is performed to maintain and enhance worker proficiencies and qualifications including lessons learned from industry and in-house operating experiences (including actual events) applicable to their craft.

The following is taken from DOE-HDBK-1118-99.

The goals of continuing training are to maintain and enhance the ability of personnel to perform job assignments and to ensure facility safety and reliability. To achieve these goals, a continuing training program should cover the knowledge and skills required for safe operations. The program should also be flexible enough to cover industry operating experiences, performance problems, facility modifications, and procedure changes. A facility can meet these needs by ensuring that the continuing training program satisfies the following broad objectives:

- Maintain and upgrade the skills and knowledge necessary for personnel to accomplish routine and emergency duties
- Maintain the employees' awareness and understanding of the need for the safe operation of the facility
- Emphasize the importance to personnel of lessons learned from operating experience to prevent repetition of errors
- Correct personnel performance deficiencies
- Evaluate individual and team performance to identify areas for improvement
- Train on facility modifications and procedure changes in a timely manner
- Maintain teamwork and diagnostic skills
- Maintain the level of understanding of applied fundamentals presented in initial training
- Maintain the professionalism of personnel
- Maintain excellence in operating practices, procedures, and facility design.

The continuing training program should address the following:

- The knowledge, skills, and abilities that support important or difficult tasks.
- Team training that should include scenarios that involve the entire operating staff.
- Training cycles designed around a cluster of related tasks, including associated theory, procedures, systems, and integrated operations.
- Evaluations of each employee and team for comprehension of the training delivered during each training cycle. Before returning the employees or team to their affected duties, correct any identified weaknesses that could impact facility safety or reliability.
- Evaluate individual and/or team performance on a periodic basis prior to conducting additional training to accurately assess understanding of subject matter presented.

The facility should incorporate operating experiences into continuing training programs. DOE-STD-7501-99, *The DOE Corporate Lessons Learned Programs* can be of assistance in this effort.

A case study is one method used to learn from the experience of others. Many different approaches and settings can be used with this method. Examples include group discussions in the classroom and role playing in the laboratory and simulator settings. Case studies can be

prepared by the training organization or an industry experience review group and provided to personnel to review and discuss. DOE-HDBK-1116-98, DOE *Handbook: Guide to Good Practices for Developing and Conducting Case Studies* can be of assistance in this effort.

Another approach is to provide all the raw data concerning an event to an individual or team attending the continuing training class. That individual or team will then analyze and present the information to the whole class.

A third approach is to provide individuals with a role to play during an event scenario conducted during a session. After the scenario, the instructor and the participants critique how the role(s) played affected the results. A modification to this approach is to have instructors play all roles in the scenario, videotape the session, and have the group observe the scenario and develop their conclusions individually. The group then discusses the problem(s), the root cause(s), and prevention or mitigation of the event consequences. A structured critique should include problems observed, the factors that affected the severity or mitigation of the event, and the short- and long-term corrective actions that should be taken to prevent recurrence.

8. Facility maintenance management personnel must demonstrate a working level knowledge of configuration management (CM).

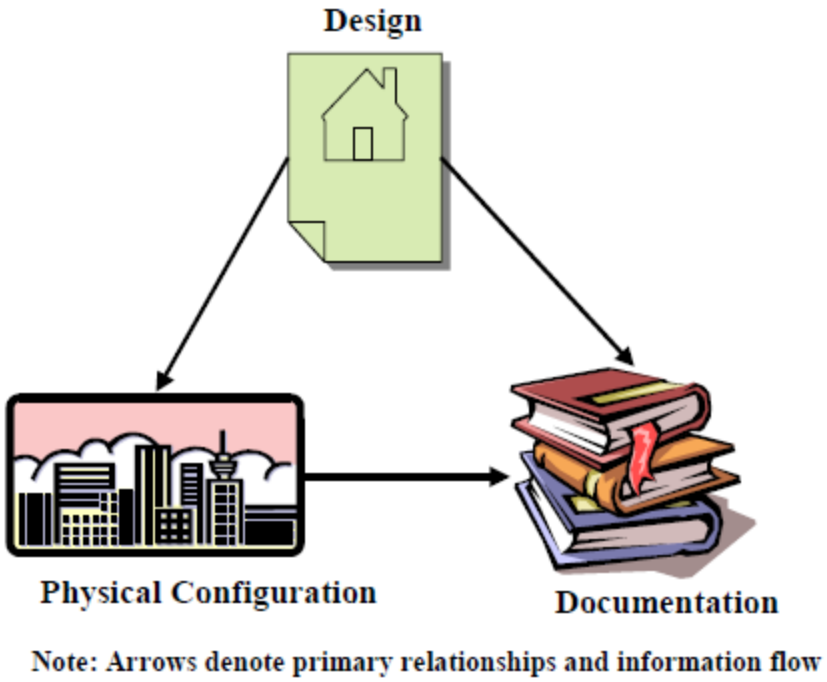
a. Describe the purpose and objectives of CM.

The following is taken from DOE-STD-1073-2003.

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.

This objective and the relationship between design, documentation, and the actual physical plant configuration of the facility, activity, or operation are illustrated in figure 4.



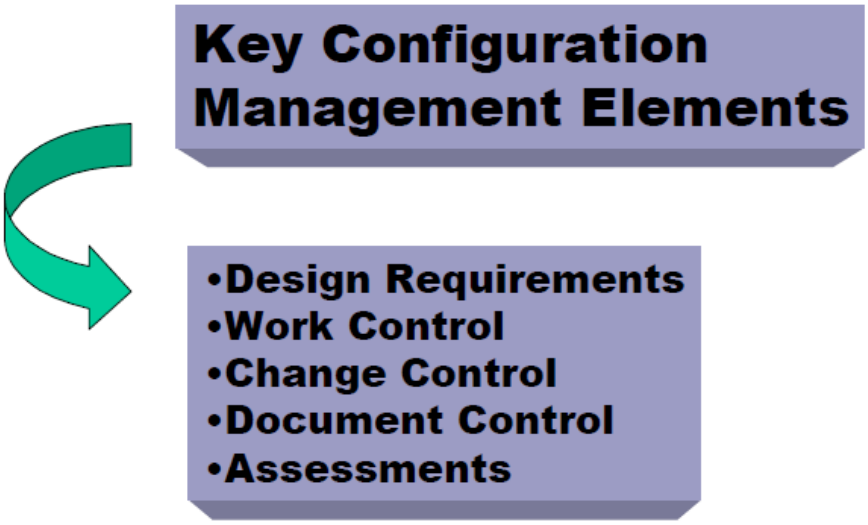
Source: DOE-STD-1073-2003

Figure 4. Basic relationships in CM

b. Discuss the five basic elements of CM from DOE-STD-1073-2003, with particular emphasis on change control/work control

The following is taken from DOE-STD-1073-2003, unless stated otherwise.

Fulfilling the CM objective is accomplished through the key CM elements as illustrated in figure 5.



Source: DOE-STD-1073-2003

Figure 5. Key CM elements

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 SSCs 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
- what programs and procedures must incorporate CM

Design Requirements

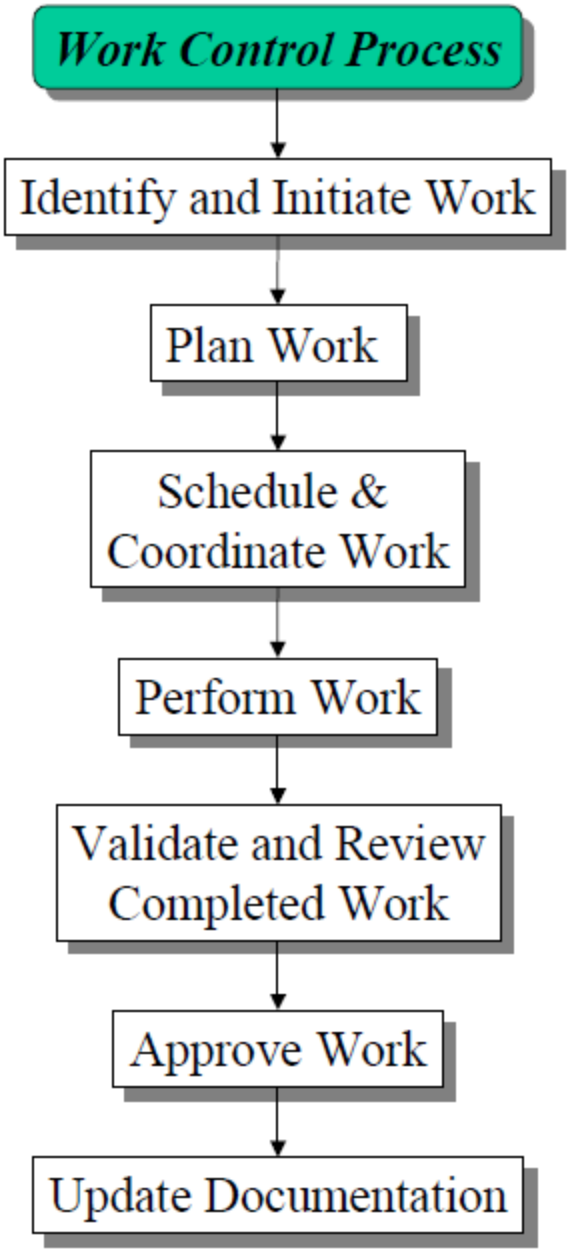
The objective of the design requirements element of CM is to document the design requirements. The design requirements define the constraints and objectives placed on the physical and functional configuration. The design requirements to be controlled under CM will envelope the safety basis and, typically, 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.

Work Control

To ensure that work is appropriately evaluated and coordinated before it is performed, contractors must incorporate a work control process into their procedures. Work control is an administrative process by which work activities are identified, initiated, planned, scheduled, coordinated, performed, approved, validated and reviewed for adequacy and completeness, and documented. (See figure 6.) Work control processes should ensure that when work activities are performed, consistency is maintained between the documents, the procedures, and the physical configuration of the nuclear facility.

The contractor must clearly communicate the responsibilities, authorities, and expectations of work control to all individuals who do work, including facility personnel, subcontractors, and non-facility personnel. The specific responsibilities, authorities, and interfaces related to work control must be defined in applicable work processes, including procedures.

Contractors must use the ISMS process to integrate safety into all aspects of work planning and execution. Safety requires the involvement of the workers and hands-on involvement of line managers. The ISMS process is designed to promote this involvement. The ISMS ensures that ES&H management is an integral part of performing work. Line managers are responsible for safety, as well as the work being performed.



Source: DOE-STD-1073-2003

Figure 6. Work control process

Authorized personnel approving the work should ensure that the change control process, including the USQ process, was used for changes that could impact the safety analysis or the hazard controls. If during the performance of work, additional changes affecting the safety analysis or the hazard controls are identified, these changes should be processed using the change control and USQ processes and work should not resume until these changes have been analyzed and approved.

The following is taken from DOE G 433.1-1A.

A maintenance work-control program should be integrated with the planning system and with ISM. The work-control program should ensure work activities are consistent with the facility safety basis and effectively identified, initiated, planned, approved, scheduled, coordinated, performed, and reviewed for adequacy and completeness. The program should ensure the availability and operability of the SSCs that are a part of the safety basis. The work-control program should apply the same policies and procedures for non-facility contractor and subcontractor personnel conducting maintenance on the site as facility personnel.

The work-control procedures should, at a minimum, address the following:

- Personnel responsibilities for identifying and tagging deficiencies and initiating WRs that adequately describe the symptoms or problems
- Supervisory responsibility for controlling the safe conduct of maintenance activities and processing WRs
- The process for initiating and processing WRs, including the pre-job review, approval cycle, and post-job review
- The priorities used to schedule work
- Determinations of the impact of maintenance activities on facility operations
- Work planning and scheduling
- Conduct of routine maintenance planning meetings
- Requirements for personnel and equipment safety and radiological protection
- Post-maintenance testing
- Collecting data for maintenance history files

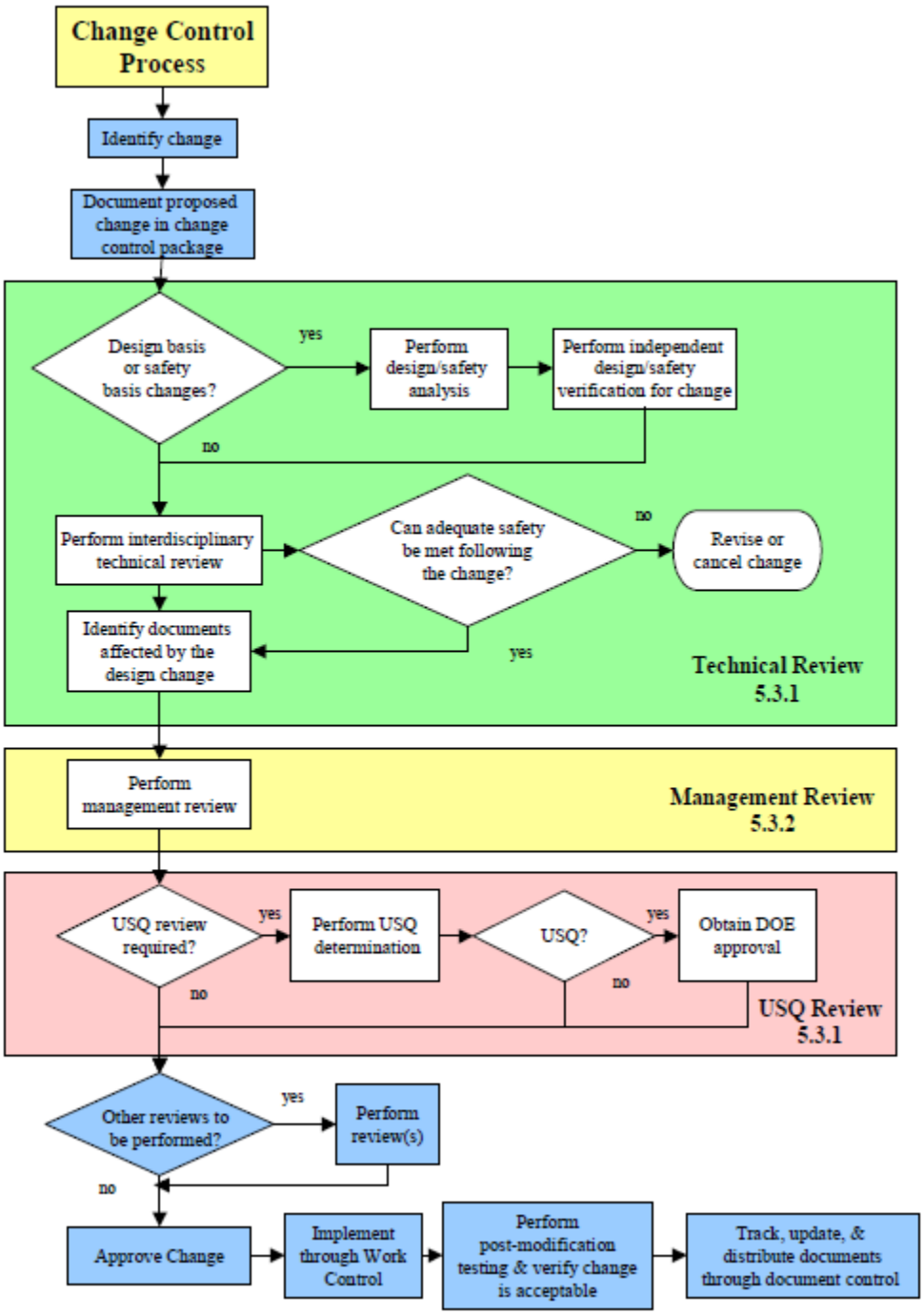
Change Control

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 the following:

- Changes are identified and assessed through the change control process.
- Changes receive appropriate technical and management review to evaluate the consequences of the change.
- 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.

A diagram of the change control functions is provided in figure 7.



Source: DOE-STD-1073-2003

Figure 7. Change control process

The contractor must ensure that each proposed change to the facility, activity, or operation is considered for processing through the change control process. To ensure that all changes are controlled as appropriate, the contractor must identify all mechanisms that can lead to temporary or permanent changes in

- the design requirements
- the physical configuration
- the documentation

For any facility, activity, or operation there are typically multiple mechanisms for initiating change. Changes may be initiated through any of a variety of organizations, such as design, operations, maintenance, procurement, procedures, training, and security. Changes can include physical, document, procedural, operations, software, or design changes. Contractors should assess each type of change to determine the mechanisms for initiating changes and link them to the change control process. Contractors should integrate the change control process into the work processes for all potential mechanisms of changes by requiring workers and organizations to use the change control process, as appropriate, when a change is to be made. The identification of change mechanisms is often the most critical step to achieving effective change control. Change mechanisms that are not identified cannot be controlled.

Once change mechanisms are defined, contractors should ensure that the change control process is properly integrated into the procedures and other work processes for that change mechanism. Contractors should consider eliminating or combining change mechanisms to make changes easier to control.

If multiple change control processes are used, they should be consolidated into a single, consistent change control process that is useful and effective. Unique change control processes for specific types of changes, such as software changes, should be integrated into the overall change control process for the activity. The change control process may provide provisions for varying levels of review based on a documented graded approach, as well as graded schedules for updating documents based upon their relative importance. Facility managers should ensure that vendors and subcontractors use the established process. All personnel in design, operations, and support organizations that do work for the facility or activity should

- be trained on the change control process
- follow the associated procedures closely
- be alert to activities that may not be planned or may occur without following appropriate procedures

DOCUMENTING PROPOSED CHANGES

The change control process must include provisions for the initiator of the proposed change to document the proposed change, including the following:

- A unique identifier for the proposed change
- A description of the proposed change sufficient to support technical and management reviews prior to approval
- The name and organization of the requester
- A description of the potentially affected SSCs
- The reason for the proposed change

- A list of the alternative solutions considered and the results
- The date by which the decision about the change needs to be completed to facilitate timely implementation or to allow implementation to occur concurrent with other activities, such as a planned maintenance shutdown
- Constraints
- Any other information needed to review, track, approve, or process the proposed change

The change control process must involve a formal change control review for each proposed change. The change control review must include a technical review and a management review. The technical review should be interdisciplinary, except where the change is so isolated as to not impact the efforts of more than one discipline. The management review should ensure that management considerations, such as funding, have been adequately examined prior to approving the change for implementation. The results of both reviews must be formally documented. Finally, some changes will need to be reviewed under the DOE-approved USQ process for the facility or activity in accordance with the requirements of 10 CFR 830. The USQ review may be performed concurrent with the technical and management reviews, but it must reflect the final configuration of the change. In addition, if during the management review modifications are made to the proposed change, those modifications must also receive a technical review.

Changes to computer software that is used to support safety functions or safety applications must also be considered under the change control process.

Design changes should be subject to the same level of management and technical review as applicable to the original design.

Document Control

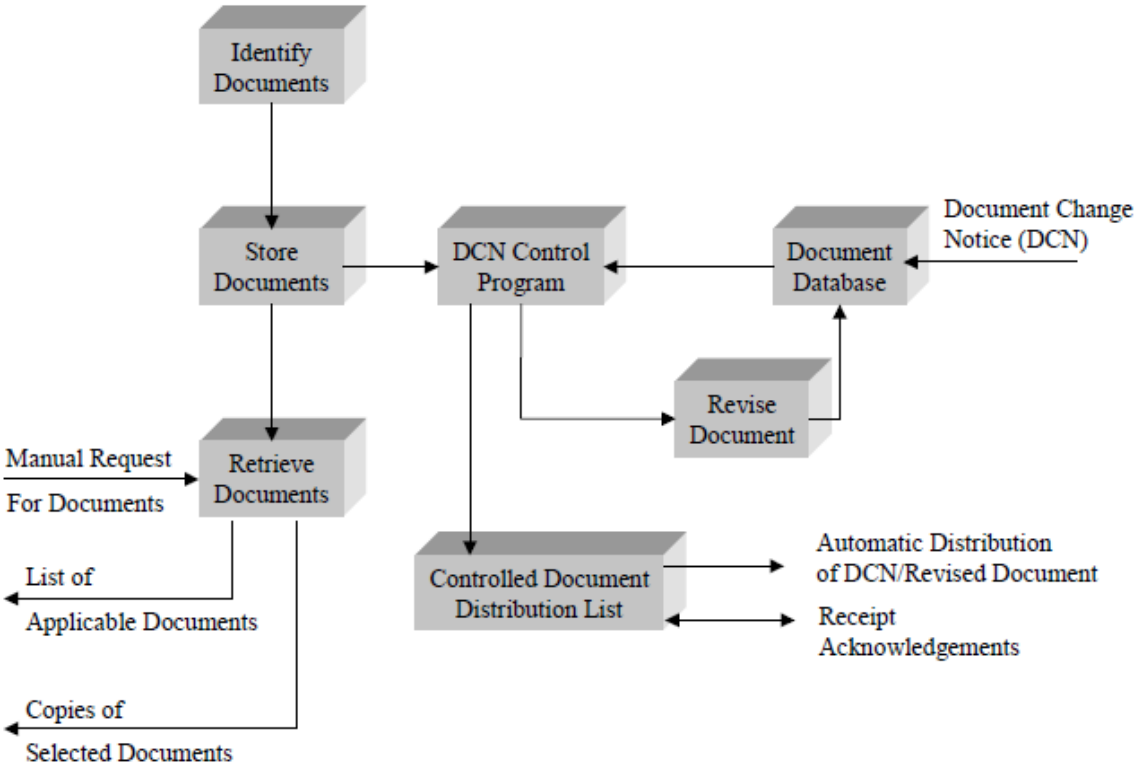
Document control ensures that only the most recently approved versions of documents are used in the process of operating, maintaining, and modifying the nuclear facility. Document control helps ensure that

- 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; and
- 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

- each updated document is uniquely identified and includes a revision number and date
- each outdated document is replaced by the latest revision

A diagram of the features of document control functions is provided in figure 8.



Source: DOE-STD-1073-2003

Figure 8. Document control process

Contractors must determine what documents need to be controlled. They also must define "document owners" who are responsible for developing and revising the technical content of the documents and ensuring they are maintained current. Document owners will also establish the schedules for document revisions, distribution, and retrieval.

Documents to be controlled should include those documents that reflect the facility's requirements, performance criteria, and associated design bases. However, the number of documents that must be controlled should be limited because of the resources required to properly control documents.

DSAs, the TSRs, the documented design requirements, the safety management plans, and any other documents that are referenced by, or support, the DSAs should be controlled documents. Contractors should assess controlled documents to determine if they need to be updated whenever changes are made to the facility or activity configuration, the design requirements, or other documentation that might impact them. Typical controlled documents include

- DSAs
- authorization agreements and associated references
- safety management plans
- hazard controls, including TSRs
- documents that identify or define design requirements

- design specification and calculations
- accident analyses
- software data and manuals for operation and maintenance of critical software
- key procedures
- key drawings
- key vendor supplied documents

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 that the persons performing the assessments

- have sufficient authority and freedom from line management
- are qualified to perform the assessments

The maintenance criteria of DOE O 433.1B, *Maintenance Management Program for DOE Nuclear Facilities*, also require periodic assessments to verify the condition of systems and equipment.

The objective of assessing CM is to detect, document, determine the cause of, and initiate correction of inconsistencies among design requirements, documentation, and physical configuration. Properly performed assessments should help identify inconsistencies between these areas, evaluate the root causes for these problems, and prescribe improvements to avoid similar inconsistencies in the future.

The five specific types of assessments discussed in DOE O 433.1B are

1. construction assessments;
2. physical configuration assessments;
3. design assessments;
4. post-construction, -modification, or -installation inspections and tests; and
5. periodic performance assessments.

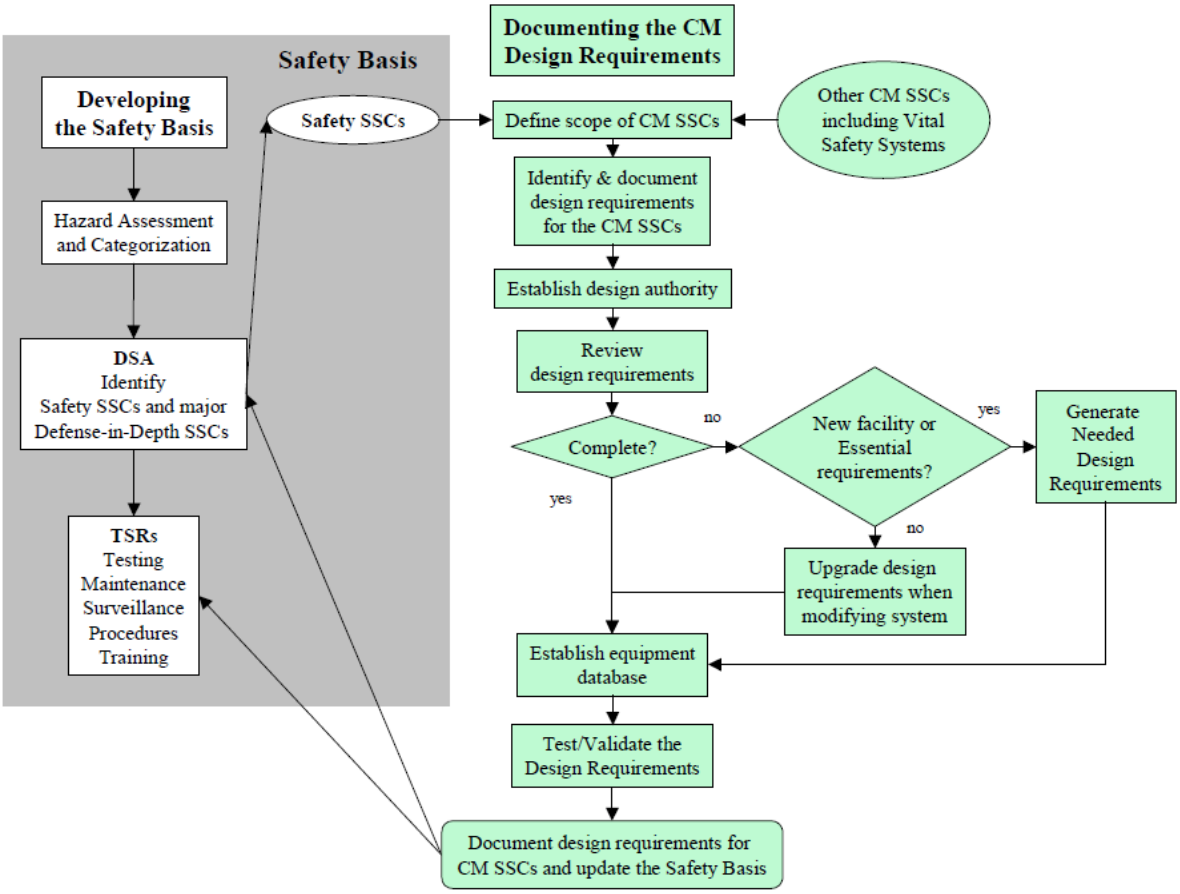
c. Discuss the process to document and maintain plant configuration and handle desired changes while maintaining the facility safety basis.

The following is taken from DOE-STD-1073-2003.

DOE-STD-1073-2003, Section 3.2, discusses how the safety SSCs identified in the DSA constitute the baseline set of SSCs that are to be controlled under the CM process. It also discusses including other SSCs such as those identified as necessary for

- DID
- critical mission functions
- environmental protection
- protection of costly equipment or functions
- protection of adjacent SSCs
- critical software functions

CM should be used to control and document changes to the safety basis. The relationship of the process of documenting the CM design requirements to the safety basis required by Subpart B of 10 CFR 830 for hazard category 1, 2, and 3 nuclear facilities is illustrated in figure 9.



Source: DOE-STD-1073-2003

Figure 9. Documenting the CM design requirements

d. Discuss the process to authorize the use of equipment repair parts and a method for workers to verify this approval.

The following is taken from DOE-STD-1051-93.

Materials management should ensure that necessary parts and materials meeting quality and/or design requirements are available when needed. The criteria include the following:

- Programs are implemented to order, receive, and issue proper parts and materials for work activities. Stock levels are adjusted, as necessary, to meet plant needs.
- Procurement documents provide clear and adequate technical and QA requirements consistent with design specifications. Areas such as storage, PM, and shelf-life requirements are addressed. Proper engineering control and approval are obtained on any deviation from design specifications for parts or materials.

- Mechanisms are in place to provide for the expeditious procurement of parts and material on a high priority basis when needed.
- Methods are established to acquire replacement parts not available from the original supplier.
- Material is inspected to ensure conformance to purchasing requirements prior to release for use and storage. Documentation for received material is accounted for and retrievable. Nonconforming items are identified and controlled to prevent unauthorized use.
- Effective material procurement status is provided including accurate stock records, tracking of purchase orders, and maintaining traceability of safety-related parts and material.
- Materials are stored and identified in a manner that results in timely retrieval.
- Safety-related parts and components are properly controlled, segregated, and identified in all material storage areas.
- The quality of stored equipment, parts, and materials is maintained by appropriate means such as environmental and shelf-life controls, and PM.
- Parts and materials issued for installation are properly controlled. Unused parts and materials are promptly returned to a controlled storage area. Safety-related parts are readily traceable from purchase to installation.
- Flammable and hazardous materials are identified, segregated, and properly controlled during receipt inspection, storage, and issue.
- Equipment and materials used by non-plant personnel are subject to inspection, storage, and issuance controls equivalent to items received through normal plant processes.
- Lessons learned from experience, such as lead times, parts usage, and supplier reliability, are factored in materials management.

e. Discuss the role of the cognizant system engineer in configuration management according to DOE O 420.1C, *Facility Safety*.

The following is taken from DOE O 420.1B (Archived).

An objective of the system engineer program is to ensure operational readiness of the systems within its scope. To achieve this, the principles of CM must be applied to these systems. Consequently, the following requirements are considered integral parts of the systems engineer program:

- CM must be used to develop and maintain consistency among system requirements and performance criteria, documentation, and physical configuration for the SSCs within the scope of the process.
- CM must integrate the elements of system requirements and performance criteria, system assessments, change control, work control, and documentation control.
- System design basis documentation and supporting documents must be compiled and kept current using formal change control and work control processes or, when design basis information is not available, documentation must include
- system requirements and performance criteria essential to performance of the system's safety functions
    - the basis for system requirements

- a description of how the current system configuration satisfies the requirements and performance criteria

- Key design documents must be identified and consolidated to support facility safety basis development and documentation.
- System assessments must include periodic review of system operability, reliability, and material condition. Reviews must assess the system for
  - ability to perform design and safety functions
  - physical configuration as compared to system documentation
  - system and component performance in comparison to established performance criteria

- System maintenance and repair must be controlled through a formal change control process to ensure that changes are not inadvertently introduced and that required system performance is not compromised.
- Systems must be tested after modification to ensure continued capability to fulfill system requirements.

9. Facility maintenance management personnel must demonstrate a working level knowledge of procurement and materials management.

a. Discuss the process to identify, order, receive, store, and install proper parts and materials for work activities while meeting all quality requirements.

The following is taken from DOE G 433.1-1A.

The procurement process should support maintenance by providing the correct parts, materials, and services in a timely and cost effective manner. Achieving this goal requires efficient coordination from the equipment designers, through processes, which compile a master parts listing, establish and maintain an appropriate supply of these parts, and make them available to the workers in the field. Additional controls are used to ensure the characteristics and quality of materials and services used in all SSCs that are part of the safety basis.

Policies should be established for the procurement of parts, materials, and services. These policies should be understood by procurement personnel and other personnel who interface with them, such as engineers, maintenance supervisors, and work planners.

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

Procedures should be available to describe specific procurement actions and the specific responsibilities of personnel involved in the procurement of special items, such as the following:

- SC SSCs
- SS SSCs

- Critical spare parts
- Major project purchases
- Routine procurement purchases
- Contracted work and services
- Hazardous materials

Procurement Control

To maintain the validity of the safety basis, replacement parts and materials should meet the equipment design criteria. A graded approach is used to verify the critical attributes of these items based on the importance of each item. Not every part of a safety system is integral to the system's safety function and may not require the degree of rigor to verify its capabilities as those items that are critical to the safety function. The QAP should specify the processes used to approve suppliers; upgrade commercially obtained materials; perform receipt inspections; and document, track, and disposition identified deficiencies. Additionally, the terms "like-for-like" or "like-in-kind" should be applied to assure the correct component or part is used.

A process should exist (typically within the engineering organization) for providing the data that forms the basis for procurement of items that support all SSCs and other major purchases that are part of the safety basis. This data should include the following:

- Critical parameters and their acceptance criteria
- Unique or special testing requirements/methods
- Reorder instructions
- Suspect/counterfeit parts information

Procurement controls should be developed and maintained to help maintenance obtain parts, materials, and services promptly. Consideration should be given to the following:

- The ability to track procurement status from receiving through delivery to issue-for-use.
- Ability of the procurement organization to track procurement progress and take necessary measures to meet maintenance and outage schedules.
- Emergency procurement policies and an expediting process to obtain parts, materials, and services that are needed immediately to support safe and reliable facility operation.
- Control and maintenance of QA records to provide documentation for qualified parts and materials, and to ensure traceability of parts and materials.
- Assurance that procurement documents and controls prevent the delivery or use of suspect/counterfeit parts.
- 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.
- Retaining special receipt inspection documentation to support future procurement.
- Provisions for qualifying nonqualified material. An effective upgrade process will result in improved availability of quality parts and materials.
- Verification of the reliability of supplier performance. This can be accomplished by audits, inspections, or surveillances of supplier facilities.

Receipt and Inspection

When parts, materials, and equipment are received, stores personnel should inspect them before they are accepted. 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, and appear to be in good condition. In the case of safety items, stores personnel and QA 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. 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. Maintenance should have access to this documentation.

Engineering and maintenance personnel may be needed to assist in the receipt inspection of more complicated parts, materials, and equipment. Recurring or special test/inspection packages may be required for maintenance personnel to conduct and document these checks on received material prior to being released for issue. In some situations, outside facilities/organizations may be used to conduct specialized testing beyond the facility's capability.

Special inspections and/or tests should be considered for products that have histories of being counterfeited, such as high strength fasteners, molded case breakers, valves, UL listed items and semi-conductors.

Engineering personnel should approve any deviation from design specifications of material or equipment received before the item is considered for issue. They should also approve any upgrade of material or equipment from a non-safety to a safety category. Nonconforming items should be clearly identified; segregated from normal items to prevent inadvertent use; documented on a nonconformance report and/or a defective or substandard material report; and tracked and resolved as soon as practical by the applicable authority.

Storage

Stored material may be staged for construction, future maintenance outage, or simply standard spares/materials used by maintenance during their ongoing work.

Material and equipment should be stored in a manner that provides adequate protection and accessibility with due consideration for environmental conditions such as temperature, humidity, and particulates. Items requiring periodic maintenance or checks, such as checking energized heaters, changing desiccant, meggering motors, rotating shafts, or changing cover gas, should be located to simplify this work. A method of tracking the requirements and documenting completion should be used. Consideration should be given to use of the PM process for this purpose vice using another stand-alone method.

The receipt and issue of items from stores should be documented promptly so that the inventory record accurately reflects the current inventory. The record system should also indicate the location of items in the warehouse or other designated storage areas. A method should be used to control access to storage areas.

Shelf life control should be provided for items that degrade over time. Various items with finite storage lifetimes 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, or the material should be disposed and new material ordered. Reordering/restocking programs should incorporate appropriate lead times to ensure sufficient material with good shelf life is available for issue.

Material and equipment subject to restricted use and distribution such as SC items, critical spare parts, certain sealants and compounds, precious metals, etc., should have clearly defined instructions that provide for

- unique identification;
- segregation from normal stock;
- access control;
- issue only to those on authorized signature lists; and
- purchase order tracking and ready traceability from design drawing through purchasing, receipt, storage, handling, and installation.

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. Controls should be established for field storage of such consumables to ensure that they are properly stored, identified, and used.

A process for periodic general inspections of storage areas should exist. Typical storage control observations should document the following:

- Reactive chemicals are segregated and secured, as required.
- Flammables are marked and stored in proper containers.
- Radioactive substances are properly shielded and marked.
- Carcinogens are segregated from other materials and equipment.
- Stainless steel and other “pedigree” metals are segregated from other metals.
- 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 and threaded surfaces are left adequately protected.
- Applicable insect and rodent controls are in effect.
- Applicable shelf life conditions are in effect.
- The building structure and support systems are adequate and in working order.
- Environmental controls that control moisture, dust, sun exposure, etc. are in effect.

b. Discuss how safety-related parts and components are properly controlled, segregated, identified, and issued in all material storage areas; and appropriate unused parts and materials are promptly returned to inventory.

The following is taken from DOE-STD-1069-94.

Maintenance tools and other support equipment should be evaluated for inclusion in the PM program. Inclusion in the PM program should enhance the availability and reliability of equipment such as cranes, portable lifting and rigging equipment, welding machines, welding rod ovens, shop machinery, and M&TE.

The following items, at 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 on established guidelines for worn/damaged/defective tools and equipment.
- Instructions should be developed that define responsibilities regarding deficiency-tagged equipment.

c. Discuss how lead times, parts usage, and supplier reliability are factored into materials management.

The following is taken from the Government Accountability Office, GAO-07-281, *Defense Inventory: Opportunities Exist to Improve the Management of DOD's Acquisition Lead Times for Spare Parts.*

Acquisition lead times are the military components' estimates as to when items will arrive, and varying from that expectation increases the likelihood that the right supplies will not be at the right place at the right time. When the components understate their lead time estimates, material shortages and reduced readiness can occur. Without more accurate lead time estimates, the components will not place orders and obligate funds as early as necessary, and they may miss opportunities to potentially improve readiness rates. Conversely, overstated and lengthy acquisition lead time estimates can cause early obligation of funds as well as increases in on-hand inventories, although spare parts that come in early could potentially improve readiness. Until the Army reviews and evaluates when deliveries are representative and should be used to update lead time values, maintains lead time data in each of its computer systems, and validates data input, later than expected deliveries and potential parts shortages will likely occur. In addition, absent actions by DLA to review and revise the methodology and inputs it uses to compute lead time estimates, DLA will continue to

obligate funds earlier than necessary and have early delivery of items. Moreover, without taking steps to review and validate default lead time estimates and consider other options for obtaining better lead time data, the Air Force will continue to experience early obligation of funds and potential parts shortages. Finally, until the Navy reviews and validates its lead time data and corrects errors, parts shortages and early obligation of funds are likely to continue. Acquisition lead time estimates will continue to vary greatly from their actual lead times until all of the military components address these problems and institute corrective procedures.

10. Facility maintenance management personnel must demonstrate a working level knowledge of maintenance tool and equipment control.

a. Discuss how proper tools, equipment, and consumable supplies support maintenance activities.

The following is taken from DOE G 433.1-1A.

Adequate tool and equipment control contributes to facility safety and efficiency, reduces maintenance delays, and limits the number of tools potentially contaminated.

b. Discuss suitable storage for tools and equipment.

The following is taken from DOE G 433.1-1A.

The maintenance organization should assign responsibility for the proper storage and issuance of stationary and portable tools and equipment. Permanent issuance of tools to individuals or groups of facility personnel who use them daily and who are responsible for maintaining them contributes to worker efficiency. Controls, such as sign-out sheets or tool crib attendants, should be used in tool storage areas to provide accountability for and availability of tools. The storage area(s) should address 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
- control of radioactive materials

A method should exist to identify the availability and sources for special tools and equipment obtained from vendors or contractors. When these special tools and equipment are at the facility, they should be controlled in the same manner as other tools and equipment.

c. Discuss actions expected when worn or defective tools or equipment are identified.

The following is taken from DOE G 433.1-1A.

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

d. Discuss the segregation and disposition of tools and equipment contaminated by radioactive or other hazardous material.

The following is taken from DOE-STD-1069-94 (Archived).

An adequate supply of tools and equipment dedicated for exclusive use in radiologically controlled areas (RCAs) should minimize the number of unnecessarily contaminated tools used to perform work within the RCA. The control of these tools, including issuance, decontamination, inventory, and repair, should be assigned to a single facility department manager, such as the maintenance or radioactive materials controls department manager. Although it may not be practical to store the total inventory of potentially contaminated tools in a single location, all satellite locations of RCA tools and equipment should be under the control of the same facility department.

A sufficient supply of RCA 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. The initiation of an RCA tools and equipment supply system may require a major one-time input of nonradioactive tools from other tool control areas or from facility stores.

All RCA tools and equipment should be stored in designated contaminated-tool control storage areas. Positive controls over all contaminated-tool storage areas should be provided, including checking items out and in and continually staffing each tool control storage area during periods of heavy demand.

Locked storage, however, should be the minimum acceptable positive control for tool storage areas during low-demand periods. The use of temporary tool storage areas and mobile cabinets should be planned as an effective method for supporting work at specific locations during maintenance activities. The program should ensure facility control over the issue and inventory of RCA tools and equipment.

Introduction into the RCA of highly specialized tools previously used in other facility's RCAs should be controlled. Allow access only when approved by the radiological protection manager or designee. Since these specialized items may contain radioactive contamination, thorough radiological surveys should be conducted prior to introducing items into the RCA.

If required, tools and equipment should be forwarded for decontamination or repair prior to restocking for further use. Criteria should be established to control whether tools are returned to tool storage areas, decontamination facilities, or field attendants, depending on the radiological conditions of the job.

Field attendants, for example, should be assigned to accept used tools from highly contaminated radiological work areas during major maintenance activities. Control all RCA tools and equipment as radioactive material.

Controlling these items as radioactive material serves to make workers aware of the potential hazard associated with the use of these tools and to assist the facility in properly retaining each item within the RCA. The following controls should be incorporated:

- Potentially contaminated tools and equipment should be handled in accordance with applicable facility procedures.
- Mark or label each potentially contaminated item as radioactive. Small hand tools and minor equipment should be identified by permanent marking to clearly distinguish them from similar items intended for non-RCAs of the facility.
- Label or mark all containers of temporarily stored RCA 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 that may cause high-radiation areas. These areas may need to be shielded and locked and should be as remote as possible from traffic areas. High-radiation areas should be controlled as specified in applicable facility procedures.

When necessary to remove tools and equipment from the RCA, adequate decontamination facilities are necessary to ensure that all tools and equipment are decontaminated and released in accordance with applicable facility procedures.

Facility policies should prohibit the release of RCA tools and equipment to uncontrolled areas except where specifically authorized. The release of potentially contaminated tools to uncontrolled areas increases the risk of uncontrolled releases of radioactive materials:

- The number of tools and equipment unconditionally released to uncontrolled facility areas should be limited. The need to unconditionally release large numbers of tools and equipment in a short time period at the end of major maintenance activities or outages should be prevented. Radiological surveys of large numbers of potentially contaminated tools that are generated during major maintenance activities or outages are time consuming. Attempting to perform surveys rapidly may result in the release to uncontrolled areas of radioactive material above facility limits.
- The facilities and equipment provided for the release of items to uncontrolled areas should be of sufficient size and layout to allow for the accurate assessment of radiological hazards, including radioactive hot particles. All radiological-release surveys of outgoing tools and equipment from the RCA should be recorded to document compliance with acceptable contamination and radioactive material control policies. Such items should be released only by qualified and authorized personnel and with the items tagged or marked as releasable to noncontrolled areas of the facility. The attached tag or marker should include written approval from both the responsible department and by authorized radiological protection personnel.

Dry radioactive-waste containers, as well as collection and sorting areas, should be monitored frequently (after establishing a tool control program) and periodically thereafter. This monitoring should include the recording of tools and equipment found in radioactive-waste receptacles, to determine the extent at which losses of these potentially contaminated items are occurring and to identify the source or reason for the losses. This information

should be used to correct the problems as soon as possible. Problems experienced should be included in lessons learned to aid future planning.

e. Discuss calibration and control of M&TE to provide accuracy and traceability.

The following is taken from DOE G 433.1-1A.

A program for control and calibration of M&TE should be established, consistent with the QA requirements of 10 CFR 830, Subpart A, and as implemented by the selected QA standard, and should ensure the accurate performance of facility instrumentation and equipment for testing, calibration, and repair. M&TE devices include tools, gauges, instruments, devices, or systems used to inspect, test, calibrate, or measure parameters. M&TE devices also include permanently installed facility process or control instrumentation. Those items or systems not influencing product quality or verifying conformity to specified requirements may be exempted from calibration. M&TE equipment exempt from periodic calibration should be clearly labeled or addressed through other means to denote its status and preclude its use where calibrated equipment is required. The basis for such exemptions should be documented.

The adequacy of tool and equipment control, including M&TE, to support maintenance and operations should be evaluated as part of the facility's self-assessment program.

f. Discuss action required for equipment calibrated/inspected/maintained with out-of tolerance test equipment.

The following is taken from Quality Digest, *Appropriate Handling of Out-of-Calibration Equipment*.

When calibrating equipment and finding it to be out of tolerance, ISO 9001 requires consideration of the product that was inspected with such equipment as suspect product. Aside from quarantining the equipment for further adjustments and calibration, the first questions to ask are: Does the calibration data suggest the equipment was broken, minimally out of tolerance, or grossly out of tolerance? Was it out of tolerance in the range in which it was used?

Review the calibration data in detail to assess the level of confidence that the product that was inspected on this equipment is meeting specifications.

Next questions are as follows:

- How much product was inspected or tested using that equipment?
- How much product that passed inspection was sent to inventory or was shipped to the customer?

If there is no confidence that the out-of-tolerance equipment was capable of producing good results, then handle the suspect product as necessary, including segregation, quarantine, recall, reinspection, or retesting and repair or rework the product. Some steps to take are listed below:

- Product that has not been shipped needs to be segregated immediately for subsequent inspection or testing.
- Product that is in the warehouse has to be pulled and retested or reinspected.
- If the product has already been shipped, the standard requires that a process is in place for how the product will be recalled. If it was already delivered to the customer, the question is: How to get the product back to inspect or test it again?

Perhaps if the customer uses the product as raw material and they have not used it yet, it will be possible to go to their facility and conduct the inspection and testing there. If that is not possible, due to equipment and the in-house setup, then proceed with the recall process and conduct the reinspection or retest at the facility.

In all cases, a plan of action must be in place if the results of the reinspection or retesting of suspect product are unfavorable. Is it possible to repair or rework the product, or must it be scrapped and replaced?

The handling of equipment that is out of calibration must be a well-planned, documented process, preferably using the same control-of-nonconformance procedure already required by the ISO 9001 standard.

11. Facility maintenance management personnel must demonstrate a working level knowledge of suspect and counterfeit Items.

a. Discuss the controls established to assure that items and services meet specified requirements as required by DOE O 414.1D and 10 CFR Part 830, Subpart A.

The following is taken from 10 CFR 830.122.

The following excerpts from the quality criteria in 10 CFR 830.122 apply to items and service requirements:

- Identify, control, and correct items, services, and processes that do not meet established requirements
- Review item characteristics, process implementation, and other quality-related information to identify items, services, and processes needing improvement
- Identify and control items to ensure their proper use
- Maintain items to prevent their damage, loss, or deterioration
- Design items and processes using sound engineering/scientific principles and appropriate standards
- Procure items and services that meet established requirements and perform as specified
- Establish and implement processes to ensure that approved suppliers continue to provide acceptable items and services
- Inspect and test specified items, services, and processes using established acceptance and performance criteria.

b. Discuss the process to prevent entry, detect, control, report, and disposition of S/CIs required by DOE O 414.1D and DOE G 414.1-2B.

The following is taken from DOE O 414.1D.

The organization's QAP must

- include an S/CI oversight and prevention process commensurate with the facility/activity hazards and mission impact;
- identify the position responsible for S/CI activities and for serving as a point of contact with the Office of Health, Safety, and Security;
- provide for training and informing managers, supervisors, and workers on S/CI processes and controls;
- prevent introduction of S/CIs into DOE work by
  - engineering involvement in the development of procurement specifications during inspection and testing and when maintaining, replacing, or modifying equipment;
  - identifying and placing technical and QA requirements in procurement specifications;
  - accepting only those items that comply with procurement specifications, consensus standards, and commonly accepted industry practices; and
  - inspecting inventory and storage areas to identify, control, and disposition for S/CIs.
- include processes for inspection, identification, evaluation, and disposition of S/CIs that have been installed in safety applications and other applications that create potential hazards. Also address the use of supporting engineering evaluations for acceptance of installed S/CI as well as marking to prevent future reuse;
- conduct engineering evaluations to be used in the disposition of identified S/CIs installed in safety applications/systems or in applications that create potential hazards. Evaluations must consider potential risks to the environment, the public and workers along with a cost/benefit impact, and a schedule for replacement;
- perform the evaluation to determine whether S/CIs installed in non-safety applications pose potential safety hazards or may remain in place. Disposition S/CIs identified during routine maintenance and/or inspections to prevent future use in these applications
  - report to the DOE Inspector General (IG);
  - collect, maintain, disseminate, and use the most accurate, up to date information on S/CIs and suppliers; and
  - conduct trend analyses for use in improving the S/CI prevention process.

The following is taken from DOE G 414.1-2B.

The organization's QAP should include an S/CI oversight and prevention process commensurate with the facility/activity hazards and mission impact. The QAP should address responsibility for ensuring that the requirements listed below are met, including the flow down of the requirements to contractors, subcontractors, suppliers and vendors. S/CI requirements include: identifying the position responsible for S/CI activities, and for serving as a point of contact with the Office of Health, Safety, and Security; reporting to the DOE

IG; and issuing lessons learned reports for use in improving the S/CI prevention process in accordance with DOE O 210.2A, *DOE Corporate Operating Experience Program*.

The responsible personnel should contact the DOE IG before destroying or disposing of the S/CI(s) and the corresponding documentation. This allows the IG to determine whether the items and documentation need to be retained for criminal investigation or litigation.

Guidance for most DOE S/CI requirements is provided in the IAEA-TECDOC-1169. The IAEA-TECDOC-1169 is available at http://www-pub.iaea.org/MTCD/publications/PDF/te_1169_prn.pdf.

12. Facility maintenance management personnel must demonstrate a working level knowledge of maintenance history.

a. Discuss how maintenance history for SSCs that are part of the safety basis is recorded and used.

The following is taken from DOE G 433.1-1A.

The maintenance history program should clearly identify the SSCs for which a history is to be maintained, the data to be collected, methods for recording data, and uses for the data. Typically, maintenance history is provided for all SSCs for which periodic maintenance is performed. The program should include the type of equipment, model, serial and identification numbers, location information, and other information listed below.

At a minimum, each SSC included in the safety basis should have a separate maintenance history file. An essential element of the history file is a chronological record of the completion data of each work order, including the date of completion, worker notes on completed WOs, labor hours expended, etc. The history file should include data on each review of the history, including results of the review, date of review, and names of personnel who performed the review.

Currently, most maintenance history systems are contained in CMMS. Some CMMS systems are linked to electronic maintenance manuals created by scanning the paper manuals. The elements of maintenance history are the same for both paper-based and software-based systems. For both types of systems, engineering review and analysis should be performed to ensure the overall maintenance history program contains all the necessary elements. Whether electronically or manually maintained, easy access to the historical data should be provided to all groups needing the information.

Program use

Regular users should be trained to access and search the history databases and files.

Maintenance coordinators, supervisors, experienced workers, and work planners should review the maintenance history file on defective and similar components. Their review should consider information on similar deficiencies and performance trends when preparing WRs/WOs and/or WP repair instructions. They should also consider the performance of similar components at other DOE and non-DOE facilities.

The following uses of maintenance history data should be considered:

- Failure analysis
- Maintenance assessments
- Preventive maintenance
- Outage planning
- ALARA
- Plant life extension

b. Discuss the consideration of maintenance history records in planning for corrective maintenance, periodic maintenance, and modifications.

The following is taken from Wise Geek, *What are Maintenance Records?*

Maintenance records are written notes that provide documentation about the upkeep of a certain piece of equipment. This documentation can prove useful to a variety of different businesses—from a large industrial plant to a small lawn mowing company. These records are particularly useful in maintenance management because they help businesses ensure their equipment is kept in good condition. In addition, they provide businesses with a way to manage that rack repair and preventive upkeep expenses.

The use of maintenance records is particularly important in a factory setting, where a large number of expensive machines are used daily. These records can help make sure that any appropriate equipment maintenance or plant maintenance has been completed so that plant operations will run smoothly. For instance, a maintenance log detailing any repairs or service upkeep may be kept on a factory machine. This log can help avoid accidents or plant shut-downs resulting from defective equipment.

Regardless of the type of business, maintenance record management can be important for a number of reasons. For instance, a maintenance schedule can be invaluable in assisting service technicians with diagnosing repeat problems with a machine or vehicle. In addition, good records help department managers and employees ensure that a piece of equipment is performing in line with any manufacturer warranties. Maintenance records also help companies track when a piece of equipment needs to undergo PM. If a company gets accused of using a faulty piece of equipment, maintenance records can be essential in supporting the company's case.

Developing a maintenance record plan requires a company to first make an inventory of all of its equipment. Any item that needs to be periodically inspected or repaired should be included on this list and assigned a tracking number.

After the inventory has been completed, maintenance records simply need to be updated whenever work is performed on a piece of equipment. Generally, the records should document what type of work was carried out and when it was performed, as well as who did the work. Additionally, when any inspections or equipment testing takes place, the maintenance record should state whether the inspection or testing followed manufacturer guidelines and company operating procedures. Expenses relating to labor and parts should also be documented to assist departments with budget forecasting.

c. Discuss periodic reviews of maintenance history to identify equipment trends and persistent maintenance problems to determine root causes and to assess the impact on facility safety and reliability.

The following is taken from DOE G 433.1-1A.

Equipment failures and abnormal trends should be analyzed and corrective action recommended in a timely manner. In addition, periodic engineering reviews of the maintenance history file should be conducted in accordance with a schedule recommended by the engineering support supervisor and approved by the responsible manager. The purpose of the reviews is to determine whether recurring maintenance problems or other performance trends indicate a need for corrective maintenance, replacements or modifications. The assigned engineer should determine the probable cause and recommend a course of action. This may result in corrective maintenance, component modification or replacement, a change in the preventive or PdM schedule, or a change in a procedure. The assigned engineer should track performance after corrective action has been performed to ensure deficiencies have been corrected.

13. Facility maintenance management personnel must demonstrate a working level knowledge of aging degradation and technical obsolescence.

a. Discuss specific SSCs subject to aging degradation.

The following is taken from the Institute of Nuclear Power Operations, AP-913, *Equipment Reliability Process Description*.

The scoping and identification of critical SSCs should be an integrated activity that is a common input to continuing equipment reliability improvement and establishing equipment performance criteria. Determine the SSC functions that are important to maintaining safety, reliability, and power generation by performing the following activities:

- Define the integrated screening criteria to determine the scope of SSCs to be evaluated. This may include such criteria as
  - safety-related and essential nonsafety-related
  - maintenance rule scoping criteria
  - license renewal scoping criteria, including passive functions
  - necessary for power generation
  - environmental qualification
  - safe shutdown
  - station blackout
  - fire protection
  - anticipated transient without scram
  - pressurized thermal shock

This activity addresses all the potentially important criteria at one time instead of in separate efforts for individual sets of requirements. Using integrated screening criteria also ensures consistency of approach. For example, it is important that PM optimization does not screen out an activity for equipment that could cause a maintenance rule functional failure.

- List the system design functions —Determine the importance of each function listed. Use the probabilistic safety assessment (PSA) model as one of the tools to perform this evaluation. Equipment performance and information exchange (EPIX) function and device records should be of assistance. If a function is required for nuclear safety, reliability, or power generation, then it is considered an important function.

Critical Components

For each function identified, identify and evaluate the SSCs that are associated with the performance of the function. It is important to consider active and passive elements of each component. If a failure of the component or its structural supports defeats or degrades an important function or a function that is redundant to an important function, then it is a critical component, and analysis should be continued. Otherwise, evaluate other considerations for continuous equipment reliability improvement.

Criteria

If the component's functional failure results in one or more of the following, it is considered a critical component:

- Significant power transient or derate
- Loss of a redundant safety function
- Unplanned entry into a technical specification LCO
- Half scram or partial trip
- Reactor shutdown
- Actuation of emergency safeguards features
- Failure to control a critical safety function such as reactor water level and pressure, primary and secondary containment, drywell temperature and pressure, or spent fuel pool temperature and level
- Degraded capability to shut down the reactor and maintain it in a shutdown condition
- Inability to perform an emergency operating procedure, or to prevent or mitigate the consequences of accidents that could result in potential offsite exposure in excess of 10 CFR 100, "Reactor Site Criteria," limits
- Operator workaround for performing any of the above functions or procedures

b. Discuss acceptance criteria, monitored parameters, and tracking/trending tools used to ensure SSCs continue to meet all safety basis requirements.

The following is taken from the Institute of Nuclear Power Operations, *AP-913, Equipment Reliability Process Description*.

Establish performance criteria and monitoring parameters for important system functions and critical components. Consider the following for development of performance criteria:

- Use performance criteria that are based on availability, reliability, or condition
- Look for leading indicators that predict performance, in addition to indicators based on equipment failures
- Understand the damage mechanisms, effects, and leading indicators of damage for critical components
- Recognize that component active performance may not be a good indicator of component material condition

- Recognize that components initially fail at very localized levels. Reliance on a “trend and replace” aging management strategy requires the use of very localized and specific trending indicators
- Relate monitored parameters and acceptable levels of performance to measurable indications of component degradation
- Employ condition monitoring techniques when performance monitoring cannot be related to component degradation
- Include specific alert values for condition-monitoring data in the component performance criteria
- Establish specific performance criteria for risk-significant systems/trains and those non-risk-significant systems/trains that are in standby mode in accordance with the station maintenance rule program
- Trend critical parameters of programs used to retard age-related damage
- Validate performance criteria for risk-significant systems against the reliability assumptions contained in the PSA model
- Establish performance criteria using maintenance rule guidance, industry experience, operating data, surveillance data, PSA assumptions, and station equipment operating experience.

Capture the relevant data from equipment history for completed work activities, completed post-maintenance test activities, PdM, equipment condition data from completed PM and surveillance activities, program test results, system engineering walkdowns, trends from process computer data, operator rounds, and any other sources of performance data. Compare the actual performance to criteria. At regular intervals, system experts will trend the plant data used to determine system/train performance against the established performance criteria.

Perform cross-system component failure and problem trending using maintenance history, condition report data, and industry operating experience such as EPIX. Establish component expertise and ownership to resolve emergent equipment problems and better identify maintenance contributors. This allows system engineers to perform longer-term equipment reliability improvement activities. Suggested component expertise includes motors, pumps, valves, motor-operated valves, air-operated valves, breakers, instrumentation and controls, and heat exchangers, with a focus beyond regulatory program compliance for short-term and long-term health.

Considerations

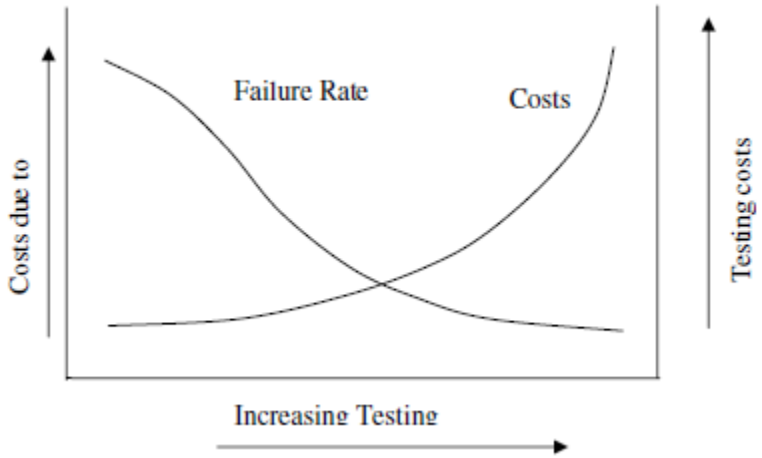
- Ensure that component and system engineers understand active and passive component damage mechanisms, effects, and indicators.
- Use equipment history and the corrective action database to trend equipment failure for components used across several systems.
- Trend as-found equipment condition codes to identify patterns of degradation by component type and the need to adjust PM tasks or frequencies. Trends of as-found equipment condition codes should also be used to update PM templates based on station equipment operating experience.
- Use as-found equipment condition codes to identify PM outliers for additional evaluation. For example, PMs coded as condition 5 or below should be reviewed for adjustments to PM task or frequency for specific components.

- Use EPIX to identify component trends being experienced by other stations, and take proactive measures to avoid similar failures at your station.
- Identify aging or obsolescence issues.
- Share component trend results with system engineers.
- Coordinate with the system engineer to evaluate the relationship between component performance and effect on system functional performance.
- Trend key data collected on operator round sheets.
- Consult nonnuclear sources of component failure information and trending parameters/strategies.
- Provide updated reliability data for PSA applications.

c. Discuss the monitoring, inspection, and testing frequency and sample size appropriate for timely detection of aging effects.

The following is taken from *Development of a Methodology for Determining the Testing Frequency of Construction Material.*

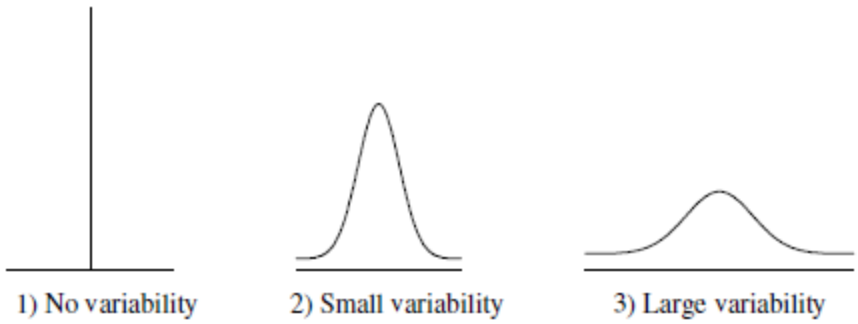
Sample size and testing frequency (TF) directly affect the reliability of a test program in characterizing the population. Using a large sample produces a more reliable decision. However, an increase in sample size is more costly. In reality, economic constraints generally force engineers to keep the sample size as small as possible. Figure 10 illustrates the trade-off between material testing costs and failure rate.



Source: Development of a Methodology for Determining the Testing Frequency of Construction Material

Figure 10. The trade-off between material testing costs and failure rate

The required sample size and TF are related to the variability of the material. Characterizing the variability of a material is a key issue in development of methodology in this research. Figure 11 illustrates three levels of variability: 1) no variability; 2) small variability; and 3) large variability.



Source: Development of a Methodology for Determining the Testing Frequency of Construction Material

Figure 11. Three levels of variability

Apparently, for situations where there is no variability at all, one test result would sufficiently represent the true characteristic of that material. However, such a situation rarely exists in the real world. For materials with larger variability, a bigger sample is required to properly characterize the material. A larger sample size also means more frequent testing. The variability of a material for a specific test value can be determined by available historical data.

By assuming that the samples are random and that the data conform to a normal distribution, the variability can be represented by the standard deviation (σ).

There are two methods for determining an adequate statistical sample size. One considers only type I error; the other considers type I and type II errors.

These two methodologies are briefly discussed as follows.

Sample Size Considering Only Type I Error

The sample size considering only type I error is a function of the standard deviation, the level of tolerance, and the level of confidence. The sample size can be mathematically expressed as

$$n = \frac{Z_{\alpha/2}^2 \sigma^2}{e^2}$$

where:
n = sample size
$Z_{\alpha/2}$ = the $(1-\alpha/2)$th percentile of the standard normal distribution
α = type I risk
σ = standard deviation
e = tolerable error

The equation is based on asymptotic theory; therefore, for a sample size n that is not infinite, n should be adjusted as follows:

$$n_a = \frac{n}{1 + \frac{n}{N}}$$

where:
n_a = adjusted sample size a
n = the sample size which ignores the finite population correction
N = population size

The sample size that considers type I and type II error can be estimated with a procedure similar to the one considering only type I error. The only difference is that the type II error has to be taken into consideration. Mathematically, the sample size can be estimated as follows:

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \sigma^2}{e^2}$$

where:
n = sample size
α = type I error
β = type II error
$Z\alpha/2$ = the $(1-\alpha/2)$th percentile of the standard normal distribution
Z_β = the $(1-\beta)$th percentile of the standard normal distribution
σ = standard deviation
e = tolerable error

It can be proven that when $\beta = 0.5$ (i.e., $z_\beta = 0$), the sample size considering type I and type II error will equal to the sample size where only type I error is considered. In other words, the sample size considering only type I error is a special case of the sample size that considers type I and type II errors.

Determination of Testing Frequency

Testing frequencies can be specified as either time-based TF or quantity-based TF. Time-based TF is expressed as "one for each day's production," "one for each 10 days' production," etc., while quantity-based TF is described as "one per 1,000 tons," "one per sublot," or "one per ton lots." Once the required sample size is estimated, the TF can be determined by using the following equation for time-based TF:

TF = Daily Production/Sample Size

For example, if the estimated sample size is two and the samples are taken every day, then the TF is "two for each day's production." If the estimated sample size is one, and the samples are taken every 10 days, the TF is "one for each 10 days' production."

Similarly, for quantity-based TF:

TF = Batch Quantity/Sample Size

For example, if the required sample size is two, assuming the batch quantity is 3000 tons, then the TF is "one per 1,500 tons." If the required sample size is two and the batch quantity is defined as one sublot, then the TF is "two per sublot."

d. Discuss technical obsolescence and its influence on maintenance management.

The following is taken from IAEA-TECDOC-1402, *Management of Life Cycle and Ageing at Nuclear Power Plants: Improved I&C Maintenance*.

The basic ageing and obsolescence management process involves the following:

- Understanding the ageing and obsolescence phenomena and identifying the (potential) effects on equipment
- Addressing the specific impact of these effects on the plant taking into account operational profiles and analyzing the risks
- Carrying out necessary mitigating actions to counteract the effects of ageing and obsolescence

Obsolescence is more of a problem in the nuclear industry than in other industries. This is because the nuclear industry usually has very strict requirements for products that are used in systems that can affect safety. Component and structural material degradation occurs as a result of long term operation. This effect is accelerated in nuclear plants due to the exposure of materials to harsh environmental conditions.

14. Facility maintenance management personnel must demonstrate a working level knowledge of seasonal facility preservation.

a. Discuss weather and environmental conditions that should be considered when developing a seasonal facility preservation plan.

The following is taken from DOE G 433.1-1A.

Seasonal facility preservation includes developing and implementing a plan to address severe weather, environmental, and wildfire conditions for the safe operation and preservation of DOE nuclear facilities, and the prevention of damage to safety SSCs. This section describes example, proactive measures that should be taken by maintenance organizations to adapt the facilities to changing external conditions. This requires that a plan be established for assessments and preventive actions for facilities to ensure protection from adverse local conditions. To give this work appropriate priority, a task team should be established to develop and implement this plan.

The plan should clearly define responsibilities, accountabilities, and interfaces for each functional organization supporting each step in the plan. A severe conditions facility preservation plan, at a minimum, should include steps to address the following:

- Cold weather, including freezing conditions, hail, snow, and ice
- Flash floods and mud slides
- Hurricane watches and warnings
- Tornado watches and warnings (high winds)
- Extreme hot/dry weather
- Wildfires

b. Discuss how nuclear safety SSCs with the potential for damage from seasonal weather and environmental conditions are identified and protected.

The following is taken from DOE G 433.1-1A.

Buildings and equipment with the potential for damage from seasonal weather conditions should be identified and a risk assessment based on a graded approach should be conducted. Damage prevention or mitigation plans should be developed that include contingencies for the critical facilities or equipment that are likely to sustain damage. The plan should ensure that, in all cases, the preparatory actions and requirements imposed to provide severe conditions protection, particularly those taken to restrict safety system functions, are reviewed by facility operations and safety personnel before implementation to ensure that the facility is maintained in a safe condition to protect the health and safety of the public.

The following is taken from DOE G 433.1-1A.

The severe conditions protection plans should be in the form of a checklist or a group of procedures that include the following actions:

- Ensuring that facility plans are validated, verified, and approved
- Ensuring that manufacturer temperature limitations are considered for exposed equipment
- Ensuring adequate foul weather and fire protection gear, tools, and equipment are available for use
- Ensuring periodic maintenance is current for emergency diesel generators, uninterruptable power supplies, and plant battery banks
- Identifying and performing corrective actions on deficiencies to systems/equipment that prevent/mitigate seasonal hazard problems to ensure that proper operation of equipment is maintained
- Inspecting on-going job sites for loose materials and debris, which may become missiles in strong winds, and securing them to the maximum extent possible
- Examining all facilities and equipment assigned to their area of responsibility on a seasonal basis to ensure their readiness (e.g., vehicles are in good repair and have fuel)
- Maintaining a crew call-in list for maintenance crews to respond to specific seasonal hazard related problems
- Ensuring removal of seasonal weather protection features after the weather season is over

- Evaluating plan activities involving maintenance organizations to determine and implement enhancement/improvement opportunities in a timely manner

Facility managers should consider severe conditions related problems as a priority and take immediate corrective action to minimize damage for anticipated or current weather conditions. Examples include the following:

- Ensuring predetermined operational changes are executed to protect equipment and facilities assigned, such as modification to set-ups or shut down/start-up of equipment as required to ensure protection from potential damage and to minimize loads on power distribution lines
- Realigning primary heating, ventilating, and air-conditioning (HVAC) equipment that may affect ambient temperatures
- Monitoring their assigned facilities for protection and assuring any necessary onsite actions are taken and/or correct personnel are notified to protect equipment and facilities assigned to their area of responsibility
- Curtailing operations (safe shutdown) of a facility identified as having a high probability for sustaining damage when subjected to unusually severe conditions
- Identifying personnel to be evacuated during severe conditions and ensuring any such evacuation is carried out in accordance with approved emergency procedures

c. Discuss possible protective responses to different severe weather events.

The following is taken from DOE G 433.1-1A.

Cold Weather Preparation

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

The following should be included to minimize equipment and building damage from cold weather conditions (temperatures less than or equal to 35º F) including hail, snow, and ice:

- Identifying areas where portable heating may be required and obtaining portable heating equipment (portable heaters should be inspected, tested, and staged by facility personnel who are trained in their safe use)
- Monitoring the conditions surrounding wet-pipe sprinkler systems to ensure a temperature of above 40º F is maintained and taking appropriate actions such as making provisions for auxiliary heat, draining, and/or posting a fire watch
- Ensuring air intakes, windows, doors and any other access points that may result in abnormal flow of cold air into an area susceptible to freeze damage are secured
- Ensuring heating systems are cleaned, serviced, and functionally tested
- Ensuring antifreeze used in cooling systems is checked and replaced as necessary
- Ensuring heating system power and temperature controls are protected against inadvertent deactivation

- Ensuring systems requiring or deserving special protection due to hazards or costs associated with freeze damage have temperature alarms and/or automatic backup heat sources
- Ensuring the main water supply cutoffs for each critical facility are identified, tested, and readily accessible to emergency personnel responding to a freeze/thaw incident
- Inspecting outside storage pads and unheated storage areas to ensure that there are no materials susceptible to freeze damage
- Implementing snow and ice removal activities
- Ensuring employees are aware of the need to identify and report any suspected problem with heating or other cold weather protection equipment (e.g., non-insulated water or process pipes, steam trace heaters isolated, broken windows)
- Evaluating the removal of freeze protection equipment from service during the seasonal freeze period
- Ensuring availability and use of salt, sand, and ice-chaser as needed
- Inspecting outside areas to ensure that gutters and downspouts are provided where there is a potential for ice buildup that may restrict egress
- Ensuring operations or facility personnel have specific responsibility for monitoring the temperatures in facilities' on and off shifts, including weekends and holidays
- Alerting personnel and providing increased surveillance in periods of extreme, unusual, or extended cold
- Ensuring contingency plans are prepared and available for temporarily curtailing operations in those nuclear facilities that are likely to sustain freeze damage when unusually severe weather is expected

Flash Floods and Mud Slides

The following should be included to minimize equipment and building damage due to flash flooding and mudslides:

- Doors and windows closed
- Vulnerable items covered with tarps
- Storm drains kept clear of debris
- Sandbags and dikes used where necessary
- Water-vulnerable items raised above the expected water line
- All vehicles parked/moved to high ground as necessary

Hurricane Watches and Warnings

The items listed below should be included to minimize equipment and building damage from a hurricane:

- Windows boarded up or taped as necessary during a hurricane watch
- Safe shutdown of vulnerable equipment
- Emergency evacuation policies and routes posted

Tornado Watches and Warnings (High Winds)

The following should be included to minimize equipment and building damage from tornadoes:

- Plan for the safe shutdown of vulnerable equipment
- Emergency evacuation policies and routes posted

Extreme Hot/Dry Weather

The following should be included to minimize equipment and building damage from extreme hot/dry weather:

- Plan for the safe shutdown of vulnerable equipment
- Restrict operations, which involve heat
- Restrict fire hazards
- Ensure an ample supply of portable fire extinguishers is available
- Ensure fire protection personnel are alerted
- Ensure all exits are kept clear.

15. Facility maintenance management personnel must demonstrate a working level knowledge of performance measures.

a. Discuss how performance indicators are established, measured, trended, and analyzed to identify organizational conditions that are impacting mission goals, including safety and the reliability of SSCs that are part of the safety basis.

The following is taken from DOE G 433.1-1A.

Performance monitoring is a valuable management tool to track the reliability of SSCs important to safety and the conduct of maintenance. However, the identification of performance indicators, which accurately predict future performance, is challenging. Metrics tend to count results like lost time accidents and PM accomplishment rate. Typically, a goal is set for each metric and possibly a grade or color associated with various performance results. Unfortunately, past performance is not always a reliable indicator of what is to come. Future performance tends to be more a result of behaviors; how workers follow safety rules or provide feedback on inefficient work practices and how management personnel interact with the staff and receive bad news.

Measuring behavior can be more subjective than objective, but standards should be as well defined as possible.

The selection of core performance indicators should reflect the most important elements of mission and safety performance. The selection of these metrics is itself a message to the organization of what management considers important.

For maintenance, typical indicators include the following:

- Safety
  - Safety system availability
  - LCOs due to equipment failure
  - Total recordable case and days away/restricted time
  - Contamination events

- Quality
  - Equipment availability
  - Maintenance rework.

- Production

- Corrective maintenance backlog
- Overdue PMs

Other examples worthy of consideration include the following:

- Close-calls may identify weak work practices, equipment, or procedures
- First aid cases may be an indication of safe work practices
- Overtime hours—Are resources adequate for the work, will backlogs rise?
- PPE infractions may be an indication of safety awareness.
- Sick days may indicate the commitment of the workforce (this should not be associated with specific individuals).
- Self-assessment compliance—Are supervisors/managers getting into the field; are their observations meaningful (reinforces good practices, discourages bad practices)?
- Training attendance—Is training the right priority, are supervisors managing their work to permit attendance?

The initial selection of performance indicators should be a thoughtful process involving all the levels of the organization. The selected metrics should be reviewed periodically and modified as necessary to ensure they provide useful data. The metrics and their purpose need to be understood by all.

EFCOG published a performance metric manual in 2002, which explains a performance measurement process piloted at the Savannah River Site. This manual provides a process for metrics, which flow from top to bottom in an organization. Even if not used exactly as described, the manual provides numerous ideas to consider in any program.

b. Discuss how goals should be established for these performance indicators/metrics.

The following is taken from DOE G 433.1-1A.

Performance indicators should be sufficiently defined so that their measurement is a simple matter of counting or transcribing from an organization record or log. Even assessment results that may be somewhat subjective can be given a grade useful for comparison. The periodicity of the data should be thoughtful – typically monthly or quarterly is sufficient. The data should be recorded, retained, and trended over multiple data periods – typically a year or more.

The data should be true and accurate to be of real value in assessing organizational conditions. Established goals should be challenging, but realistic. It would be laudable if an organization never had an occurrence or even a close call, but significant management pressure to achieve that goal may discourage reporting. A close call, properly handled, could fix an organizational deficiency that if left unreported could lead to a significant event. That is clearly not the desired result.

c. Discuss how metrics which do not achieve their goal or have undesirable trends should be analyzed to determine the causal factors for this performance.

The following is taken from DOE G 433.1-1A.

When the analysis has identified causal factors for undesirable trends in performance, a plan of action should be developed, implemented, and validated to actually have improved performance without undesirable unintended consequences. Too often worker deficiencies are deemed the problem and training the solution, but rarely does discipline, making procedures more complex, and retraining solve broad performance issues. Management should look deeper at the underlying organizational issues that lead to undesired behavior and work to improve those processes and approaches. This may include additional data gathering to refine the problem definition before finalizing the action plan.

d. Discuss how corrective actions should be defined and implemented for unsatisfactory performance or trends in performance.

The following is taken from DOE G 433.1-1A.

Undesirable performance trends should be assessed to determine the contributing and root causes. Corrective actions should be developed and implemented to correct undesirable conditions.

Corrective actions should address the analyzed causes rather than the symptoms of the problem. The objective of causal analysis should be to identify failures at an appropriate level. Where possible, corrective actions should prevent not merely a reoccurrence of the specific problem, but also prevent other problems, which may result from that same cause. Corrective actions should be developed with input from appropriate facility and staff members, including those tasked with implementing the actions, to achieve ownership of the corrective actions. Facility line management should approve corrective actions and ensure the actions are implemented in a timely manner. Input from organizations such as QA or corporate support/oversight groups should be considered when determining actions in response to deficient conditions they identified. Management should track corrective actions' completion and effectiveness.

Responsible managers and supervisors should be held accountable for the timely and effective implementation of corrective actions. Delays in the completion of approved corrective actions should be brought to the attention of the responsible manager who assigned the corrective actions. An escalation process should provide higher levels of management attention to problem areas where corrective action continues to be incomplete or ineffective.

e. Discuss the process for validating the effectiveness of corrective action plans.

The following is taken from DOE G 433.1-1A.

Follow-up on the effectiveness of corrective actions for deficient conditions should be scheduled as part of the management-monitoring program to determine whether the immediate condition has been corrected and the root causes eliminated. Some cases will require monitoring of the immediate corrective actions and, after sufficient time for completion of all corrective actions, subsequent monitoring to determine whether recurrence of the condition is minimized. Based on the results of the follow-up monitoring, the item can

be closed or a new corrective action may be required. Closeout methods should be streamlined to prevent a backlog of completed items.

f. Discuss the routine management review of the status of performance indicators.

The following is taken from DOE G 433.1-1A.

What is done with performance indicator data is the most important aspect of performance measures. How are changes in data evaluated to be significant or a trend? Some organizations have employed statistical process control techniques to establish data normal and standard deviations – this may be a reasonable approach if there is access to the specialized expertise required to make this meaningful. However, most organizations simply look for changes and the apparent causes, and if other related indicators are consistent. If this condition is considered important by the responsible manager or their boss, they are further analyzed.

The purpose of analyzing changes in performance indicators is to identify the factors causing the indicator to change. There will be obvious factors, however, these are typically superficial—fixing them is not a long-term solution and may hide an error producing condition. There will likely be human performance factors, but the vast majority of these factors are influenced by organizational conditions that affect more than a single individual. Data gathering and analysis, using the event analysis techniques described in the references above, should go beyond fault finding and determine the underlying organizational conditions or processes that should be addressed.

The following factors should be considered in these analyses:

- Availability of physical resources:
  - tools, equipment;
  - spare parts, materials;
  - workers, support personnel;
  - workspace, light, ventilation;
  - sufficient labels, gauges, annunciators, and control devices;
  - availability of tools, materials, technology, equipment, improved lighting, adequate budget, spare parts, etc.; and
  - adequate predictive/PM.

- Organization/Facility structure including
  - clear responsibilities, policies, goals;
  - logical reporting structure;
  - effective CM—drawings, procedures, training up-to-date;
  - available support personnel
  - consistent scheduling and adequate work planning; and
  - effective oversight, self-assessment, and supervision.

- Information including
  - adequate pre-job brief, turnover;
  - clear and accurate maintenance, operating, or special test procedures/instructions;

- accurate and available drawings, equipment manuals, technical specifications;
- adequate time to review work procedure and prepare for task;
- lessons Learned appropriately applied/shared; and
- post-maintenance testing verifies equipment operability.

- Knowledge/Skills/Abilities including
  - effective qualification program;
  - appropriate worker and supervisor training programs and materials;
  - effective OJT and skills training;
  - proper use of self-check and peer-check; and
  - adequate QA/QC.

- Motivation including
  - reasonable work schedule, overtime not excessive;
  - appropriate recognition, bonuses; and
  - fair pay, benefits, job security, advancement opportunity, etc.

g. Discuss how performance measures are included in the organizational self-assessment program.

The following is taken from United States Agency for International Development, USAID, *Performance Monitoring and Evaluation Tips.*

Seven Criteria for Assessing Performance Indicators

1. DIRECT. A performance indicator should measure as closely as possible the result it is intended to measure. It should not be pegged at a higher or lower level than the result being measured.

   If using a direct measure is not possible, one or more proxy indicators might be appropriate. For example, sometimes reliable data on direct measures are not available at a frequency that is useful to managers, and proxy indicators are needed to provide timely insight on progress. Proxy measures are indirect measures that are linked to the result by one or more assumptions. For example, in rural areas of Africa it is often very difficult to measure income levels directly. Measures such as percentage of village households with tin roofs (or radios or bicycles) may be a useful, if somewhat rough, proxy. The assumption is that when villagers have higher income they tend to purchase certain goods. If convincing evidence exists that the assumption is sound (for instance, it is based on research or experience elsewhere), then the proxy may be an adequate indicator, albeit second-best to a direct measure.

2. OBJECTIVE. An objective indicator has no ambiguity about what is being measured. That is, there is general agreement over interpretation of the results. It is unidimensional and operationally precise. To be unidimensional means that it measures only one phenomenon at a time. Avoid trying to combine too much in one indicator. Measures of access and operational precision mean no ambiguity over what kind of data would be collected for an indicator. For example, a number of successful export firms is ambiguous; something like the number of export firms experiencing an annual increase in revenues of at least 5 percent is operationally precise.

3. ADEQUATE. Taken as a group, a performance indicator and its companion indicators should adequately measure the result in question. A frequently asked question is "how many indicators should be used to measure any given result?" The answer depends on 1) the complexity of the result being measured; 2) the level of resources available for monitoring performance; and 3) the amount of information needed to make reasonably confident decisions. For some results that are straightforward and have tried and true measures, one performance indicator may be enough. For example, if the intended result is increased traditional exports, the indicator dollar value of traditional exports per year is probably sufficient. Where no single indicator is sufficient, or where there are benefits to be gained by "triangulation"—then two or more indicators may be needed. However, avoid using too many indicators. Try to strike a balance between resources available for measuring performance and the amount of information managers need to make reasonably well informed decisions.

4. QUANTITATIVE, WHERE POSSIBLE. Quantitative indicators are numerical (number or percentage of dollar value, tonnage, for example). Qualitative indicators are descriptive observations (an expert opinion of institutional strength, or a description of behavior). While quantitative indicators are not necessarily more objective, their numerical precision lends them to more agreement on interpretation of results data, and are thus usually preferable. However, even when effective quantitative indicators are being used, qualitative indicators can supplement the numbers and percentages with a richness of information that brings a program's results to life.

5. DISAGGREGATED, WHERE APPROPRIATE. Aggregating people-level program results by gender, age, location, or some other dimension is often important from a management or reporting point of view. Experience shows that development activities often require different approaches for different groups and affect those groups in different ways. Disaggregated data help track whether or not specific groups participate in and benefit from activities intended to include them. Therefore, it makes good management sense that performance indicators be sensitive to such differences.

6. PRACTICAL. An indicator is practical if data can be obtained in a timely way and at a reasonable cost. Managers require data that can be collected frequently enough to inform them of progress and influence decisions. Operating units should expect to incur reasonable, but not exorbitant, costs for obtaining useful performance information. A rule of thumb, given in the reengineering guidance, is to plan on allocating three to ten percent of total program resources for performance monitoring and evaluation.

7. RELIABLE. A final consideration in choosing performance indicators is whether data of sufficiently reliable quality for confident decision-making can be obtained. But what standards of data quality are needed to be useful? The data that a program manager needs to make reasonably confident decisions about a program is not necessarily the same rigorous standard a social scientist is looking for. For example, a low cost mini-survey may be good enough for a given management need.

16. Facility maintenance management personnel must demonstrate a working level knowledge of facility condition inspections.

a. Discuss planning, conducting, and trending periodic inspections of the material condition of nuclear facilities and systems to support safe and reliable operation.

The following is taken from DOE G 433.1-1A.

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. After initial facility construction, ongoing maintenance and the control of modifications are prime contributors to keeping systems and equipment in optimum condition to support safe and reliable operation.

The facility condition inspection should be integrated with the condition assessment program so that identified repairs can be included as part of deferred maintenance reporting as applicable.

Establishing a program for identification and correction of condition deficiencies and housekeeping discrepancies is an important step in maintaining facilities and equipment in a condition of maximum safety, reliability, and availability.

The appearance and proper functioning of facility systems and equipment are key indicators of a well-maintained and -operated facility. Cleanliness and good housekeeping are the responsibilities of all facility employees. Additionally, there should be a periodic, focused inspection effort, by thoroughly trained personnel, to assist in effective identification and correction of facility condition deficiencies. Identification of technical obsolescence in a facility condition inspection is also important to determine whether the performance of SSCs is threatened. The maintenance of systems and equipment within design conditions produces such benefits as minimizing fluid leakage, minimizing 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.

Additionally, facility condition inspections should include items such as asbestos and lead based paint locations and material to assure that they are not damaged or contaminating the area and that they are included in the required identification surveys required by codes, laws, or policies. A good facility condition inspection program, often called condition assessment survey (CAS), should include these building materials as a way to account for them. By combining the surveying and accountability of these hazardous building materials as part of a site's CAS program it will make it more efficient and effective.

Properly used, a facility condition and housekeeping inspection program is an effective means for identifying and correcting deficiencies. The inspection programs should include such elements as the following:

- Facility managers should set high facility condition and housekeeping standards and communicate them to all personnel to promote a clear understanding.

- 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.
- A CAS with assigned risk assessment code should be used to prioritize schedules for repair.
- Instructions should 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 should be prepared to assist the assigned inspectors in performing their inspections.

The following is taken from DOE O 430.1B.

Condition Assessment System

An important step in an effective facility management strategy is to know the condition of the facilities and how much it will cost to replace and repair facility systems and components. The assessment or inspection process supports the vital process of identifying facility conditions that are founded on recognized, fully defined industry based inspection and deficiency standards. An assessment program is an essential tool in determining realistic requirements needed to obtain budgetary funding. It provides a picture across a site that can be used along with mission and other prioritization criteria to direct limited resources to crucial areas. A condition assessment program is the basis for developing supportable asset management projects and funding requests.

MINIMUM CONDITION ASSESSMENT SYSTEM CHARACTERISTICS

A standardized, documented inspection process that provides accurate, consistent, and repeatable results.

A detailed, ongoing inspection of real property assets, including facilities; infrastructure; and large, in-place non-programmatic equipment that is validated at predetermined intervals.

Standardized cost data using a condition assessment information system (CAIS) or another nationally recognized cost estimating system to determine repair and replacement costs.

A user-friendly information management system or process that prioritizes current and anticipated maintenance and repair requirements to maximize the utilization of resources (labor and dollar) and return on investment and minimizes the cost of irreversible loss of service life and total penalty cost.

A facility condition assessment program that identifies deficiencies in order to take timely, cost-effective corrective actions. Condition assessments must involve inspections by craft or engineering specialists of all architectural, civil/structural, mechanical, and electrical components of each asset to determine asset deficiencies and must provide a comprehensive evaluation that can be used to make informed facilities management decisions.

Condition assessments must provide for the following:

- Inspection of all assets using applicable codes and accepted industry standards
- A tailored approach based on facility status, mission, and importance; and the magnitude of the hazards within the facility
- A valid estimate of deferred maintenance costs
- A 5-year maintenance plan based on projections of serviceability, economic life, the mission of facilities and projected funding for deferred maintenance reduction
- Identification of safety and health hazards
- Accurate and supportable information for budget planning and justification
- Comparison of conditions and costs between sites and programs
- Supportable cost estimates and funding priorities for general plant project, institutional general plant project, line item projects, and other site funded maintenance projects

CONDITION ASSESSMENT INFORMATION SYSTEM DATABASE

Use the DOE CAIS database or another nationally recognized cost estimating system to estimate deficiency costs. The costs must include contractor overhead/burden. The database or cost estimating system must accommodate site craft, engineering service contractor, or other data entry. Each must a) break out asset deferred maintenance cost by asset components or systems, b) calculate a facility condition index by system, and c) have the ability to separate rehabilitation and improvement costs from deficiency costs.

The condition assessment data collected will feed the Federal information management system.

The following is taken from DOE-STD-1072-94 (Archived).

The objectives of a facility inspection program are 1) to provide a means for owner/operators to have an awareness of the way business is actually being conducted on the shop floor and 2) to provide a means for maintenance managers to impart their expectations to craftspersons as to how maintenance should be conducted.

Key indicators of a well-maintained and operated facility are the appearance and proper functioning of facilities, systems, and equipment.

Daily observation of conditions should be performed at local job sites by the owner/operator. However, all facility personnel should be encouraged to be active observers during the normal course of daily duties. Good material condition, cleanliness, and housekeeping are established and maintained by a knowledgeable work force alert to deficiencies in their work areas and who inform responsible managers for prompt corrective actions.

A facility inspection program should include the following key elements:

- A systematic approach that ensures information is gathered throughout the facility. Ideally, the program should ensure that each area of the facility is inspected by a manager/supervisor on a periodic basis.
- A focal point to evaluate the gathered information, identify recurring problems, and develop corrective action plans (CAPs).
- Conscientious management involvement in specifying corrective action and assigning responsibility for implementation.
- A means to follow up on the program to measure its effectiveness.

The facility material inspection program should address the following:

- Material condition and documentation
- Industrial safety
- Housekeeping practices
- Radiological protection practices
- Opened system and component protection
- Reporting and follow-up

Facility Inspection Guidelines

The following process applies to inspection zones:

- The facility should be divided into inspection zones. Inspection zones should be numbered for identification.
- Inspection zones should be assigned to department managers by job title (e.g., zone 1 assigned to the maintenance administration manager).
- Periodically, each inspection zone should be assigned to a different department manager. This should help ensure consistency throughout the facility.

The following process applies to scheduling:

- A schedule should be established that ensures each inspection zone is inspected approximately every two weeks.
- Schedules should specify the week in which the inspection should be accomplished and what general inspection category should be concentrated on. The day and time of inspection should be left to the department manager's discretion.
- At the beginning of the quarter, the inspection coordinator should notify each department manager of the inspection zones for which he/she is responsible by publishing a schedule matrix. This schedule should indicate the inspector, zone, and type of inspection for each week of the quarter.

The following process applies to types of inspection:

- Inspections should be separated into general categories and identified as follows:
  - Material condition (M)
  - Industrial safety (S)
  - Cleanliness/housekeeping (H)
  - Radiological protection/control (R)

- Each inspection should concentrate on one general category. This should allow an in-depth look at one specific aspect of facility performance. However, other deficiencies should not be overlooked.

- All applicable general categories should be completed for each inspection zone by the end of each calendar quarter.

The following process applies to the conduct of the inspection:

- Each department manager or his/her designated representative should conduct an inspection of his/her assigned inspection zone during the week scheduled. The inspection may be conducted as one evolution, or as a series of smaller inspections during the week.
- Each inspection should include detailed walk-downs of the inspection zone. Key areas to consider are out-of-the-way and limited-access areas. The inspection should not only identify deficiencies; it should also identify those things that are being done to improve facility conditions. In this manner, the program serves as a positive feedback mechanism.
- Subordinates should be included on inspections-periodically. This should provide a method to teach inspection techniques and convey high standards.
- The owner/operator should accompany each department manager periodically to ensure his/her (owner/operator's) standards are adequately understood by other department managers.

b. Discuss how material deficiencies are identified, logged, and corrected in the work control system.

The following is taken from DOE G 433.1-1A.

Material deficiencies should be tracked. Inspectors should enter a description of the deficiency in the tracking system. Deficiency tracking systems may include use of deficiency tags, status logs, and/or computer tracking systems, or other equivalent means. Multiple deficiencies of a similar nature, in proximity to each other, or that are to be included on the same WR/WO may be grouped. The fact that there are multiple deficiencies should be indicated in the tracking system. The date should be used in conjunction with the tracking system identifier to obtain the WR/WO number.

In locations where used, the inspector will attach a deficiency tag to the equipment or component, as close as possible to the deficiency. Deficiency tags should be applied in a manner that does not obscure system controls, status indicators, or operating parameter displays. The duplicate copy, which contains the information necessary for completing a WR/WO, should be retained until a WR/WO is initiated.

If the deficiency is inaccessible because of radiation or physical constraints, the hard copy of the deficiency tag should be hung in a clearly visible area as close as possible to the deficiency. For those situations where a deficiency tag may restrict the visibility of facility instrumentation or controls, a smaller deficiency identification sticker should be used.

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

- Enter the deficiency identification tag or sticker number in the WR/WO index, if applicable. (Because the date on the deficiency tag is the date of the WR/WO, the index provides a cross-reference.)

- Use the duplicate portion of the deficiency identification tag to enter key information on the WR/WO.
- Record the tag or sticker serial number, date, and description of deficiency on the WR/WO.
- Note whether it was possible to place the deficiency identification tag in proximity to the deficiency.

The duplicate may be affixed to the WR/WO or discarded. The system now provides complete traceability from a deficiency, using the tag number and date, to the WR/WO index and then to the WR/WO. The age of a deficiency may be determined in the field from the date on the tag and the status of its repair determined from the work-control system.

Responsible 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.

If the tag is lost, or cannot be located, the circumstances should be noted on the original WR/WO. As a part of their review of the completed WR/WO, the maintenance supervisor should verify that the tag or sticker has been removed.

At least semiannually, the maintenance-planning manager should initiate the following review to check the use of deficiency identification tags and stickers. This review should be a management tool only and should not be considered a permanent record. Alternative methods of status tracking, such as computer databases, status logs, shift turnovers, etc. may be used instead of tags or stickers:

- A representative sample of pending WR/WOs and associated tags or stickers should be verified.
- A list should be prepared of all deficiencies not included in the work-control system or some other corrective action system, with responsibility for correction or disposition of each. Personnel assigned corrective action should periodically report to the inspection coordinator the results of the actions planned or conducted and deficiencies should be tracked to resolution by personnel assigned corrective actions and the inspection coordinator, as a fail-safe mechanism.
- Reported deficiencies should be monitored to identify recurring, generic, and long-term problems. Action taken to resolve these problems should include a failure or root-cause analysis.
- Follow-up of selected corrective actions from previous inspections is necessary for evaluating the timeliness and effectiveness of corrective actions and for obtaining the maximum benefit from the inspection program.
- The inspection coordinator or an assigned individual should periodically review inspection reports and facility conditions to evaluate the effectiveness of the inspection program.

17. Facility maintenance management personnel must demonstrate a working level knowledge of post maintenance testing.

a. Discuss when and how post-maintenance testing should be specified.

The following is taken from DOE G 433.1-1A.

Post maintenance testing integrates with the work-control system, and the health and safety permit system. The post maintenance test (PMT) should be commensurate with the maintenance work performed and the importance of the equipment to facility safety and reliability. In some cases, testing additional equipment may be required to verify system performance. The status of equipment that has undergone maintenance should be tracked to ensure that all testing is completed before work closeout. Planners should coordinate with system engineers, as applicable, regarding PMTs.

A PMT should include the following elements:

- The scope, initial conditions and prerequisites, hold points, test requirements, acceptance criteria and post-test restoration
- Methods for documenting the results, and verifying that the resulting data meets acceptance criteria

PMTs may be part of the facility work-control system, which uses the facility WR, or WP to specify testing, assign responsibility, and document acceptance of all PMTs. The WR should provide specific instructions or cross-reference a test procedure and should provide traceability to PMT data by recording the PMT data directly on the WR or by referencing data recorded on PMT data sheets or documents.

During the initial processing of a WR/WO, the maintenance planner should include predefined PMTs in job instructions based on consultation with the owner/operator. Tests of any equipment affected by code or TSR should be reviewed by cognizant personnel. The WR should be reviewed by the operations organization to verify that the PMT requirements listed will provide adequate verification that the equipment will be capable of performing its design functions. WR/WOs should include applicable post-maintenance testing requirements that verify that the intent of the maintenance was accomplished (i.e., the intended repair or service was accomplished), the required configuration was restored, and SSC operability was verified.

In addition, post maintenance testing should be done following PM and troubleshooting activities that might have affected normal functioning of the SSC. Tests should be conducted under conditions that represent normal operating parameters, such as flow, differential pressure, temperature, input signal values, and fluid type.

b. Discuss how PMTs are documented and reviewed.

The following is taken from DOE G 433.1-1A.

A PMT control may be filled out by the planner and attached to the WR/WO, as appropriate. PMT control instructions may also be provided via procedures/work instructions that are

approved as part of the WR/WO during the planning and authorization process. When a maintenance activity involves several different tests, a separate PMT control form may be used to document each test.

If the scope of work expands beyond the original WR/WO, work should be stopped and the WR/WO should be returned to planning along with any PMT control forms for further direction.

At the completion of post maintenance testing, the owner/operator should review the test results and sign the PMT control form/procedure/instructions, indicating acceptability of the equipment based on satisfactory completion of all PMTs. The owner/operator should make the final determination of operability.

The owner/operator is responsible for restoring SSCs to a correct set point for operating or standby mode following testing. This may be accomplished by instructions in the test procedure, by conducting specific system lineups, or by other formal methods.

For troubleshooting WR/WOs, the test requirements normally cannot be determined until the troubleshooting is complete. A record should be kept of work performed during troubleshooting to ensure that post maintenance testing covers the troubleshooting scope. The supervisor responsible for the troubleshooting should generate a new WR/WO for necessary work. Testing requirements should then be identified through the normal planning and review process.

If facility conditions dictate that the PMT cannot be completed immediately after maintenance is performed, the WR/WO should be held as an open WR/WO until testing may be completed. Danger or caution tags may be required for the equipment until proper post maintenance testing can be completed. Safety equipment should not be declared operative until the PMT is complete. WR/WOs waiting testing should be tracked to closure. Examples of delayed testing would include steam system valves or flanges repaired during unit outage periods that cannot be tested until normal operating facility conditions exist.

When the stop work conditions are corrected, retest requirements should be evaluated to determine whether prior testing should be repeated.

If the PMT is unsatisfactory, deficiencies identified during testing should be documented and corrected by generating a WR/WO.

If a PMT is unsatisfactory, the SSC should be tagged to indicate that a deficiency still exists. The owner/operator may tag the component out of service; declare it inoperable; or, depending on the test results and significance of the existing deficiency, return it to service with the documented deficiency.

Various classifications of equipment will require different levels of procedure support for PMT. Where applicable, existing surveillance test procedures can be used to evaluate the operational acceptability of the equipment. If an existing surveillance test is used for the PMT, it should also verify operability of all components and features either directly or potentially affected by the maintenance activity, verify that maintenance was performed

properly, and ensure that the initial deficiency was corrected. If only part of the procedure is to be performed, the applicable sections, including necessary prerequisites and precautions, should be identified and caution should be used to ensure that previous sections are reviewed for system status, lineups, or prerequisites. An engineering or system acceptance test procedure, alignment check procedure, generic test procedure, special test procedure, or craft/maintenance work instructions may also be used to provide PMT instructions. PMT procedures/instructions used for a range of generic equipment, such as manual valves or flow controllers, should include data sheets for specific equipment when acceptance specifications or performance data are required.

Test equipment should be specified and provision made for recording the equipment identification and calibration due date.

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 acceptability should be entered or cross-referenced to maintenance history on the WR.

Deficiencies identified during post maintenance testing should be documented and corrected on the original WR, 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.

c. Discuss the role of the cognizant system engineer in PMT according to DOE O 420.1C.

The following is taken from DOE O 420.1C.

The CSE is responsible to review, and provide input into the development of, and concur on operating, maintenance, and test procedures related to their assigned systems.

d. Discuss actions required if a PMT cannot be completed immediately after maintenance is completed.

The following is taken from DOE G 433.1-1A.

If a PMT fails and the equipment or system cannot be repaired and tested satisfactorily in a short time, 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.

18. Facility maintenance management personnel must demonstrate a working level knowledge of assessment techniques (such as planning and use of observations, interviews, and document reviews) to assess facility performance, report results of assessments, and follow-up on actions as a result of assessments.

a. Describe the role of facility maintenance management personnel with respect to oversight of government-owned contractor-operated facilities.

The following is taken from DOE G 226.1-2.

The maintenance program defines expectations for developing implementing procedures, conducting the preventive and predictive surveillance requirements, and conducting post-maintenance testing.

The following is taken from DOE O 433.1B, Chg. 1.

Periodic self-assessments in accordance with DOE O 226.1B must be conducted to evaluate the effectiveness of oversight of NMMPs.

Assessments of NMMP implementation must be conducted, at least every three years or less frequently if directed by the SO in accordance with DOE O 226.1B, to evaluate whether all CRD requirements are appropriately implemented.

For GOGO activities under the SO's cognizance, approve or designate the approval authority for NMMP documentation prepared in accordance with the CRD.

The following is taken from DOE G 433.1-1A.

DOE involvement in the oversight of nuclear facility maintenance programs should include reviews by the DOE facility representative, field and area offices, and HQ. 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. A comprehensive assessment of maintenance program elements should be conducted periodically and should include input from managers and supervisors from maintenance and other groups such as operations, technical staff, and appropriate corporate departments.

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 local Qualifying Official will evaluate the completion of this KSA.

c. Discuss the essential elements of a performance-based assessment including the following:
- **Investigation**
- **Fact finding**
- **Exit interview**
- **Reporting**
- **Follow-up**
- **Closure**

The following is taken from DOE G 414.1-1B.

Investigation/Fact Finding
Effective assessments use a combination of tools and techniques to maximize the productivity of the assessment team and resources. Such assessment techniques include interviews, document reviews, observation, inspection, and performance testing.

Exit Interview/Meeting
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 made every effort possible during the conduct of the assessment to ensure that the assessed organization was aware of the team's findings and concerns.

Reporting
Assessment reports are required for documentation of assessment results. 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/Closure
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 advantage or limitations of each method:
- **Document review**
- **Observation**
- **Interview**

The following is taken from 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 O 414.1A (Archived).

CAP dispute resolution process:

- Disputes over the CAP or its implementation (such as timeliness or adequacy) must be resolved at the lowest possible organizational level. The organization that disagrees with the disposition of a given issue may elevate the dispute for timely resolution.
- The organization that disagrees with the disposition of a given issue must elevate the dispute in a step-wise manner through the management hierarchy.
- The dispute must be raised via a deliberate and timely dispute resolution process that provides each party with equal opportunity for input and a subsequent opportunity to appeal decisions up to the Secretary of Energy, if necessary.

The following is taken from DOE G 414.1B.

Assessments should be thorough and information gathered with sufficient diligence such that accurate, detailed conclusions can be provided to the organizations that will receive the final report. Assessors should maintain good records of the assessment results. These may include personal notes or other information to support the assessment, and may be included in the checklist information. These records are useful in writing the report, and any associated findings and recommendations, and will be valuable if questions arise during the report review process.

Mandatory Performance Activities:

a. Participate as a team member on an assessment at a nuclear facility that includes the activities in c & d above.

This is a performance-based KSA. The Qualifying Official will evaluate its completion.

19. Facility maintenance management personnel must demonstrate a working level knowledge of problem analysis and techniques.

a. Discuss the elements of an analysis program.

The following is taken from DOE G 433.1-1 (Archived).

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 (Archived).

When all initial information related to the unplanned occurrence is collected, additional information pertinent to the investigation should be identified and obtained. This may include diagnostic information, 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 (Archived)

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 (Archived).

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 problem analysis techniques including the following:
- **Root cause analysis**
- **Causal factor analysis**
- **Change analysis**
- **Barrier analysis**
- **Management oversight risk tree analysis**

Root Cause Analysis

The following is taken from Wikipedia, *Root Cause Analysis*.

Root cause analysis is a method of problem solving that tries to identify the root causes of faults or problems that cause operating events. Root cause analysis practice tries to solve problems by attempting to identify and correct the root cause of events, as opposed to simply addressing their symptoms. By focusing correction on root causes, problem recurrence can be prevented.

In the U.S. nuclear power industry, the NRC requires that "in the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to prevent repetition." In practice, more than one cause is allowed and more than one corrective action is not forbidden. Conversely, there may be several effective measures (methods) that address the root cause of a problem. Root cause analysis is often considered to be an iterative process, and is frequently viewed as a tool of continuous improvement.

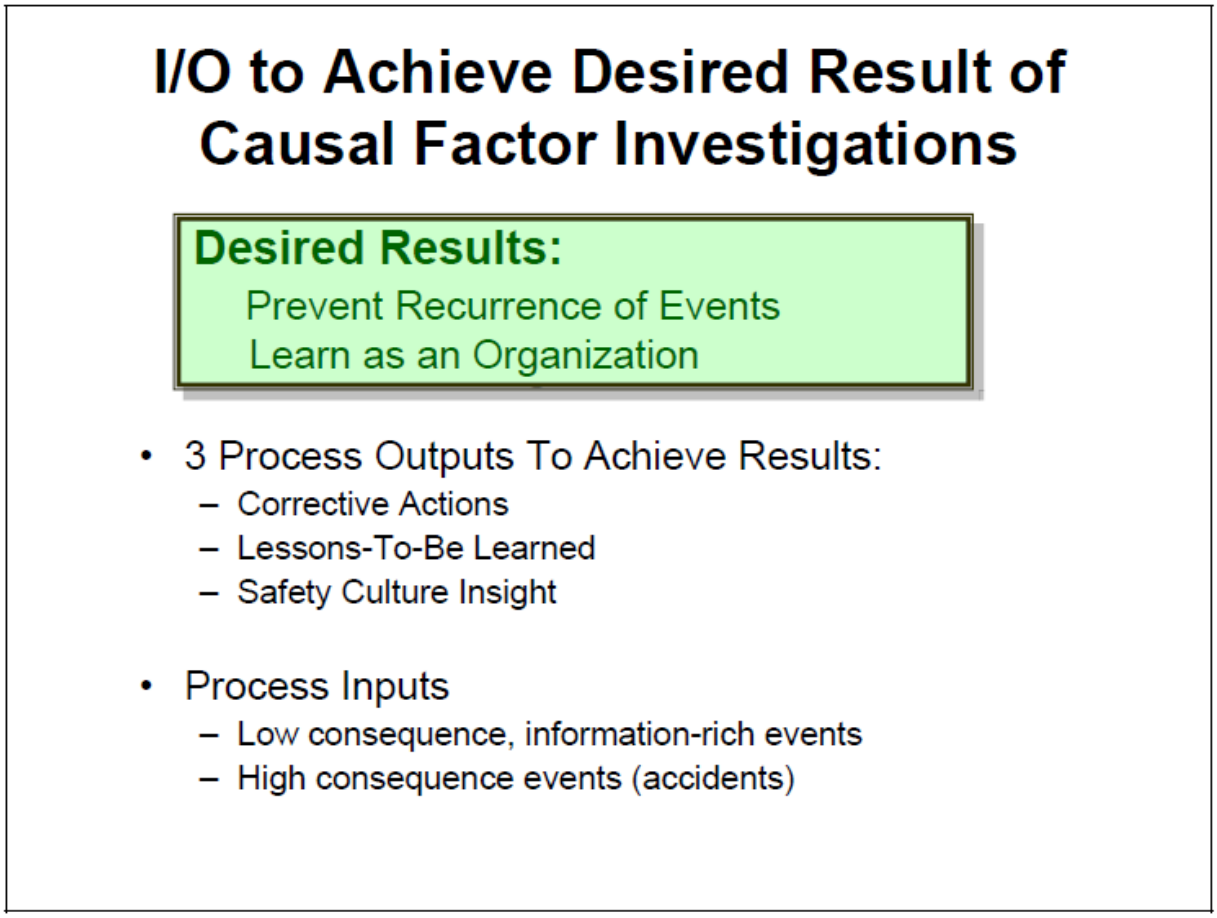
Root cause analysis is typically used as a reactive method of identifying event(s) causes, revealing problems and solving them. Analysis is done after an event has occurred. Insights in root cause analysis may make it useful as a proactive method. In that event, root cause analysis can be used to forecast or predict probable events even before they occur.

Video 4. Root cause analysis
http://www.youtube.com/watch?v=GOVeO5_0qD0

Causal Factor Analysis

The following is taken from B&W Pantex, *Causal Factor Analysis: An Approach to Organizational Learning.*

The desired results of causal factor analysis (CFA) investigations are to prevent recurrence of undesirable events and to learn as an organization. (See figure 12.)



Source: B&W Pantex, Causal Factor Analysis: An Approach to Organizational Learning.

Figure 12. Input and output to achieve desired results from CFA investigations

To achieve these results, there are three primary output products from the causal factors process:

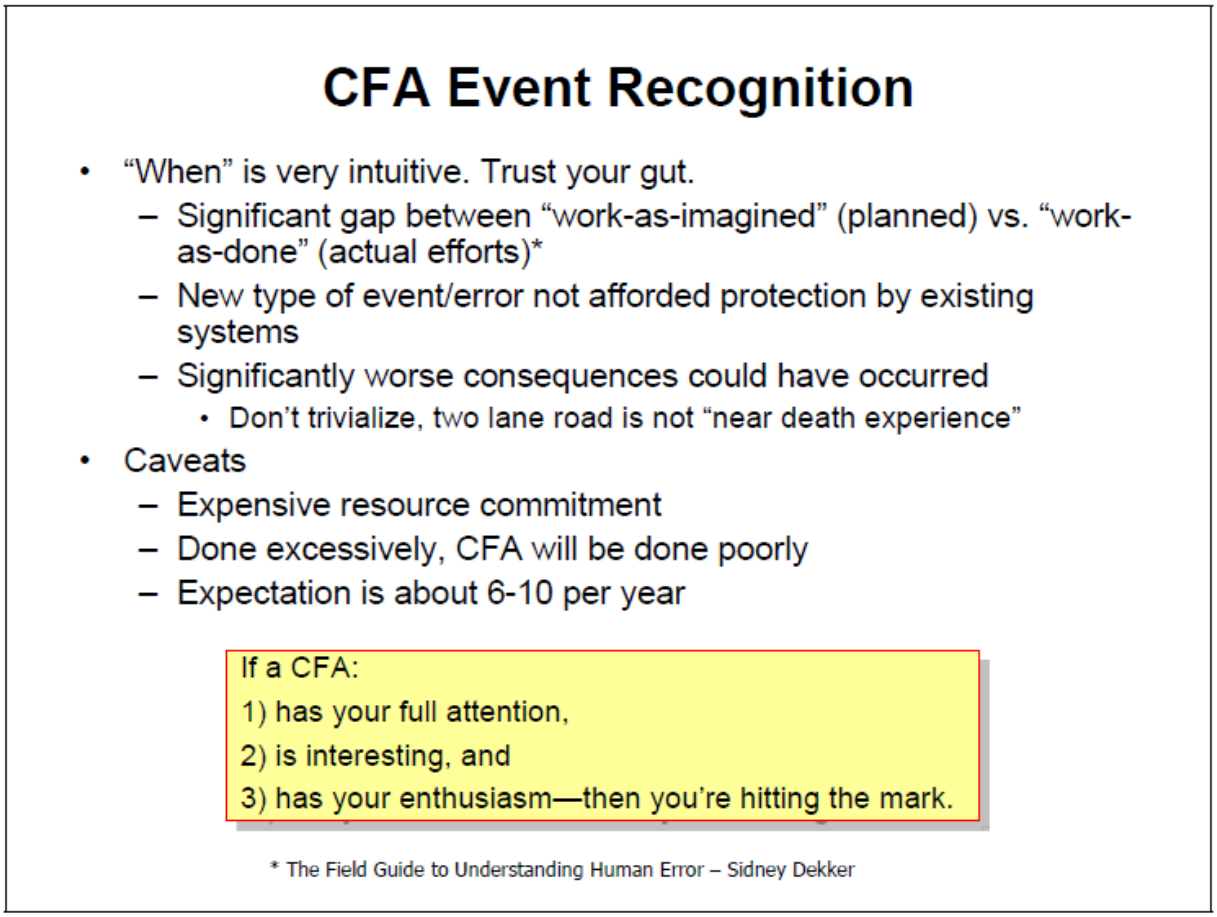
1. Corrective actions
2. Lessons-to-be-learned
3. Safety culture insight

The CFA process is a disciplined approach to separate "what" happened from "why" it happened. No lectures are needed to amplify the age-old concept that treating the symptoms is not as effective as treating the disease. However, the consequences of the event trigger most CFA approaches; in other words, a "big" consequence must have a correspondingly "big" cause. While this may be true in many instances, the approach tends to blind the

organization to the minor consequence events that may be information-rich in telling us of defects within the organization.

This CFA approach will help operating organizations identify the information-rich events, separate what happened from the causal factors, and methodically define corrective actions relative to the organization that will result in learning and improvement at all levels. While the approach is equally workable for high consequence and low/no-consequence events, the core strength of the approach is that organizations may continually learn and improve without having to suffer from high consequence events to do so.

The criteria for recognizing information-rich events is key to event recognition. Suggested information rich criteria are provided in figure 13. Although every event could benefit from causal analysis, proper screening is required for CFA because of the resource commitment to run them effectively.



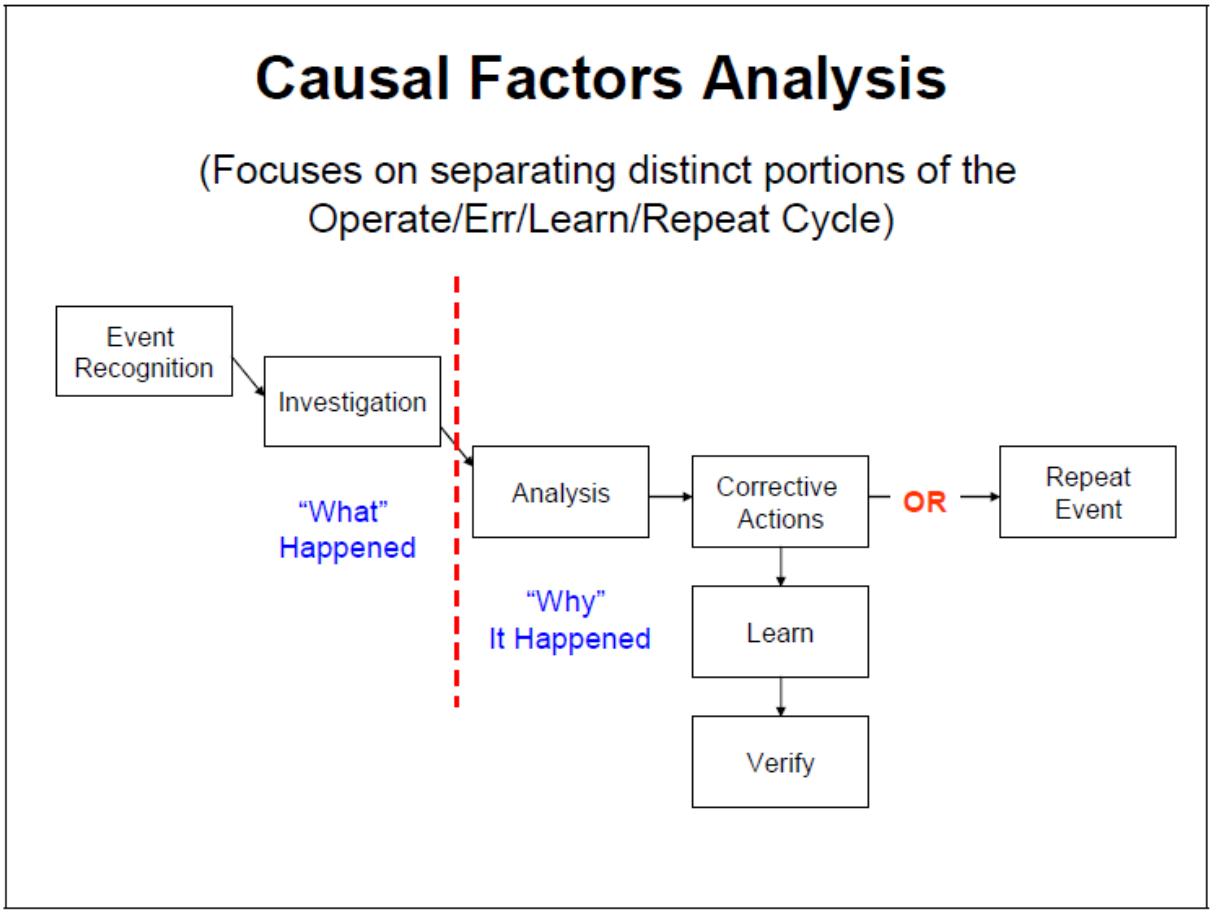
Source: B&W Pantex, Causal Factor Analysis: An Approach to Organizational Learning.

Figure 13. CFA event recognition

The key to the CFA is a discipline in executing the process steps (see figure 14), which are

- event recognition
- investigation
- analysis

- judgments of need—corrective actions
- learning



Source: B&W Pantex, Causal Factor Analysis: An Approach to Organizational Learning.

Figure 14. Steps in the CFA process

After the information-rich event has been recognized, the CFA process begins. The investigative phase, to determine "what" happened, begins only after forming the investigation team and establishing a preliminary timeline. The investigative phase attempts to interview every person involved, validate all interviews through review of objective media such as forms, logbooks, etc. Exculpatory facts and conflicting testimony or witness statements receive particular emphasis to avoid new information, critical to the investigation, from entering the process as a surprise at the end of the investigation. In the investigative phase, the team separates the event from its consequences to compose a chain of physical steps from the event, back to a set of verifiable physical precursor conditions. In a sense, this is a very engineering-oriented approach. The intent during the investigation phase is not to determine motivations, organizational weaknesses, or performance issues, rather to ensure the absolute veracity of what actually did occur, thus avoiding analyzing the wrong event. The investigative phase ends when the team believes it completely understands "what" happened.

During the analysis phase to determine "why" the event happened, all of the information is developed in a causal factors chart that allows an understanding of how the organizational factors allowed the event to develop. The CFA chart text is organized to emphasize the time and distance from the event to see how the event flowed through the organization. The final step in this phase is to sort out those factors that really matter, could have made the event much worse, and that perhaps are the most difficult to address.

For a complete description of the CFA chart and each of the steps in the CFA process, please refer to B&W Pantex, *Causal Factor Analysis: An Approach to Organizational Learning*, currently available at
http://www.efcog.org/wg/ism_pmi_hpi/docs/CFA_Vol_2_Textbook_Rev_3_3-17-08.pdf

Video 5. Causal factor analysis
http://www.bing.com/videos/search?q=causal+factor+analysis&view=detail&mid=688B9B1584793737F29D688B9B1584793737F29D&first=0

Change Analysis

The following is taken from Wikipedia, *Change Impact Analysis*.

Change impact analysis (IA) is defined by Bohner and Arnold as "identifying the potential consequences of a change, or estimating what needs to be modified to accomplish a change," focusing on scoping changes within the details of a design. By contrast, Pfleeger and Atlee focus on the risks associated with changes and state that IA is "the evaluation of the many risks associated with the change, including estimates of the effects on resources, effort, and schedule." The design details and risks associated with modifications are critical to performing IA within change management processes.

IA techniques can be classified into three types:

1. Traceability
2. Dependency
3. Experiential

In traceability IA, links between requirements, specifications, design elements, and tests are captured, and these relationships can be analyzed to determine the scope of an initiating change. In dependency IA, linkages between parts, variables, logic, modules, etc., are assessed to determine the consequences of an initiating change. Dependency IA occurs at a more detailed level than traceability IA. Within software design, static and dynamic algorithms can be run on code to perform dependency IA. Static methods focus on the program structure, while dynamic algorithms gather information about program behaviors at run-time.

Literature and engineering practice suggest a third type of IA, experiential IA, in that the impact of changes is often determined using expert design knowledge. Review meeting protocols, informal team discussions, and individual engineering judgment can be used to determine the consequences of a modification.

Barrier Analysis

The following is taken from Brighthub PM, *An Understanding of What Barrier Analysis is With Examples.*

Barrier analysis (BA) is a tool that aids in the investigation of possible reasons that cause a system to fail. It traces the pathways by which a hazard affects a target, and identifies any failed or missing countermeasures that could have, or should have, prevented the undesired effect.

HOW IT WORKS

BA defines the hazards, targets, and the pathways through which hazards affect targets, and identifies barriers and controls that would block the pathway, and maintain the target within the specified range or set of conditions.

The target is a person, equipment, a set of data, or anything else that exists under a specified range or set of conditions. Hazard is any adverse effect on the target, or anything that moves the target outside the required range or set of conditions. A barrier is a passive construct between a hazard and a target, used by an active control mechanism to cut off a pathway between hazard and target. A review of BA examples reveals that such barriers and controls often manifest themselves as systems, or planned activities, to ensure specific behavior or actions.

A simple illustration of the concept is possible through an analogy of a computer network susceptible to virus, malware, and other vulnerabilities. The target is the PC, the hazard is malware or virus, and the pathway is the network or the Internet connection through which the malware or virus infects the PC. A firewall to filter data and a system to scan all incoming mail for viruses serve as controls.

BA is, however, much more complex than such straightforward targets, hazards, barriers and controls. The complexity of designs and plans, and the presence of hidden hazards and unrecognized pathways through which the hazard travels in real life situations can make the analysis ineffective. Success requires a thorough evaluation of conforming and non-confirming targets, and identification of all unprotected pathways and ineffective controls.

APPLICATION

BA finds use in any project, including, but not limited to, physical manufacturing, management science, computing, healthcare, social welfare, and other disciplines. It is conceptually simple, easy to grasp, and an easy to use method of identifying obstacles that hinder any project and require minimal resources.

A common application of this technique is in health and community development programs, where cultural barriers hinder local communities from adopting healthy behaviors. The analysis identifies such behavioral determinants and helps in developing effective behavioral change interventions. The results identify whether the target group behaves in a desired way, the reasons for behaving in a non-desirable way, if any, and reveal effective barriers to block non-desirable behaviors.

Management Oversight and Risk Tree Analysis

The following is taken from International Crisis Management Association, *Theory and Practice, MORT*.

The management oversight and risk tree (MORT) is an analytical procedure for determining causes and contributing factors. MORT arose from a project undertaken in the 1970s. The work aimed to provide the U.S. nuclear industry with a risk management program competent to achieve high standards of health and safety. Although the MORT chart was just one aspect of the work, it proved to be popular as an evaluation tool and lent its name to the whole program.

In MORT, accidents are defined as unplanned events that produce harm or damage, that is, losses. Losses occur when a harmful agent comes into contact with a person or asset. This contact can occur either because of a failure of prevention or as an unfortunate but acceptable outcome of a risk that has been properly assessed and acted-on (assumed risk). MORT analysis always evaluates the failure route before considering the assumed risk hypothesis.

In MORT analysis, most of the effort is directed at identifying problems in the control of a work/process and deficiencies in the associated protective barriers. These problems are then analyzed for their origins in planning, design, policy, etc.

To use MORT, first identify key episodes in the sequence of events. Each episode can be characterized as a vulnerable target exposed to an agent of harm in the absence of adequate barriers.

MORT analysis can be applied to any one or more of the episodes identified; it is a choice to be made in the light of the circumstances particular to a specific investigation. To identify these key episodes, a BA must be undertaken. BA allows MORT analysis to be focused; it is very difficult to use MORT, even in a superficial way, without it.

MORT is the ultimate hazard identification tool. It uses a series of MORT charts developed and perfected over several years by DOE in connection with their nuclear safety programs. Each MORT chart identifies a potential operating or management level hazard that might be present in an operation. The attention to detail characteristic of MORT is illustrated by the fact that the full MORT diagram or tree contains more than 10,000 blocks. Even the simplest MORT chart contains over 300 blocks. Full application of MORT is a very time-consuming and costly venture. The basic MORT chart with about 300 blocks can be routinely used as a check on the other hazard identification tools. By reviewing the major headings of the MORT chart, an analyst will often be reminded of a type of hazard that was overlooked in the initial analysis. The MORT diagram is very effective in assuring attention to the underlying management root causes of hazards.

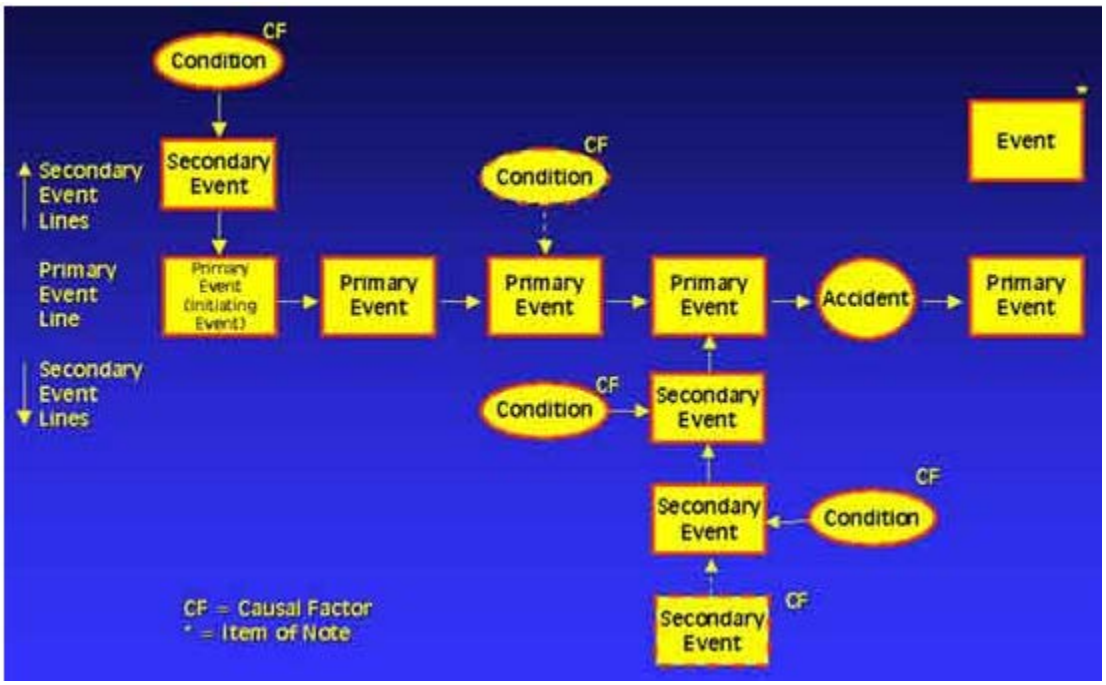
The MORT diagram is essentially an elaborate negative logic diagram. The difference is primarily that the MORT diagram is already filled out for the user, allowing a person to identify various contributing cause factors for a given undesirable event. Since the MORT is very detailed, a person can identify basic causes for essentially any type of event.

f. Describe the following root-cause analysis processes in the performance of occurrence investigations:

- **Events and causal factors charting**
- **Root cause coding**
- **Recommendation generation**

Events and Causal Factors Charting

The following is taken from OSHA Academy, *Event and Causal Factor Charting*.



Source: OSHA Academy, Event and Causal Factor Charting

Figure 15. Event and causal factor charting

Figure 15 shows a written or graphical description for the time sequence of contributing events associated with an accident. The charts produced in event charting consist of the following elements:

- Condition—A distinct state that facilitates the occurrence of an event. A condition may be equipment status, weather, employee health, or anything that affects an event.
- Event—A point in time defined by a specific action occurring.
- Accident—Any action, state, or condition in which a system is not meeting one or more of its design intents. Includes actual accidents and near misses. This event is the focus of the analysis.
- Primary event line—The key sequence of occurrences that led to the accident. The primary event line provides the basic nature of the event in a logical progression, but it does not provide all of the contributing causes. This line always contains the accident, but it does not necessarily end with an accident event. The primary event line can contain events and conditions.

- Primary events and conditions—The events and conditions that make up the primary event line.
- Secondary event lines—The sequences of occurrences that lead to primary events or primary conditions. The secondary event lines expand the development of the primary event line to show all of the contributing causes for an accident. Causal factors are almost always found in secondary event lines, and most event and causal factor charts have more than one secondary event line.
- Secondary events and conditions—The events and conditions that make up a secondary event line.
- Causal factors—Key events or conditions that, if eliminated, would have prevented an accident or reduced its effects. Causal factors are such things as human error or equipment failure, and they commonly include the following:
  - The initiating event for an accident
  - Each failed safeguard
  - Each reasonable safeguard that was not provided
- Items of note—Undesirable events or conditions identified during an analysis that must be addressed or corrected but did not contribute to the accident of interest. These are shown as separate boxes outside the event chain.
- Limitations of event and causal factor charting—Although event charting is an effective tool for understanding the sequence of contributing events that lead to an accident, it does have two primary limitations:
  1. It will not necessarily yield root causes—event charting is effective for identifying causal factors; however, it does not necessarily ensure that the root causes have been identified, unless the causal factor is the root cause.
  2. Overkill for simple problems—using event charting can overwork simple problems. A two-event accident probably does not require an extensive investigation of secondary events and conditions.

Root Cause Coding

The following is taken from AFRL-ML-WP-TR-2007-4113.

Cause codes can be tailored to a specific incident being investigated. The coding system is depicted in table form and is broken down into seven main categories:

1. Equipment/material deficiency
2. Procedure problem
3. Personnel error
4. Design problem
5. Training deficiency
6. Management problem
7. External phenomenon

These cause codes are listed in AFRL-ML-WP-TR-2007-4113, *Investigation and Root Cause Analysis Guidelines in Safety-of-Flight Aircraft* Structure, Appendix E, “Cause Codes,” and in DOE O 232.2. See the following table:

Table 1. Root cause codes

Category	Code Description	Category	Code Description
A1 Design/Engineering Problem		A5 Communications LTA	
B1	Design input LTA	B1	Written communications
B2	Design output LTA	B2	Written communications
B3	Design documentation LTA	B3	Written communication not
Category	**Code Description**	**Category**	**Code Description**
B4	Design installation verification LTA	B4	Verbal communication LTA
B5	Operability of design/environment LTA		
A2 Equipment/Material Problem		A6 Training Deficiency	
B1	Calibration for instruments LTA	B1	No training provided
B2	Periodic / corrective maintenance LTA	B2	Training methods LTA
B3	Inspection / testing LTA	B3	Training material LTA
B4	Material control LTA		
B5	Procurement control LTA		
B6	Defective, failed or contaminated		
A3 Human Performance LTA		A7 Other Problem	
B1	Skill-based error	B1	External phenomena
B2	Rule-based error	B2	Radiological/hazardous
B3	Knowledge-based error	B3	Legacy
B4	Work practices LTA	B4	No cause is applicable
A4 Management Problem			
B1	Management methods LTA		
B2	Resource management LTA		
B3	Work organization and planning LTA		
B4	Supervisory methods LTA		
B5	Change management LTA		

Source: DOE O 232.2

Recommendation Generation

The following is taken from GlobalSpec, *Root Cause Analysis Handbook: A Guide to Effective Incident Investigation*, Chapter 5: "Recommendation Generation and Implementation," by James R. Rooney.

The most significant aspect of root cause analysis is the final step. Following the identification of root cause(s) for a particular causal factor, recommendations for preventing

its recurrence must be generated. The identification of effective corrective actions is addressed explicitly in the definition of root causes. Root causes are defined as the most basic causes that can reasonably be identified, that management has control to fix, and for which effective recommendations for preventing recurrence can be generated. The emphasis is on correcting the problem so that it will not be repeated. The following criteria for ensuring the viability of corrective actions are suggested:

- Will these corrective actions prevent recurrence of the condition or event?
- Is the corrective action within the capability of the organization to implement?
- Are the recommendations directly related to the root causes?
- Can it be ensured that implementation of the recommendation will not introduce unacceptable risks?

g. Compare and contrast immediate, short-term, and long-term actions as the result of problem identification or an occurrence.

[Note: Corrective actions are no longer classified as short term and long term.]

The following is taken from DOE G 225.1A-1.

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 CAPs. 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:

1. Immediate corrective actions that are taken by the organization managing the site where the accident occurred to prevent a second or related accident.
2. 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.
3. 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.
4. DOE HQ 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 (Archived).

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
- industry experience

Mandatory Performance Activities:

a. Using problem analysis techniques identify the causes of a maintenance issue, identify effective actions that could correct the issue and prevent recurrence.

This is a performance-based KSA. The Qualifying Official will evaluate its completion.

20. Facility maintenance management personnel must demonstrate a working level knowledge of the content of the safety basis requirements, as described in 10 CFR 830, Subpart B.

a. Discuss the purpose and objective of the nuclear facility safety basis.

The following is taken from 10 CFR 830, Subpart B.

The contractor responsible for a DOE nuclear facility must analyze the facility, the work to be performed, and the associated hazards, and identify the conditions, safe boundaries, and hazard controls necessary to protect workers, the public, and the environment from adverse consequences. These analyses and hazard controls constitute the safety basis upon which the contractor and DOE rely to conclude that the facility can be operated safely. Performing work consistent with the safety basis provides reasonable assurance of adequate protection of workers, the public, and the environment.

b. Describe how TSRs are derived and used, and what constitutes a violation.

The following is taken from DOE G 423.1-1A.

TSRs define the performance requirements of SSCs and identify the safety management programs personnel use to ensure safety. TSRs are aimed at confirming the ability of the SSCs and personnel to perform their intended safety functions under normal, abnormal, and accident conditions. These requirements are identified through hazard analysis and through the identification of the potential sources of safety issues. Also contributing to the development of TSRs are safety analyses to identify and analyze a set of bounding accidents that take into account all potential causes of releases of radioactivity. Through the analyses of the encompassing bounding accidents, the necessary safety systems and accident mitigating systems are identified and their characteristics are defined. Flowing from the analyses is information that provides the bases for controls, limits, and conditions for operation, known as TSRs. TSRs explicitly show this relationship. The content of the DSA must remain valid so that the safety basis of the facility, as implemented in operations through the TSR, remains valid.

Although the TSR elements have an importance hierarchy, a TSR violation can occur for each type of TSR. Violations of a TSR occur as a result of the following four circumstances:

1. Exceeding a safety limit (SL)
2. Failure to complete an action statement within the required time limit following exceeding a limiting control setting or failing to comply with an LCO
3. Failure to perform a surveillance within the required time limit
4. Failure to comply with an AC statement

Failure to comply with an AC statement is a TSR violation when either the AC is directly violated, as would be the case with not meeting minimum staffing requirements for example, or the intent of a referenced program is not fulfilled. To qualify as a TSR violation, the failure to meet the intent of the referenced program would need to be significant enough to render the DSA summary invalid. TSR violations involving SLs require the facility to begin immediately to go to the most stable, safe condition attainable, including total shutdown.

c. Discuss the entry conditions and process for performing a USQ determination.

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

Temporary or Permanent Changes in a Facility

USQDs should be performed on changes in nuclear facilities as described in the existing safety analysis text, drawing, or other information that is part of the facility safety basis. An SSC would be considered changed if any of the following were to be altered: 1) its function(s), 2) the method of performing those functions, or 3) its design configuration. Although safety analyses include descriptions of many SSCs, a nuclear facility also contains many SSCs not explicitly described in the safety analyses. These can be components, subcomponents of larger components, or even entire systems.

Changes to SSCs that are not explicitly discussed in the safety analyses should not be excluded from the USQ process because changes to these SSCs may have potential to alter

the function of an SSC explicitly described in the safety analysis. Also, a change to an SSC that does not involve equipment important to safety could initiate an accident or affect the course of an accident, so virtually no change can be ignored.

It is important to distinguish between changes and routine maintenance activities. Routine maintenance activities—except those that are not enveloped by current safety analyses or that might violate a TSR—do not require review under 10 CFR 830.203, "Technical Safety Requirements." A TSR limitation on maintenance activities might require limiting the number of systems or components that can be taken out of service at one time, or allowable outage times. Changes to maintenance procedures would constitute changes that should be reviewed under USQ requirements.

Routine maintenance activities include calibration, refurbishment, replacement with an equivalent component, and housekeeping. However, some maintenance activities may constitute changes, such as plant heat exchanger tube plugging, where limits are not specified.

A TSR should specify allowable outage times, permissible mode conditions, and permitted reduction in redundancy for systems or components removed from service for maintenance. A USQD need not be performed for these activities.

A USQD should be completed for changes to systems or components that are included in safety analyses for a nuclear facility and for which allowed outage times are not included in the TSRs. "Change" as it applies to modes of operation or facility processes is important when, for example, a facility designed to accommodate several nuclear processes will modify equipment lineups to accommodate shifting from one process to another. Changes performed in accordance with approved procedures and considered within the safety basis of the facility are not considered changes in the facility procedures for the purposes of 10 CFR 830.203.

Temporary changes such as jumpers and lifted leads, temporary lead shielding on pipes and equipment, temporary blocks and bypasses, temporary supports, and equipment used on a temporary basis in a nuclear facility should be evaluated to determine whether a USQ exists unless such changes are specifically described in existing approved procedures.

The conservative approach is to provide a written USQD for any change to a nuclear facility, whether discussed in existing safety analyses or not.

The actual modification implementation process used in the field should be reviewed for possible development of USQs. Changes to plant configuration while work is in progress may involve a USQ relating to facility operations independent of the safety of the specific work on a modification.

For example, if work involves interrupting a water supply that a fire protection system depends on, which is not covered by a TSR, that interruption should be examined through the USQ process. Modifications that are performed in separate, distinct stages may leave affected SSCs in conditions not addressed by a USQD that addresses only the final modification configuration but not the interim times between stages. The work authorization system should include a step to consider these types of possibilities.

Temporary or Permanent Changes in the Procedures

A USQD may need to be prepared for changes to procedures that are identified in the facility DSA. However, it may not be necessary for some procedure changes such as non-technical administrative procedures.

Procedures may be identified explicitly or implicitly in a facility DSA. If the procedure is implied directly by the nature of a topic in the safety basis, that change should be considered to be to a procedure described in the DSA, so that a USQD is done when appropriate. Such implicitly described procedures include

- the procedures that implement a safety management program described in the safety basis;
- procedures for implementing a specific AC; and
- operating, testing, surveillance, and maintenance procedures for equipment when that equipment is identified in the DSA.

If characteristics of a safety management program described in the safety basis remain correct, complete, and valid, the result of the USQD would be expected to be negative, signifying that DOE approval is not needed.

Procedures are not limited to those specifically identified by type but could include anything described in the DSAs that defines or describes activities or controls over the conduct of work. Changes to these activities or controls qualify as changes to procedures as described in the DSA, and therefore need to be evaluated as potential USQs.

Changes to procedures include revisions to existing procedures and developing a new procedure. For a new procedure that could not have already been described, the question is, if a DSA were to be prepared after the new procedure had been approved, is the new procedure of a type that would be identified in the DSA. If so, a USQD should be prepared.

Tests or Experiments Not Described in Existing Documented Safety Analyses

Written USQDs are required for tests or experiments not described in the existing safety analyses. Tests and experiments should be broadly interpreted to include new activities or operations. These activities could degrade safety margins during normal operations or anticipated transients or could degrade the ability of SSCs to prevent accidents or mitigate accident conditions.

A USQD should be performed to ascertain whether a DOE review and approval of a new process configuration is needed. For preoperational, surveillance, functional, and startup tests performed regularly, USQDs are not needed every time a test is performed if the procedures are not changed. However, one-of-a-kind tests that measure the effectiveness of new techniques or a new system configuration will need to be evaluated before the tests can be conducted. Post modification testing should be considered and included in the USQD for the modification.

Discovery of Potential Inadequacies in the Existing Safety Analyses

Written USQDs are needed when a contractor identifies or is informed of a situation that indicates that the safety analyses that support the DOE-approved safety basis may not be bounding or may be otherwise inadequate.

In general, potential for inadequate safety analysis arises from the following entry conditions:

- A discrepant as-found condition
- An operational event or incident
- New information, including discovery of an error, sometimes from an external source

The main consideration is that the analysis does not match the current physical configuration, or the analysis is inappropriate or contains errors. The analysis might not match the facility configuration because of a discrepant as-found condition. Analytical errors might involve using incorrect input values, invalid assumptions, improper models, or calculation errors. The USQ process starts when facility management has information that indicates that there is a potential that the facility DSA might be inadequate.

Implementation Guidance

The USQ review process should be integrated into all technical aspects of the contractor organization responsible for design, engineering, maintenance, inspection, operations, and assessment of the nuclear facility or activity. Individuals involved in these aspects should be familiar with the requirements of 10 CFR 830.203 and should be able to identify activities that might need to enter the USQ process.

Each facility should identify the methods for making facility changes. After methods have been identified, the contractor needs to maintain control of the facility change process and perform and document changes in accordance with approved procedures. Performing a modification under the guise of maintenance is not acceptable because the proper control processes to analyze the proposed change and document its outcome would probably be absent. All reasonable means for performing a change should be identified because each one provides direct input into the USQ process and should be integrated accordingly.

The USQ process is intended to be implemented along with a change control process that includes generalized steps for

- identifying and describing the temporary or permanent change
- technical reviews of the change
- management review and approval of the change
- implementation of the change
- documenting the change

As part of the technical reviews of a change and separate from the USQ process, the contractor performs the appropriate type of safety analysis to ascertain whether the change is indeed safe. The USQ process is used subsequently to determine if final approval of the change by the contractor is sufficient or if DOE approval must be obtained.

In performing USQDs of a proposed change, documented justification for the USQ determination should be developed. Consistent with the intent of 10 CFR 830.203, this

documentation should be complete in the sense that a qualified independent reviewer could draw the same conclusion.

Contractors should develop procedures that provide detailed guidance for the performance of the USQ process, including any screening and the USQDs. The procedures should

- define the purpose;
- set forth applicability;
- provide definitions of appropriate terms, screening criteria, and the bases for their application;
- include detailed guidance on what is to be considered and evaluated when performing or reviewing a USQD;
- define the qualifications and responsibilities of personnel performing and reviewing USQDs; and
- require documentation for each USQD.

DOE relies on contractor implementation of the USQ process to preserve the integrity of the safety basis while allowing flexibility in operations. The contractor responsible for DOE hazard category 1, 2 or 3 nuclear facilities must submit the procedure that defines its USQ process to DOE for approval as required by 10 CFR 830.203.

INTEGRATED UNREVIEWED SAFETY QUESTION PROCESS

The USQ process should be integrated into the facility's change control processes. The change processes should ensure that the USQ process is integrated into existing procedures, or that new procedures are developed as necessary and that the need for completion of a USQD is not overlooked.

Facility change flow processes for temporary and permanent changes to SSCs and documents should be described by a governing policy, procedure, flowchart, or other description to define clear relationships between the USQ process and other change control procedures, including design change, configuration control, temporary change, and procedures governing the preparation, review, and approval of procedures.

Facility procedures should provide that USQ documents are prepared by one individual and are given independent technical review by a person that has not been involved in document preparation. That person need not be organizationally independent.

Facility procedures should provide that facility line management approves action on the USQ documents. This ensures that line management is informed of the results of the USQ process and can take whatever follow-up actions are appropriate to enable prompt submission of changes to DOE for safety review and approval or cancellation of proposed changes.

Facility operating committee review may be beneficial but should not replace line management approval. Excessive levels of approvals should be avoided when one internal approval and a second line management approval is sufficient.

SCREENING

USQ screening is used to ascertain if it is necessary to expend the valuable time and resources necessary to perform a USQD, or whether there is reasonable technical justification for not performing a USQD.

When screening eliminates an item, rationale should be well-supported, documented and retained. Screening should be performed only by personnel qualified to perform USQDs.

10 CFR 830.203 has no specific reference to screening. Conditions for entering the USQ process are listed in 10 CFR 830.203. If these conditions are not factors in proposed changes, then screening out such changes may be appropriate. Screening is intended to be a simple go/no-go decision-making step without evaluative consideration. When appropriately streamlined, a screening decision can often be completed in a matter of minutes.

Changes to SSCs not explicitly described in a DSA have the potential to affect the course of an accident that is addressed in the DSA or create the possibility of an accident not addressed in the DSA. If evaluating whether an item can be screened out takes the character of answering the seven USQD questions, the item should not be screened out unless there is a categorical exclusion. If an item has not been screened out, a USQD should be completed.

Candidate items for screening out include situations wherein the USQ process may not be applicable as follows:

- Changes to or the addition of a new TSR
- Changes that management has already decided will be submitted to DOE for safety review and approval (including TSR changes)
- Installation of an item with an exact replica
- Installation of an item that is on the facility list of “approved equivalent parts,” which a facility engineer has evaluated and determined that the replacement item meets all the requirements pertinent to the specific application, including the service conditions
- Changes when common commercial practices would suffice and a formal nuclear grade change control process is not warranted
- Changes that are purely editorial and make no technical change to documents

Another manner in which screening criteria may be applied is through categorical exclusions. A categorical exclusion is an exclusion from the requirements that USQDs be performed on proposed changes to a category of SSCs or procedures as a result of a determination that the category cannot credibly have the capability of creating a USQ if changed. Documentation of proposed categorical exclusions should be submitted to DOE.

Categorical exclusions are regarded as part of the contractor’s USQ procedure and require DOE approval.

Four criteria define a USQ. Three can be addressed by answering seven questions. The fourth potentially inadequate safety analysis (PISA) criterion also invokes the seven questions:

1. Could the proposed change increase the probability of an accident previously evaluated in the facility’s existing safety analyses?

2. Could the proposed change increase the consequences of an accident previously evaluated in the facility's existing safety analyses?
3. Could the proposed change increase the probability of a malfunction of equipment important to safety previously described in the facility's existing safety analyses?
4. Could the proposed change increase the consequences of a malfunction of equipment important to safety described in the facility's existing safety analyses?
5. 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?
6. 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?
7. 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. The term "safety analyses" in these questions refers to those potential events and their controls considered in the DSA. These include not only the explicit description of the analyses in the DSA but also any analyses performed to support the summary descriptions of the analyses in the DSA. When a potential event is discovered that is not treated in the DSA, it should be considered as a possible new event or as an indicator of a PISA issue.

Equipment important to safety should be understood to include any equipment whose function can affect safety either directly or indirectly. This includes SC and SS SSCs, including support systems to these systems that are necessary for the safety function, and other systems that perform an important DID safety function, equipment relied on for safe shutdown, and, in some cases, process equipment.

In the case of a PISA, the fact that there is reason to believe a safety analysis may be inadequate invokes paragraph 10 CFR 830.203, including performance of a formal USQD. When a PISA finding arises from an as-found condition, the seven questions can be used in a backward-looking manner as if the current configuration were a proposed modification. If the USQD is found to be negative, the contractor could have approved the discrepant condition without DOE involvement. This would resolve the discrepancy and provide justification for the current configuration.

The contractor's USQ procedures should include documenting defensible technical explanations based on sound engineering judgment for each of the answers to the seven questions. It is inappropriate to perform extensive analyses or to set a numerical margin for increases in the probability or consequences within which a positive USQD would not be triggered.

Such analyses and margins lend themselves to excessive efforts in calculations and abuse of the intent of the USQ process through manipulations of assumptions and accident parameters when accident analyses results are highly uncertain, and the possibility that the results might be a function of the calculation methods used, rather than of safety differences.

Changes should be evaluated using a method that can determine the direction of change on frequency or consequence, or on margin of safety, by comparing the situations before-during-

and-after the change is made, isolating the effects of the change, and evaluating and comparing the situation with and without the change and during implementation.

Except for a PISA based on analytic errors, a discernible direction of change refers to the effects of the actual change, not to a comparison of the results of a new analysis to the values cited in the DSA. It is the direction that the change has on probability, consequences, or margin of safety, not the magnitude that is important.

For example, if the wall thickness of a pressure vessel is going to be increased or the reaction time of a relay in a safety system is shortened, it is likely that the change is in the direction of increased safety. If changes are in the opposite direction, safety is likely to be decreased. Potential increases should be clearly discernible on a qualitative basis. It is important to recognize that the bounding accidents for workers may be different from bounding accidents for the public.

If, as a result of a proposed change, additional protective measures are warranted during a postulated accident situation to ensure adequate protection of the public or to provide worker safety, the USQD should be found to be positive on the basis that the change will result in either an increase in probability or an increase in consequences of an accident absent additional protective measures. A proposed change should not be defined as including additional protective measures to reduce exposures such as those related to ALARA levels and not related to potential accidents. DOE wants to be involved for several reasons: first, to verify that the degree of protection is adequate; second, to ensure that the safety basis is properly revised to include the additional protective measures; and third, to verify that hardware involved is properly classified and will receive appropriate S&M.

When evaluating “increased potential consequences” of an accident, if the previously bounding case for that family of accidents is unchanged, then generally there is no increase in the consequences within the USQ process. It is important that the family of accidents be related (the same type, fires, for example) and uses the same set of preventative measures and mitigation. While this is appropriate for public safety, adequate protection of workers necessitates further evaluation. Each change is evaluated for increases in the consequences to workers. Further, when considering a new scenario within a family of accidents, the probability of an accident in that family would be expected to increase.

The bases of hazard control documents should identify some relevant margins of safety. However, all safety basis documents should be reviewed to identify any relevant margins of safety. Specific responsibilities of those performing or reviewing USQDs should be clearly defined. Documentation should also be discussed in the implementing procedures. The procedures should identify the level of detail necessary to document performance of a USQD and conclusions reached and include a list of references relied on to reach the conclusions as well as guidance for the retention of records.

d. Discuss the actions to be taken by a contractor and DOE upon identifying information that indicates a potential inadequacy of the safety basis.

The following is taken from 10 CFR 830.203.

Because a safety analysis inadequacy has potential to call into question information on which authorization of operations is based, per 10 CFR 830.203 the contractor is to

- take action, as appropriate, to place or maintain the facility in a safe condition until an evaluation of the safety of the situation is completed;
- notify DOE of the situation;
- perform a USQD and notify DOE promptly of the results; and
- submit the evaluation of the safety of the situation to DOE prior to removing any operational restrictions that were initiated.

Mandatory Performance Activities:

a. Review and evaluate a USQD, including walking down the proposed change/potential inadequacy.

b. Walk down a safety SSC to identify the safety controls contained in a TSR.

These are performance-based KSAs. The Qualifying Official will evaluate their completion.

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