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DOE HANDBOOK

GUIDE TO GOOD PRACTICES FOR TRAINING AND QUALIFICATION OF MAINTENANCE PERSONNEL

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

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FOREWORD

The purpose of the *Guide to Good Practices for Training and Qualification of Maintenance Personnel* is to provide contractor training organizations with information that can be used to verify the adequacy of and/or modify existing maintenance training programs, or to develop new training programs. DOE contractors should not feel obligated to adopt all parts of this guide. Rather, they can use the information contained in this guide to develop programs that are applicable to their facility.

This guide, used in conjunction with facility-specific job analyses, provides a framework for training and qualification programs for maintenance personnel at DOE reactor and nonreactor nuclear facilities. Recommendations for qualification are made in four areas: education, experience, physical attributes, and training. The functional positions of maintenance mechanic, electrician, and instrumentation and control technician are covered by this guide. Sufficient common knowledge and skills were found to include the three disciplines in one guide to good practices.

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

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by letter or by using the self-addressed Document Improvement Proposal (DOE F 1300.3) appearing at the end of this document.

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1. SCOPE

1.1 Purpose

This guide provides recommended education, experience, and training for maintenance personnel. Training and qualification programs based on the content of this guide should provide assurance that maintenance personnel perform their jobs safely and competently.

1.2 Background

DOE and contractor representatives identified the need for maintenance personnel training and qualification guidance. This need was based on the increasing emphasis on properly conducting maintenance activities in the nuclear industry. Maintenance has become a focal point because of its impact on facility operation and safety.

This guide was based on a detailed review of maintenance mechanic, electrician, and instrumentation and control technician Job/Task Analysis (JTA) data. Sufficient common knowledge and skills were found to include the three disciplines in one guidance document.

This guide to good practices was developed based on the results of the commercial utility industry-wide JTA, industry operating experience, and general industry Occupational Safety and Health Administration (OSHA) training requirements.

1.3 Application

The content of this guide is generally applicable to all DOE reactor and nonreactor nuclear facilities with the exception of those topics which relate specifically to reactor activities. Portions of the programs outlined may not be applicable to all facilities because maintenance department organizations, disciplines, titles, and responsibilities vary among DOE reactor and nonreactor nuclear facilities. Facility training personnel can verify the adequacy or improve existing training programs by adapting this guide to their specific facility and individual maintenance disciplines.

1.3.1 Discussion

Each facility should use a systematic approach to analyze its training needs to develop a facility-specific training program. Analysis results should be used to establish training program learning objectives, test items, instructional methods, and instructional settings. Performance measures used to evaluate employees' performance and assess training effectiveness can also be derived from the analysis. By modifying this guide, users may develop training programs for each discipline that meet facility-specific needs.

Full implementation of quality training requires a long-term commitment. Training activities should be carefully managed to produce effective results. Training plans should be developed, organizations should be staffed with qualified instructors, and sufficient controls should be applied to ensure delivery of an effective training program.

Training programs should be evaluated on a regular basis to determine the extent to which established learning objectives are being accomplished. Evaluation results should be used to improve training plans, facilities, programs, materials, and procedures. In addition, a systematic method to update training program content as a result of facility modifications, operating experiences, procedure changes, and changes in job requirements should be implemented.

2. GOALS

2.1 Initial Qualification

The goal of initial training and qualification is to ensure that maintenance personnel, including maintenance trainers, possess the knowledge and skills necessary to perform their assigned responsibilities in an efficient, cost-effective manner that promotes safe and reliable facility operations.

2.2 Continuing Training

Continuing training programs are designed and implemented to maintain and enhance the proficiency of maintenance personnel. The goal of this program is to provide assurance that maintenance personnel knowledge and skills are maintained with regard to changes in facility physical and procedural modifications, changes to DOE and regulatory requirements, and lessons learned from industry and facility-specific operating experience. Improvement in job performance and development of broader scope and depth of job-related knowledge and skills are also goals of a continuing training program.

Maintenance trainers should continue their professional development both in subject matter and instructional skills by such activities as attending conferences, taking additional college and/or specialized skill courses, and exchanging training ideas with other training organizations.

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3. QUALIFICATIONS

3.1 Qualification Levels

This guide does not attempt to establish a minimum or maximum number of qualification levels. However, it is recommended that more than one level within each discipline be established to allow early entry of trained personnel into the maintenance workforce and to provide a career path (e.g., apprentice, journeyman, master). Qualification levels should be defined and included in job descriptions, and the training needs for each level should be identified during the design of individual training programs.

3.1.1 Maintenance Disciplines

This guide should be taken as indicative of the training necessary to achieve the highest qualification level in each discipline. Each individual may not need to qualify for every task. Training should include, as a minimum, those fundamentals applicable to the tasks on which the individual is being qualified.

Fundamentals will ordinarily be defined by a job analysis. The trainee should demonstrate mastery of the tasks or type of tasks assigned under the direction of a person qualified to perform the task prior to assuming independent responsibility. Incumbents should be qualified at their present level before advancing to the next level.

3.1.2 Maintenance Trainers

Minimum qualifications for all maintenance training positions should be documented for the following areas:

- Education
- Training experience
- Applicable job experience.

Documentation should clearly state who verifies that instructors meet the minimum qualifications for the positions they hold. Additional guidance relative to qualification of training personnel may be found in *DOE-STD-1001-96 Guide to Good Practices for Training and Qualification of Instructors.*

3.2 Education

Educational requirements should be consistent with those stipulated in DOE Orders and in regulatory documents. A high school education or General Education Development (GED) equivalent is recommended for entry into maintenance training programs.

3.3 Physical Attributes

The following physical attributes are recommended for safe performance of assigned tasks:

- Natural or corrected near-distance visual acuity
- Color vision sufficient to discern system and component color coding
- Hearing sufficient to respond properly to audible alarms and use communications systems
- Sufficient strength, motor power, range of motion, and dexterity to allow access to facility equipment and meet job performance requirements.

3.4 Training

The trainee should complete the training described in this guide or be granted an exception in accordance with Section 5. When an individual has equivalent previous experience, education, and/or training in a college or university, technical school, or another nuclear facility or military facility, that individual may be excepted from training.

3.5 Subcontractor Personnel

Training for subcontracted-services personnel should be consistent with the duties being assigned. These personnel should be qualified on the task they will be performing or should be directly supervised by a person qualified to perform the task.

4. ON-THE-JOB TRAINING (OJT)

OJT is designed to prepare employees for job performance through one-on-one training and performance testing that is conducted by qualified OJT instructors in the actual work environment. It provides hands-on experience, and has the advantage of providing training for tasks that are of immediate need to the employee. OJT is limited to those situations where it is administratively and physically possible to conduct the training (i.e., where facilities are adequate, where OJT can be conducted without significant interference with facility operations, and where qualified personnel are available to conduct and manage the OJT program).

All on-the-job training programs at DOE facilities should be based on a systematic approach to training. For further guidance on developing, implementing, and evaluating an OJT program, refer to *DOE-STD-1012-92 Guide to Good Practices for On-the-Job Training*.

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5. TRAINEE EVALUATION

5.1 Introduction

The quality of training programs, course content, and instructional methods is best evaluated by monitoring trainee performance. This guide outlines training that occurs in multiple training settings. Different methods of evaluating trainee performance during these training programs are appropriate. Among these methods are written examinations and quizzes, oral examinations, and performance tests. It is important that evaluation methods are consistent with the training setting. General guidelines for using these evaluation methods are given below.

5.2 Knowledge Evaluation

In knowledge areas such as administrative, academic, and systems training, the recommended method of trainee evaluation is the use of written short-answer, multiple-choice, or essay examinations at the conclusion of each course. Oral examinations may also be used to determine knowledge level. Periodic written quizzes can measure trainee retention during training courses. The examination should address all subjects within that course and be designed to measure retention, understanding, and the ability of the trainee to apply theoretical knowledge. To test the trainees' ability to apply theoretical knowledge, the examination may include a number of essay questions. Performance on written examinations should be measured against established learning objectives and an answer key.

5.3 Performance Tests

Performance tests should be structured to measure trainees' performance against established criteria. Areas that should be covered include:

- Technical and facility administrative procedure usage
- Tool and equipment selection
- Equipment operation
- Industrial safety practices
- Facility safety and reliability awareness
- Task performance.

The evaluation of each trainee should be conducted as the trainee either performs or simulates and discusses the complete task. The perform option is preferred whenever practical. Evaluation standards should be used to ensure consistency in evaluating performance tests. When the trainees have completed fundamental training, they may be considered ready for individual task qualification.

5.4 Exceptions

Maintenance personnel may be excepted from training on the basis of their prior education, experience, and/or training. Appropriate level management review of an individual's prior training record and job performance history may provide the basis for this exception. Exceptions granted and justification for the exception should be documented and included in the individual's training record.

Tests may be provided to except newly hired, experienced personnel from specific training requirements. When tests are used to establish the basis for an exception, the individual considered for exception should pass examinations on the specific subject areas and demonstrate competency in the skills areas. Exception from training requirements should not include exception from successfully completing the required qualification examination(s).

6. CONTINUING TRAINING

6.1 Introduction

Continuing training needs should be identified from job analysis information and the results of ongoing training program evaluation. Evaluation ensures that the training program is current and relevant and that job performance does not degrade.

6.2 Facility-Specific Systems Training

Facility-specific systems training provides an understanding of overall facility operations. Since much of this subject matter is not reinforced by direct use, a biennial training schedule is recommended. As a minimum, safety-related systems identified in the facility Safety Analysis Report should be included. Lectures or self-study are methods of presenting the material. Written examinations, similar in difficulty and scope to initial examinations, should be administered in accordance with Section 5, Trainee Evaluation.

6.3 Fundamentals Training

The fundamentals continuing training program should maintain and improve technical skills and knowledge. Since basic technical knowledge as well as specialized technical knowledge could be lacking when infrequently repaired or newly supplied equipment breaks down, fundamentals instruction should be provided on a continuing basis.

Written examinations, similar in difficulty and scope to initial examinations, should be administered in accordance with Section 5, Trainee Evaluation.

6.4 Special Training

Special training should be provided to address seldom-used skills, observed problems, or anticipated training needs. Infrequently performed tasks should be evaluated to determine if training is needed. Task difficulty, importance to facility safety and reliability, and As Low As Reasonably Achievable (ALARA) should be used to help determine training needs and required depth of coverage. Written

examinations or performance tests should be administered in accordance with Section 5, Trainee Evaluation.

Special training is recommended to address the following situations:

- Degraded job performance
- Changes to procedures
- Facility modifications
- Industry and in-house operating experience.

6.5 Scheduling and Attendance

Continuing training should be conducted using a published schedule that minimizes interference with facility operational schedules. Topics should be chosen that meet the needs of individuals assigned during the training cycle. Training provided should be of high quality and be responsive to time-sensitive input. Attendance should be mandatory and documented.

7. TRAINING EFFECTIVENESS EVALUATION

7.1 Introduction

To establish and maintain an effective qualification program, a periodic evaluation of program effectiveness is necessary. A thorough evaluation process includes assessment of the training process and of the qualified individual's performance on the job.

7.2 Evaluation of the Training Process

In evaluating the training process, the content of the program, the training materials, and the quality and method of instruction should be considered. Requirements for the conduct and frequency of these evaluations should be defined in appropriate procedures.

Program content should be reviewed and modified to reflect feedback from previous programs, changes to facility systems or procedures, new or different test equipment, regulations, codes, or standards affecting the worker. Also modifications should reflect any other pertinent changes that have occurred since the course content was established. Such a review could involve course instructors, the training supervisor, the maintenance supervisor, management, training specialists from other sites, or training consultants.

Instructional techniques should be evaluated periodically during the course of the training program.

The methods of instruction used in various portions of the program should be evaluated periodically during and after the program. These evaluations should be used to determine if more appropriate or effective methods could be used for portions of the program. For example, certain topics might be covered better in a laboratory or during on-the-job training rather than in a classroom lecture. Input for this kind of evaluation could come from trainees, instructors, the training supervisor, training specialists or consultants, and the job analysis.

7.3 Evaluation of Post-Training Job Performance

The effectiveness of the training program can be measured only by evaluating the performance of trained individuals. At some facilities, formal performance appraisals may be conducted periodically as part of the salary review process. While some useful training feedback can be obtained from such an appraisal, a more effective training feedback system would focus specifically on training-related items.

Several methods for obtaining training-related feedback can be used in a formal evaluation program and should include one or more of the following:

- Interviews with job incumbents after the completion of training (for example, three months) - these interviews should reveal the individual's perception of the adequacy and usefulness of the training received, including questions directed at specific topics, tasks, or duty areas
- Interviews with supervisors after the completion of a program - the supervisor should provide valuable feedback on the strengths and weaknesses of the training program revealed through the job performance of recently trained workers
- Evaluations of workers' skills and knowledge by the training organization after completion of training.

To maximize the effectiveness of any technique used in a training evaluation program, the individuals responsible for gathering the information should be trained. Whatever techniques are used, they should be formalized to establish the specific objectives of the program and the procedures for achieving those objectives. A recommended method for structuring the evaluation program is to focus feedback on the stated learning objectives of the training program (i.e., was this learning objective valid, was it achieved, what objectives were missed?). Procedures should be utilized to ensure that evaluation findings are resolved. The quality of the maintenance training program can be improved in the following ways:

- Facility operating, maintenance and industrial safety experiences are reviewed to identify areas in which new or improved training may be needed to solve operational problems
- Employees provide feedback on how well training enabled them to perform their jobs and how training might be improved

- Managers and supervisors observe maintenance activities to verify adequacy of training and adherence to policies and procedures
- Facility inspection and evaluation reports are reviewed for training implications
- Facility modifications and procedure changes are reviewed for training implications
- Regulatory changes are reviewed for their impact on training.

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8. PROGRAM RECORDS

Auditable records of each individual's participation and performance in, or exception(s) granted from, the training program(s) should be maintained. Individual training records should include the following (as appropriate):

- Verified education, experience, employment history, and most recent health evaluation summary
- Training programs completed and qualification(s) achieved
- Latest completed checklists, graded written examinations (with answers corrected as necessary or examination keys) and operational evaluations used for qualification (this requires controlled access to training records to maintain examination security)
- Lists of questions asked and the examiner's overall evaluation of responses on oral examinations
- Correspondence relating to exceptions granted to training requirements (including justification and approval)
- Records of qualification for one-time-only special tests or operations
- Attendance records for required training courses or sessions.

A historical record that documents initial qualification on each position should be maintained as part of individual training records. For example, if an individual initially qualified in 1986, the record should have the date and name of the qualification entered into it. If more than one qualification is achieved and maintained, the individual training record should contain documentation to that effect.

For presently held qualification(s), the completed examinations, checklists, operational evaluations, etc., should be maintained in the record. (Some facilities may prefer to maintain a separate file of completed examinations with answer keys for each individual.) When an individual holds qualification for multiple positions, records that support current qualifications for each position should be maintained. Duty area or task qualification should be documented using a similar method (for facilities that use duty area or task qualification instead of position qualification). Functional supervisors should have access to qualification records, as necessary, to support the assignment of work to qualified personnel.

Upon requalification, records that support the previous qualification may be removed from the record and replaced with the information documenting present qualification. Superseded information should be handled in accordance with procedures contained in *DOE 1324.5B, Records Management Program*.

In addition, records of the training programs (which should include an audit trail documenting the development of and modifications to each program) and evaluations of the effectiveness of those programs should also be maintained.

APPENDIX A
ADMINISTRATIVE TRAINING

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ADMINISTRATIVE TRAINING

Administrative training should be designed to provide the trainees with the knowledge necessary to locate and retrieve applicable documentation maintained at the facility. This training is applicable to all maintenance personnel. The trainee will learn what information is available and what kinds of information are included in each document.
Administrative training should include areas such as:

- Documents, records and forms
- Procedures
- Engineering drawings
- Lists, tables and vendor-supplied documents
- Work requests.

A.1 Documents, Records and Forms

Instruction should enable the trainee to identify the following:

- Applicable governmental regulations and guidance
- Applicable standards for design, construction and operation
- Facility-specific reports and forms, such as
  - calibration record forms
  - equipment history records
  - maintenance work requests
  - radiation work permits
- Types of equipment references available, such as
  - vendor manuals
  - equipment lists
  - data tables.

A.2 Procedures

Instruction should enable the trainee to perform the following:

- Name/list the types of procedures available
- Explain why procedures are used in nuclear facilities
- Explain the purpose of the following types of procedures
  - administrative
  - operating (normal and abnormal)
  - maintenance
  - surveillance/test
  - emergency
- Describe how procedures are prepared
- Describe how procedures are revised
- Describe administrative controls of procedures
- Explain the filing system for procedures
- Explain the numbering system for procedures
- Explain how a temporary procedure change is obtained
- Identify procedure locations
- Identify procedure access authority
- Describe maintenance department personnel responsibilities for procedure use
- Explain what to do if procedures are wrong.

A.3 Engineering Drawings

Instruction should enable the trainee to perform the following:

- Name/list the types of engineering drawings available
- Explain the importance and purpose of using controlled drawings
- Describe the kinds of information displayed on various types of drawings
- Identify various symbols used on drawings and find the explanation of each
- Explain use of the coordinate system
- Explain how to use drawing reference information
- Explain the coding system of drawing numbers

- Explain the coding system of facility equipment
- Locate applicable drawings
- Explain the filing system for drawings
- Explain the operation of the drawing retrieval system
- Explain the purpose and use of "for information only" drawings.

A.4 Lists, Tables and Vendor-Supplied Documents

Instruction should enable the trainee to perform the following:

- Explain the filing system for documents
- Explain the numbering system for documents
- Identify documents
- Locate documents
- Describe the general categories of information included in each document
- Explain the administrative controls of documents.

Documents to be addressed, as applicable to the craft, include the following:

- Calibration data
- Equipment list
- Instrument list
- Motor data table
- Technical manuals
- Vendor drawings.

A.5 Work Requests

Instruction should enable the trainee to perform the following:

- Describe the information to be entered on the work request
- Locate and retrieve information to be written on the work request (source references)
- State the importance of giving a full description of the problem, repair activity and test performed

- Describe environmental qualification requirements contained on work requests
- Describe applicable administrative routing procedures
- Identify initiation, approval and closeout authority
- Describe safety requirements and safety-related information contained on work requests.

APPENDIX B

INDUSTRIAL SAFETY TRAINING

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INDUSTRIAL SAFETY TRAINING

Industrial safety training should be designed to increase the trainee's awareness of the hazards associated with the industrial environment and the precautions to be observed and practiced in the performance of daily activities. The facility industrial safety manual should be addressed and referenced. Industrial safety training should include topical areas such as:

- Lock and tag program
- Industrial safety hazards
- Chemicals, gases, and solvents
- Electrical safety
- Working from heights
- Working in confined spaces
- Personnel protective equipment.

Additional training should be designed to cover those portions of the facility industrial safety manual not addressed by this Appendix or by the general employee training program. This Appendix identifies recommended knowledge and skills requirements for the topical areas listed above. These are based, in part, on the general industrial Occupational Safety and Health Administration (OSHA) requirements, and are applicable to all maintenance personnel.

B.1 Lock and Tag Program

Instruction should enable the trainee to perform the following:

- Describe the general requirements of OSHA Standard 29 CFR 1910.147, the facility lock and tag procedure, and any other augmenting procedures
- Describe how to verify proper lockout/tagout prior to commencing work on equipment
- Describe the types and magnitude of hazardous energy sources and the methods for energy isolation and control
- Explain the responsibilities assumed by individuals working within a locked/tagged boundary
- Explain the consequences of violating locks/tags
- Explain the step-by-step procedure to initiate, post and remove each type of lock/tag used at the facility.

B.2 Industrial Safety Hazards

Instruction should enable the trainee to describe safe work practices in the following situations:

- Working near
  - cutting/welding/burning activities
  - grinding activities
  - high-voltage areas or equipment
  - cranes, manlifts, and hoists (above, below or on)
- Working on or near
  - rotating equipment
  - energized electrical equipment or panels
- Working in or near
  - high temperature and/or pressure environment
  - high radiation areas including non-ionizing radiation areas
  - radiologically controlled areas
- Working in
  - an area where work is being performed overhead
  - a high noise area
  - adverse conditions, e.g., rain, snow, wet surfaces
- Working near or over water
- Drilling into
  - concrete
  - electrical panels.

B.3 Chemicals, Gases and Solvents

Instruction should enable the trainee to perform the following:

- Describe the general requirements of the hazards communication program and any related procedures
  - explain the information contained on the Material Safety Data Sheets (MSDS)
  - locate the MSDS in the work area
- Name/list hazardous chemicals and gases
- Describe the proper storage of chemicals and gases
- Demonstrate the proper handling of chemicals and gases
- Describe the proper procedure for transporting chemicals and gases
- Explain the hazardous properties of chemicals and gases encountered at the site
- Describe the proper disposal methods for chemicals
- Explain the reasons for avoiding chemical contamination of systems and components
- Explain the precautions associated with each group of chemicals and gases
- Demonstrate the proper application and use of chemicals and gases commonly used by the trainee's craft, including environmental concerns
- Demonstrate proper use of special protective equipment and emergency facilities for chemicals
- Explain the reasons for avoiding personal contamination with chemicals and solvents, including inhalation, ingestion and skin absorption.

B.4 Electrical Safety

Instruction should enable the trainee to perform the following as appropriate to their job function:

- Define electrical shock and shock symptoms
- Demonstrate the proper response for the discovery of an electrical shock victim
- Describe the precautions associated with maintenance activities near energized electrical equipment
- Explain the procedures for discharging stored electrical energy
- Explain the procedures for working in or near exposed energized parts
- Explain precautions related to electrical lines embedded in earth and structures

- Explain precautions related to overhead lines at the facility
- Identify electrical safety hazards
- Describe the techniques to distinguish live parts from other parts of electrical equipment
- Describe the techniques to determine the nominal voltage of exposed live parts
- Identify the clearance distances when working in or near exposed electrical parts
- Explain the inspection requirements for commonly used electrical components (e.g., drop light, extension cord, etc.)
- Verify properly grounded tools
- Explain the proper use of a ground-fault interrupter
- Identify grounding hazards
- Properly install and remove grounding straps as appropriate to job discipline
- Identify the proper ladders used for work near electrical circuits.

B.5 Working from Heights

Instruction should enable the trainee to perform the following:

- Identify the types of safety equipment used to work from heights
- Describe the criteria for proper selection and application of each type of safety equipment
- Explain inspection requirements prior to use of each type of safety equipment
- Describe the causes of accidents involving each type of safety equipment and how to prevent them
- Demonstrate the proper use of each type of safety equipment
- Identify special safety equipment to be used
- Demonstrate the proper use of special safety equipment.

B.6 Working in Confined Spaces

Instruction should enable the trainee to perform the following:

- Define confined space
- Describe responsibilities of the
  - shift supervisor/manager
  - industrial safety engineer

  - maintenance supervisor
  - worker
- Describe procedural requirements for controlling confined space access
  - isolating, draining and flushing space prior to entry
  - ventilating space prior to personnel entry
  - testing atmosphere for oxygen concentration
  - testing atmosphere for explosive gas concentration
  - testing atmosphere for toxic gases
  - testing confined space for toxic contaminants
  - clearing internal obstructions (to prevent fouling safety lines)
  - identifying and correcting other hazards (e.g., slippery surfaces)
  - installing temporary lighting
  - using the "buddy" system
  - maintaining visual and verbal contact with outside personnel
- Identify the tools and equipment that may not be used in confined spaces
- Explain personnel, tool and equipment accountability
- Describe the physiological effects of working in high temperature and high humidity environments
- Explain the use of safety equipment that may be used in confined spaces, emphasizing unique applications (e.g., special clothing, ice vests)
- Explain methods of maintaining and monitoring temporary ventilation equipment
- Explain the danger of inert gases, such as nitrogen and argon, in confined spaces.

B.7 Personnel Protective Equipment

Instruction should enable the trainee to perform the following:

- Locate the special storage facilities for protective equipment
- Explain the inspection requirements for protective equipment prior to use
- Explain the procedural controls for protective equipment
- Explain the cleaning, decon or disposal of protective equipment
- Explain the limitations of the protective equipment
- Identify faulty protective equipment
- Describe the application of each type of protective equipment

- Demonstrate the use of each type of protective equipment.

Equipment discussed should include items such as the following:

- Air-fed hoods and respirators
- Chemical handling clothing and equipment
- Eye and face protection
- Ear protection
  - rubber plugs
  - foam plugs
  - ear muffs
- Foot protection
- Gloves
- Electrical insulating equipment
- Ground fault interrupter
- Hard hats
- High temperature clothing
- Nonsparking tools
- Self-contained breathing apparatus
- Protective clothing
- Respirator filters
- Rope grabs
- Safety line and rope
- Safety harness.

APPENDIX C
FUNDAMENTALS TRAINING

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FUNDAMENTALS TRAINING

Fundamentals training is designed to provide the trainee with the knowledge necessary to understand maintenance concepts and successfully apply them to the job. Subjects include:

- Mathematics
- Classical physics
- Electrical science
- Instrumentation and control
- Principles of radiation detection
- Basic atomic and nuclear physics
- Heat transfer and fluid flow
- Chemistry
- Properties of materials
- Reactor protection.

Actual course content should take into account personnel entry-level requirements as well as job analysis results. Matrices developed from commercial utility, industry-wide job and task analyses, and modules which indicate the necessary level of knowledge for the various maintenance disciplines are included in this Appendix.

C.1 Fundamentals Matrices

The following matrices show the applicability of topics to the various maintenance disciplines, and modules A and B indicate the necessary level of knowledge and performance. The matrices can be changed to reflect facility structure and responsibility assignments.

C.1.1 Module A

Instruction should enable the trainee to explain the terms, units, definitions and basic concepts to support subsequent training.

C.1.2 Module B

Instruction should enable the trainee to explain and use the terms, units and definitions and to successfully apply the concepts on the job.

C.1.3 Mathematics Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Basic mathematical concepts	Basic arithmetic functions	B	B	B
	Percentage	B	B	B
	Square root	B	A	B
	Averages	B	B	B
Scientific notation	Conversion of numbers	A	-	B
	Application of scientific notation	A	-	B
Dimensional analysis	Unit conversions	B	B	B
	Unit modifiers	B	-	B
	Metric measurements	B	A	B
Algebra	Basic equation solving	B	A	B
	Quadratic equations	-	-	A
Trigonometry	Basic relationships	A	A	A
Geometry	Basic relationships	B	A	B
	Vectors	B	A	B
Calculus	Concept of rate of change	-	-	A
	Concept of integration	-	-	A
Analysis of graphs and control charts	Obtaining information from graphs	B	B	B
	Rectangular coordinate system	-	-	B
	Polar coordinate system	B	A	B
	Logarithmic coordinate system	-	-	B
Nomogram	Obtaining information from a nomogram	B	B	B
Exponent base	"E" exponents (Natural/Napierian)	-	-	B
Numbering systems	Binary system	A	-	B
	Octal system	-	-	B
	Hexadecimal system	-	-	B
	Conversion of systems	-	-	B

C.1.4 Classical Physics Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Units	Systems of units	B	B	B
	Pressure (vacuum/pressure differential pressure) measurement	B	B	B
	Temperature measurement	B	B	B
	Periodic motion measurement	B	A	B
	Flow	B	B	B
	Volume	B	B	B
	Mass	A	B	B
	Weight	B	B	B
	Distance measurement	B	B	B
	Time measurement	B	B	-
Mechanical principles	Acceleration	B	A	B
	Cams	A	A	A
	Conditions of equilibrium	A	A	A
	Conservation of energy	A	A	A
	Density, height, and temperature effects on process fluids	A	A	B
	Energy	A	A	A
	Force	A	A	A
	Friction	A	A	A
	Gear ratios	B	B	B
	Gravitation	A	A	A
	Heat	A	A	A
	Hydraulics	A	A	A
	Inclined planes	A	A	A
	Laws of motion	A	A	A
	Mass	A	A	A
	Momentum	A	A	A
	Power	A	A	A
	Pulleys	B	B	B
	Simple machines	B	A	B
	Temperature systems	A	A	B
	Temperature system conversions	B	A	B
	Translational and rotational motion	B	A	B
	Velocity	A	A	B
	Weight	A	A	A
	Work	A	A	A

C.1.5 Electrical Science Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Basic electrical	Electron theory	B	-	B
	Insulators	B	-	B
	Conductors	B	-	B
	Static electricity	B	-	B
	Magnetism	B	-	B
	Direct current (DC)	B	-	B
	DC sources	B	-	B
	Units of electrical measurement	B	-	B
	Fundamental electrical laws	B	-	B
	Electrical hazards and safety	B	B	B
	Electrical grounds	B	A	B
	Basic electrical circuits	B	A	B
	Bistables	B	-	B
	Relays	B	-	B
Alternating current (AC)	Basic AC theory	B	-	B
	Sources	B	A	B
	Simple circuits	B	A	B
	AC waveforms	B	-	B
	Inductance and inductive reactance	B	-	B
	Mutual inductance and transformers	B	-	B
	Capacitance and capacitive reactance	B	-	B
	Impedance	B	-	B
	Series, parallel and combination circuits	B	-	B
	Resonance	B	A	B
	Power factor	B	-	B
	Single-phase circuits	B	-	B
	Multi-phase circuits	B	-	B
Basic electronics	Semiconductors	A	-	B
	Diodes	A	-	B
	Transistors	A	-	B
	Amplifier basics	A	-	B
	Operational amplifiers	A	-	B
	Integrated circuits	A	-	B
	Solid state circuits	A	-	B
	Wave-shaping circuits	A	-	B
	Noise suppression techniques	A	-	B

C.1.5 Electrical Science Matrix (continued)

SUBJECT	TOPIC	ELEC	MECH	I&C
Facility electrical	Sources of electrical power	B	A	B
	Switchgear components	B	A	B
	Power distribution (AC and DC)	B	A	B
Power transformers	Theory	B	-	B
	Internal construction	B	A	A
	Tap changers and hazards	B	-	-
	Effect of exceeding ratings	B	-	-
	Cooling systems	B	A	-
	Insulating oil	B	-	-
	Oil system air entrainment	B	-	-
	Safety precautions associated with cooling mediums	B	A	-
	Construction of terminal connections	B	-	-
	Fault symptoms	B	A	A
	Fire protection systems	B	A	A
Current transformers	Theory	B	-	B
	Use	B	-	B
	Hazards	B	A	A
Potential transformers	Theory	B	-	B
	Use	B	-	B
	Hazards	B	A	A
Advanced electrical	AC motors	B	A	A
	AC generators	B	A	A
	DC motors	B	A	A
	DC generators	B	A	A
	Voltage regulators	B	-	B
	Ground detection	B	A	A
	Control circuits for in-facility electrical switchgear	B	A	A
	Protective relaying	B	A	A
	Lightning arresters	B	A	A
	Batteries	B	A	-

C.1.6 Instrumentation and Control Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Digital electronics	Boolean algebra	-	-	B
	Combinational logic	-	-	B
	Sequential logic	-	-	B
	Logic circuit timing	-	-	B
	Input/output methods	-	-	B
	Programming	-	-	B
Process measurement	Pressure measurement	A	A	B
	Temperature measurement	A	A	B
	Fluid flow measurement	A	A	B
	Level measurement	A	A	B
	Analytical measurements	A	A	B
Process control	Automatic control fundamentals	A	A	B
	Basic control circuits	A	-	B
	Open-loop control	A	A	B
	Closed-loop control	A	A	B
	Two-position control	A	A	B
	Proportional control	-	-	B
	Reset action	-	-	B
	Rate action	-	-	B
	Control loop tuning	-	-	B

C.1.7 Principles of Radiation Detection Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Detectors	Geiger-Mueller (G.M.)	-	-	B
	Scintillation	-	-	B
	Proportional counter	-	-	B
	Ion chamber	-	-	B
	Fission chamber	-	-	B
	Self-powered neutron	-	-	B

C.1.8 Basic Atomic and Nuclear Physics Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Atomic structure	Atomic mass unit	A	A	A
	Protons	A	A	A
	Neutrons	A	A	A
	Electrons	A	A	A
Nuclear interactions	Ionization	A	A	A
	Radiation interactions	A	A	A
	Neutron interactions	A	A	A
	Radioactive decay process	A	A	A
Fission process	Definition	A	A	A
	Theory of fission process	A	A	A
	Control of fission process	A	A	A
	Neutrons associated with fission	A	A	A
	Neutron leakage	-	-	A
Residual heat/decay heat	Sources of decay heat	A	A	A
Reactor operation	Basic reactor types	A	A	A
	Reactor parameters	A	A	A
	Power-to-flow relationships	A	A	A
	Axial flux	-	-	A
	Core imbalance	-	-	A
	Core quadrant power tilt	-	-	A
	Reactivity	-	-	A
	Reactor response to control rods	A	A	A
	Reactor start-up and shutdown	A	A	A
	Reactivity accidents	-	A	A
	Neutron flux effects on reactor power	A	A	A

C.1.9 Heat Transfer and Fluid Flow Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Basic thermodynamics	Temperature	B	A	B
	Sensible heat	B	A	B
	Latent heat-vaporization, condensation	B	-	B
	Properties of water and steam	-	A	B
	Specific volume	-	A	B
	Basic steam-water cycle	-	B	B
	Steam tables	-	A	B
	Specific heat	-	A	A
	Boiling	A	A	A
	Saturation	A	A	A
	Properties of gases, gas-liquid interfaces	A	A	A
	Heat transfer mechanisms	A	A	A
	Heat cycles (basic)	A	A	A
	Heat exchangers	A	A	A
Properties of fluids	Flow rate	A	A	A
	Fluid statics	A	A	A
	Density	A	A	A
	Buoyancy	A	A	A
Principles of fluid flow	Pump theory	A	A	A
	Cavitation	A	A	A
	Fluid flow in a closed system	A	A	A
	Water hammer	A	A	A
	Heating a closed system	A	B	B
	Draining a closed system	A	B	B
	Filling and venting	A	B	B

C.1.10 Chemistry Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Fundamentals of chemistry	Mixtures, solutions, compounds	A	A	A
	Properties and uses of gases	-	-	B
	oxygen	A	B	B
	nitrogen	A	B	B
	hydrogen	A	B	B
	noble gases	A	B	A
	Ideal gas law	A	A	B
	Conductivity	A	A	B
	Acids and bases	A	A	A
	Corrosion chemistry	B	A	B
	pH	A	A	A
	Ion exchangers	A	A	-
Principles of water treatment	Purpose	A	A	A
	Methods	A	A	A
	Water quality/purity	A	A	B
	Grades of water	A	A	B
Water chemistry control	Steam generator chemistry	A	A	A
	Secondary chemistry control	A	A	A
	Water chemistry control methods	-	A	A
Reactor water chemistry	Types of impurities	A	A	A
	Sources of impurities	A	A	A
	Effects of impurities	A	A	A
	Control/removal of impurities	A	A	A
	Radiochemistry	A	A	A
	Analytical results and core	-	-	A
	conditions	-	-	A
	Sampling methods	-	A	A
	Radiolysis and recombination	A	A	A
	Hydrogen gas in reactor water	A	A	-

C.1.11 Properties of Materials Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Properties of metals	Structure basics	A	A	A
	Changes in structure	A	A	A
	Expansion	A	A	A
	Embrittlement	A	A	A
Alloy	Definition	A	A	A
	Applications	A	A	A
Brittle fracture	Characteristics	-	A	-
	Mechanisms	-	A	-
	Heatup/cooldown effects	-	A	-
	Heat treating	-	A	-
	Annealing	-	A	-
Material problems	Fatigue failure/work hardening	A	A	A
	Corrosion	A	A	A
	Contamination	A	A	A
	Radiation-induced embrittlement	-	A	-
Thermal shock/stress	Definition	A	A	A
	Causes and effects	A	A	A
Strength of materials	Compressive strength	A	A	A
	Tensile strength	A	A	A
	Torque limits	A	A	A
Corrosion and corrosion control	General	A	A	A
	Pit and crevice	A	A	A
	Galvanic	A	A	A
	Chloride stress	-	A	A
	Caustic stress	-	A	-
	Stress corrosion cracking	-	A	-

C.1.12 Reactor Protection Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Reactor protection concepts	Thermal-hydraulic operation	A	A	A
	Safety limits	A	A	A
	Limiting conditions for operation	A	A	B
	Administrative controls and procedural concepts	A	A	B
	Automatic reactor protection concepts	A	A	B
Design basis accident	Discussion	A	A	A
	Symptoms and indications	A	A	A
	Anticipated radiation levels	A	A	A
	Effect on work place	A	A	A
	Evacuation criteria	A	A	A
	Recovery process	A	A	A
Transient prevention and mitigation of core damage	Integrated transient response	A	A	A
	Core cooling mechanisms	A	A	A
	Potentially damaging operating conditions	A	A	A
	Core damage	A	A	A
	Hydrogen hazards during accidents	A	A	A
	Monitoring critical parameters during accident conditions	A	A	B
	Radiation hazards and radiation monitor response	A	A	B

APPENDIX D
TOOLS AND EQUIPMENT TRAINING

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TOOLS AND EQUIPMENT TRAINING

This training provides the trainee with the knowledge and skills necessary to properly select, inspect, use, and care for the tools and test equipment used in the performance of assigned tasks. Matrices developed from commercial utility, industry-wide job and task analyses, and modules which indicate the necessary level of knowledge for the various maintenance disciplines are included in this Appendix.

The following matrices show the applicability of topics to the various maintenance disciplines, and modules A, B and C indicate the necessary level of knowledge and performance. The matrices can be changed to reflect facility structure and responsibility assignments.

D.1 Hand Tools

D.1.1 Module A

Instruction should enable the trainee to perform the following:

- Describe administrative controls on hand tools
- Explain personal responsibility for tools
- Identify those tools that may not be removed from the shop or maintenance area
- Explain procedures to check out and return radioactively contaminated tools
- Identify those tools that may not be taken into a radiologically controlled environment
- Explain procedures to check out and return tools maintained in the tool room
- Locate and describe the use of tool room inventory lists
- Identify the proper storage facility or receptacle for tools maintained outside the tool room.

D.1.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to perform the following:

- Identify the types of manual hand tools available
- Describe the design characteristics of each type of tool
  - identify the parts of each tool
  - explain the function of each part
  - describe the application(s) for which each tool was designed
  - describe and compare the advantages and disadvantages of each tool
- Identify the types of materials on which each type of tool may be used
- Explain the requirements for using insulated and non-sparking tools
- Identify the personnel protective equipment needed when using hand tools (as applicable)
- Explain the limitations of each tool (as applicable)
- Explain the importance of maintaining tools in excellent condition
- Describe the common failure mechanism(s) of each type of tool
- Identify indications of common failures of each type of tool
- Identify repairable and nonrepairable defects in tools
- Describe procedures for tagging and disposing of defective tools
- Describe procedures for repairing defective parts of tools (e.g., dressing screwdriver blades and replacing wooden handles)
- Describe procedures for maintaining and cleaning each type of tool
- Identify cleaning substances and materials that may be applied to each type of tool
- Demonstrate proper methods of protecting tools
  - in a radiologically controlled environment
  - in a confined space
  - when working from heights
  - when working near open systems
- Demonstrate the proper use of each type of hand tool, including precautions and consequences of improper use.

D.1.3 Hand Tool Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Hammers	Machinist (ballpeen)	B	B	B
	Carpenter (claw)	B	B	A
	Sledge	B	B	A
	Chipping	A	B	A
	Slide	A	B	A
Mallets	Plastic	B	B	B
	Rubber	B	B	B
	Rawhide	B	B	B
	Brass	B	B	B
	Lead	B	B	B
Punches	Drift	B	B	A
	Center	B	B	B
	Pin	B	B	B
	Hole	B	B	A
	Alignment	B	B	A
Wrenches	Open-end	B	B	B
	Box-end	B	B	B
	Combination	B	B	B
	Socket	B	B	B
	Socket set attachments			
	handles	B	B	B
	extensions	B	B	B
	adapters	B	B	B
	Tubing	B	B	B
	Adjustable open-end	B	B	B
	Adjustable pipe			
	open jaw	B	B	B
	strap	B	B	A
	chain	B	B	A
	Slugging	B	B	B
	Spanner			
	pin	B	B	B
	hook	B	B	-
	face	-	B	B
	Hexagonal (Allen)	B	B	B
	Splined (Bristol)	B	B	B
	Torque	B	B	-

D.1.3 Hand Tool Matrix (continued)

SUBJECT	TOPIC	ELEC	MECH	I&C
Pliers	Snap ring	B	B	B
	Parallel jaw (channel/pump)	B	B	B
	Locking	B	B	B
	Lockwire	B	B	B
Vises and clamps	Mechanics bench vise	B	B	B
	Pipe vise			
	yoke	B	B	B
	bench	B	B	B
	Vise grips	B	B	B
	C-clamps	B	B	B
	V-clamps	B	B	B
	Spring clamps	B	B	B
	Table clamps	B	B	B
Cutting	Saws			
	wood cutting	B	B	B
	metal cutting	B	B	B
	Knives	B	B	B
	Scissors/shears	B	B	B
	Bolt cutter	B	B	B
	Chisels	B	B	B
	Files	B	B	B
Other	Crimpers	B	-	B
	Nut drivers	B	B	B
	Cable strippers	B	-	B
	Wire strippers	B	-	B
	Threaders	B	B	B
	Benders	B	B	B

D.2 Power-Driven Hand Tools

D.2.1 Module A

Instruction should enable the trainee to perform the following:

- Describe administrative controls for power-driven tools
- Explain personal responsibility for tools
- Identify personnel protective equipment needed when using power-driven hand tools
- Identify those tools that may not be removed from the shop or maintenance area
- Explain procedures to check out and return radioactively contaminated tools
- Identify those tools that may not be taken into a radiologically controlled environment
- Explain procedures to check out and return tools maintained in the tool room
- Locate and describe the use of tool room inventory lists
- Identify the proper storage facility or receptacle for tools maintained outside the tool room
- Identify the types of power-driven hand tools available
- Describe the design characteristic of each type of tool
  - identify the parts of each tool
  - describe the application(s) for which each tool was designed
  - describe and compare the advantages and disadvantages of each tool
- Identify attachments for each tool
- Describe the function of each attachment
- Identify power sources that may be connected to power-driven hand tools
- Identify power source connection equipment
  - air hoses
  - extension cords
  - connectors
  - adapters
- Explain any limitation associated with each tool.

D.2.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to perform the following:

- Explain the importance of maintaining tools in excellent condition
- Describe the common failure mechanism(s) of each type of tool and connection equipment
- Identify indications for common failure of each type of tool and connection equipment
- Describe procedures for tagging and disposing of defective tools and connection equipment
- Identify cleaning substances and materials that may be applied to each type of tool
- Demonstrate proper method of protecting tools
    - in a radiologically controlled area
    - in a confined space
    - when working from heights
    - when working near open systems
- Demonstrate the proper use of each type of tool
- Demonstrate the proper procedure to connect and disconnect each type of tool
- Demonstrate the proper use of connectors and adapters.

D.2.3 Module C

In addition to the items in Modules A and B, instruction should enable the trainee to demonstrate the proper procedure to:

- Assemble and disassemble each tool
- Inspect and clean each tool
- Adjust and repair each tool.

D.2.4 Power-Driven Hand Tool Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Pneumatic	Hammer	B	C	A
	Drill	B	C	A
	Chisel	B	C	A
	Grinder	B	C	A
	Punch	B	C	A
	Wrench	B	C	A
	Screwdriver	B	C	A
	Saw	B	C	A
Electrical	Drill	C	B	B
	Grinder	C	B	B
	Wrench	C	B	B
	Screwdriver	C	B	B
	Saw	C	B	B
	Spot welder	C	B	B
	Heat gun	C	B	B
	Vacuum cleaner	C	B	B

D.3 Measuring and Test Equipment (M&TE)

D.3.1 Module A

Instruction should enable the trainee to perform the following:

- Define calibration
- Explain requirements for maintaining an auditable calibration program
- Explain calibration cycle
- Explain requirements for instruments and test equipment found out of calibration
- Identify information displayed on a calibration sticker
- Explain the use of information on a calibration sticker to determine calibration status
- Determine calibration status for tools and equipment without M&TE calibration stickers
- Identify M&TE that may not be removed from the shops or maintenance area
- Identify M&TE that may not be taken into a radiologically controlled area

- Explain procedures for obtaining M&TE
- Identify types of M&TE
- Explain the use of inventory lists or printouts in selection of M&TE
- Define the term "or equivalent" as applied to M&TE
- Describe procedures to determine equivalency.

D.3.2 Module B

Instruction should enable the trainee to perform the following:

- Explain the special handling procedures for each type of test equipment
- Demonstrate proper methods of protecting M&TE
  - in a radiologically controlled area
  - in a confined space
  - when working from heights
  - when working near open systems
- Explain end-user responsibilities toward use and control of M&TE
- Explain the procedure to be followed in the event M&TE is dropped or damaged during use, or yields questionable readings
- Explain the proper procedure to connect and disconnect each type of equipment
- Explain the proper procedure to operate each type of equipment
- Explain the proper use of connectors, adapters and leads.

D.3.3 Module C

In addition to the items in Module B, instruction should enable the trainee to demonstrate the proper procedure to:

- Inspect and clean each type of equipment
- Adjust and calibrate each type of equipment
- Repair each type of equipment.

D.3.4 Measuring and Test Equipment (M&TE) Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
General M&TE	All	A	A	A
Sources	Current	B	-	C
	Frequency	B	-	C
	Heat	B	-	C
	Pressure	-	-	C
	Radiation	-	-	C
	Resistance	B	-	C
	Vibration	-	-	C
	Voltage	B	-	C
Measuring devices	Capacitance	B	-	C
	Current	B	-	C
	Distance	B	B	C
	Frequency	B	-	C
	Mass	B	B	C
	Pressure	B	B	C
	Differential pressure	B	B	C
	Resistance	B	-	C
	Speed	B	B	C
	Temperature	B	-	C
	Time	B	B	C
	Torque	-	B	C
	Vibration	B	B	C
	Voltage	B	-	C
	Scales	B	B	B
	Radiation	B	B	B
	Flow	-	B	B
Analytical devices	Oscilloscope	B	-	C
	Vibration analyzer	B	B	C
	Gas analyzer	-	-	C
Special purpose devices	Facility protection system test set	-	-	C
	Hydrostatic test set	-	-	C
	Inverter test set	B	-	C
	Leak-rate test set	-	B	C

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APPENDIX E
FACILITY SYSTEMS AND COMPONENT KNOWLEDGE TRAINING

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FACILITY SYSTEMS AND COMPONENT KNOWLEDGE TRAINING

This section provides the trainee with the knowledge necessary to understand systems and components and apply that knowledge to the job. Matrices developed from commercial utility, industry-wide job and task analyses, and modules which indicate the necessary level of knowledge for the various maintenance disciplines are included in this Appendix. As a minimum, training should be provided on safety-related systems identified in the facility's safety analysis report for those maintenance personnel performing work on those systems/components. Included in this category are systems having a direct impact on the safe operation of the facility.

The following matrices show the applicability of topics to the various maintenance disciplines, and modules which indicate the necessary level of knowledge and performance. The matrices can be changed to reflect facility structure and responsibility assignments.

E.1 Facility Systems

E.1.1 Module A

Instruction should enable the trainee to perform the following:

- Explain the purpose
- Identify the major components
- Identify the alarms and indications affected by maintenance
- Describe each system at the block diagram level
- Explain the importance to facility operation
- Identify conditions that preclude safe work in the vicinity of system components
- Describe the effect of isolating system components on facility operation
- Identify the basic interrelationships with other facility systems.

E.1.2 Module B

In addition to the items in Module A, instruction should enable the trainee to perform the following:

- Describe the control logic diagrams
- Identify indications of normal and abnormal system performance
- Identify the probable causes of abnormal indications.

E.1.3 Facility Systems Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Reactor systems	Confinement/containment	A	A	B
	Fuel handling/storage	A	A	B
	Engineered safety features	B	A	B
	Sampling	A	A	B
	Reactor protection	A	A	B
	Automatic control	B	A	B
Steam cycle	Steam	B	A	B
	Feedwater	A	A	B
	Condensate	A	A	B
	Sampling	A	A	B
	Automatic control	A	A	B
	Water treatment	A	A	B
Auxiliary	Component cooling	A	A	B
	Confinement/containment cooling	A	A	B
	Air supply	A	B	B
	Gas supply	A	A	B
	Water supply	A	B	B
	Oil	A	B	B
	HVAC	B	A	B
	Radwaste	A	B	B
	Bulk storage	A	A	B
	Waste treatment	A	A	A
Electrical	Switchyard	B	A	B
	Generator	B	A	B
	AC distribution	B	A	B
	DC distribution	B	A	B
	Heat tracing	B	A	B
	Grounding	B	A	B
Monitoring	Seismic	A	A	B
	Loose parts	A	A	B
	Radiation	A	A	B
	Environmental	A	A	B
	Neutron	A	A	B
	Facility computer	A	A	B
	Safety parameter displays	A	A	B

E.2 Rotating Equipment

E.2.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Identify appropriate engineering drawing symbols
- Explain the purpose and use of equipment.

E.2.2 Module B

In addition to the items in Module A, instruction should enable the trainee to perform the following:

- Describe the major differences in equipment types
- Identify the major parts of the equipment
- Explain the principles of operation.

E.2.3 Module C

In addition to the items in Modules A and B, instruction should enable the trainee to identify the following:

- Normal and abnormal indications of equipment performance during troubleshooting and testing
- Probable causes of abnormal indications
- Abnormal conditions that preclude safe work in the vicinity of equipment.

E.2.4 Module D

In addition to the items in Modules A, B, and C, instruction should enable the trainee to identify vibration limits.

E.2.5 Rotating Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Prime movers	Electrical			
	AC	D	A	B
	DC	D	A	B
	Diesel	A	D	A
Electrical generators	Main	D	A	A
	Auxiliary	D	A	A
	Emergency	D	A	A
Pumps	Centrifugal	A	D	A
	Positive displacement	A	D	A
	Jet	A	D	A
Compressors	Rotary vane	A	D	A
	Reciprocating	A	D	A
	Rotary screw	A	D	A
	Centrifugal	A	D	A
Fans	Vaneaxial	C	D	C
	Propeller	C	D	C
	Squirrel cage	C	D	C
	Centrifugal	C	D	C

E.3 Heat Transfer Equipment

E.3.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Identify appropriate engineering drawing symbols
- Explain the purpose and use of equipment.

E.3.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to perform the following:

- Describe the major differences in equipment types
- Identify the inlet(s) and outlet(s)
- Describe the principles of operation.

E.3.3 Module C

In addition to the items listed in Modules A and B, instruction should enable the trainee to identify the following:

- Indications of normal and abnormal equipment performance during troubleshooting and testing
- Probable causes of abnormal indications
- Abnormal conditions that preclude safe work in the vicinity of equipment.

E.3.4 Heat Transfer Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Mechanical	Heat exchangers	B	C	C
	Feedwater heaters	B	C	C
	Moisture separators	B	C	C
	Condensers	B	C	C
	Cooling towers	B	C	C
	Reboilers	-	C	C
Electro-mechanical	Air handlers	C	C	B
	Refrigeration units	C	C	B
Electrical	Recombiners	C	A	C
	Heat tracing	C	A	A
	Heaters	C	A	C

E.4 Electrical Equipment

E.4.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Use appropriate engineering drawing symbols to interpret print information
- Explain the purpose and use of applicable types of equipment.

E.4.2 Module B

In addition to the items in Module A, instruction should enable the trainee to identify the following:

- Indications of normal and abnormal equipment operation during troubleshooting and testing
- Probable cause of abnormal indications
- Abnormal conditions that preclude safe work in the vicinity of equipment.

E.4.3 Module C

Instruction should enable the trainee to perform the following:

- Locate equipment in panels and cabinets
- Identify breaker, switch, and disconnect position indications.

E.4.4 Electrical Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Supply	Buses	B	-	A
	Cables	B	-	A
	Transformers			
	general	B	A	B
	station	B	A	B
	current	B	A	B
	potential	B	A	B
	Batteries	B	A	A
	Inverters	B	A	A
	Battery chargers	B	A	A
Control	Switchgear	A,C	A,C	A,C
	Breakers	A,C	A,C	A,C
	Relays	A,C	A	A,C
	Switches	A,C	A,C	A,C
	Disconnects	A,C	A,C	A,C
	High voltage breakers	A,C	A,C	A,C

E.5 Process Conditioning Equipment

E.5.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Identify appropriate engineering drawing symbols
- Explain the purpose and use of equipment.

E.5.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to perform the following:

- Describe the major differences in equipment types
- Identify the inlet(s) and outlet(s)
- Explain the principles of operation.

E.5.3 Module C

In addition to the items listed in Modules A and B, instruction should enable the trainee to identify the following:

- Indications of normal and abnormal equipment operation during troubleshooting and testing
- Probable cause of abnormal indications
- Abnormal conditions that preclude safe work in the vicinity of equipment.

E.5.4 Process Conditioning Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Chemical	Ion exchangers	A	C	A
	Demineralizers	A	C	A
	Purifiers	A	C	A
	Absorbers	A	C	A
	Catalytic recombiners	-	C	-
Gaseous	Mechanical recombiners	A	C	A
	Ejectors	A	C	A
	Eductors	A	C	A
Mechanical	Filters	A	C	A
	Strainers	A	C	A
	Screens	A	C	A
	Centrifuges	A	C	A
	Traps	A	C	A

E.6 Control Elements

E.6.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Identify appropriate engineering drawing symbols
- Explain the purpose and use of equipment.

E.6.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to perform the following:

- Describe the major differences in equipment types
- Identify the major parts
- Explain the principles of operation
- Identify position indications.

E.6.3 Module C

In addition to the items listed in Modules A and B, instruction should enable the trainee to identify the following:

- Indications of normal and abnormal equipment performance during troubleshooting and testing
- Probable cause of abnormal indications
- Abnormal conditions that preclude safe work in the vicinity of equipment.

E.6.4 Module D

In addition to the items listed in Modules A, B, and C, instruction should enable the trainee to explain the proper use of applicable lubricants.

E.6.5 Control Elements Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Valves	Gate	A	D	A
	Globe	A	D	A
	Butterfly	A	D	A
	Diaphragm	A	D	A
	Ball	A	D	A
	Plug	A	D	A
	Check	A	D	A
	Stop-check	A	D	A
	Relief	A	D	A
Actuators	Electric	D	D	A
	Pneumatic	B	D	A
	Explosive	B	D	C
Dampers	Blade	A	D	A
	Vane	A	D	A
	Louver	A	D	-

E.7 Instrumentation and Control Equipment

E.7.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Identify appropriate engineering drawing symbols
- Explain the purpose and use of equipment.

E.7.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to identify the following:

- The instrument range

- The instrument units.

E.7.3 Module C

Instruction should enable the trainee to identify the following:

- The input and output ranges
- The input and output medium.

E.7.4 Module D

Instruction should enable the trainee to identify the following:

- The power source(s)
- The indications of normal and abnormal equipment performance during troubleshooting and testing
- The probable causes of abnormal indications
- The abnormal conditions that preclude safe work in the vicinity of equipment.

E.7.5 Instrumentation and Control Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Instruments	Sensors	A,C	A	A,C,D
	Indicators	B,C,D	A	B,C,D
	Recorders	B	A	B,C,D
	Switches	A,C,D	A	A,C,D
	Controllers	A,C,D	A	A,C,D
	Positioners	A,C,D	A,C,D	A,C,D
	Transmitters	A	A	A,C,D
	Annunciators	B,C,D	A	B,C,D
	Detectors	A,C	A	B,C,D
Electronic equipment	Analyzers	B	B	B,C,D
	Signal converters	A	A	A,C,D
	Monitors	B	B	B,C,D
	Computers	B	B	B,D

E.8 Passive Components

E.8.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Identify appropriate engineering drawing symbols
- Explain the purpose and use of equipment
- Describe the properties of any contained fluids.

E.8.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to perform the following:

- Describe the physical characteristics
- Describe the capacity limits (pressure, volume, flow rate, as applicable).

E.8.3 Passive Components Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Pressure vessels	Confinement/containment	B	B	B
	Reactor	B	B	B
	Pressurizer	B	B	B
Volume	Tanks	B	B	B
	Reservoirs	A	B	B
	Pools	A	B	B
	Accumulators	A	B	B
	Piping	A	B	B
	Tubing	B	B	B
Flow	Orifice	-	A	B

E.9 Miscellaneous Equipment

E.9.1 Module A

Instruction should enable the trainee to perform the following:

- Identify types of equipment
- Identify appropriate engineering drawing symbols
- Explain the purpose and use of equipment.

E.9.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to identify the following:

- Load limits
- Major parts.

E.9.3 Module C

Instruction should enable the trainee to perform the following:

- Explain the principles of operation
- Identify indications of normal and abnormal equipment performance
- Identify the probable causes of abnormal indications
- Identify abnormal conditions that preclude safe work in the vicinity of equipment.

E.9.4 Miscellaneous Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Auxiliary equipment	Hoists	B,C	B,C	B,C
	Elevators	B,C	A	B,C
	Cranes	B,C	B,C	B,C
	Boilers	B,C	B,C	B,C
Structural equipment	Mounts	B	B	A
	Bases	B	B	A
	Supports	A	B	A
	Hangers	A	B	A
	Cable trays	B	A	B
	Conduits	B	A	B
	Fire barriers	B,C	A,C	B,C
	Snubbers	A	B,C	A
	Anchor bolts	A	B,C	A

APPENDIX F

FACILITY SYSTEMS AND COMPONENT SKILLS TRAINING

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FACILITY SYSTEMS AND COMPONENT SKILLS TRAINING

This section provides the trainee with the skills necessary to perform maintenance on facility systems and components. Matrices developed from commercial utility, industry-wide job and task analyses, and modules which indicate the necessary level of knowledge for the various maintenance disciplines are included in this Appendix. As a minimum, training should be provided on safety-related systems identified in the facility's safety analysis report for those maintenance personnel performing work on those systems or components. Included in this category are systems having a direct impact on the safe operation of the facility.

The following matrices show the applicability of topics to the various maintenance disciplines, and modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect facility structure and responsibility assignments.

F.1 Facility Systems

F.1.1 Module A

Instruction should enable the trainee to demonstrate proper performance of surveillance or maintenance procedures.

F.1.2 Facility Systems Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Reactor systems	Confinement/containment	-	-	A
	Fuel handling/storage	-	-	A
	Engineered safety features	A	-	A
	Sampling	-	-	A
	Reactor protection	-	-	A
	Automatic control	A	-	A
Steam cycle	Steam	-	-	A
	Feedwater	-	-	A
	Condensate	-	-	A
	Sampling	-	-	A
	Automatic control	-	-	A
	Water treatment	-	-	A
Auxiliary	Component cooling	-	-	A
	Containment cooling	-	-	A
	Air supply	-	-	A
	Gas supply	-	-	A
	Water supply	-	-	A
	Oil	-	-	A
	HVAC	A	-	A
	Radwaste	-	A	A
	Bulk storage	-	-	A
Electrical	Switchyard	A	-	-
	Generator	A	-	-
	AC distribution	A	-	-
	DC distribution	A	-	-
	Heat tracing	A	-	-
	Grounding	A	-	-
Monitoring	Seismic	-	-	A
	Loose parts	-	-	A
	Radiation	-	-	A
	Environmental	-	-	A
	Neutron	-	-	A
	Facility computer	-	-	A
	Safety parameter displays	-	-	A

F.2 Rotating Equipment

F.2.1 Module A

Instruction should enable the trainee to demonstrate the following:

- Assembly and disassembly methods
- Inspection and cleaning techniques
- Equipment repair
- Use of special purpose tools and equipment.

F.2.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to demonstrate the ability to measure equipment vibration properly.

F.2.3 Module C

Instruction should enable the trainee to demonstrate the ability to:

- Install and remove couplings/belts
- Align rotating equipment
- Lubricate designated equipment.

F.2.4 Rotating Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Prime movers	Electrical			
	AC	B	C	-
	DC	B	C	-
	Diesel	-	B,C	-
Electrical generators	Main	B	C	-
	Auxiliary	B	C	-
	Emergency	B	C	-
Pumps	Centrifugal	-	B,C	-
	Positive displacement	-	B,C	-
	Jet	-	B,C	-
Compressors	Rotary vane	-	B,C	-
	Reciprocating	-	B,C	-
	Rotary screw	-	B,C	-
	Centrifugal	-	B,C	-
Fans	Vaneaxial	A	B,C	-
	Propeller	A	B,C	-
	Squirrel cage	A	B,C	-
	Centrifugal	A	B,C	-

F.3 Heat Transfer Equipment

F.3.1 Module A

Instruction should enable the trainee to demonstrate the following:

- Methods for opening the system/component/equipment
- Techniques for testing tubes for leaks
- Techniques to repair or plug leaking tubes.

F.3.2 Module B

Instruction should enable the trainee to demonstrate the following:

- Assembly and disassembly methods
- Inspection and cleaning techniques
- Equipment repair
- Use of special purpose tools and equipment.

F.3.3 Heat Transfer Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Mechanical	Heat exchangers	-	A,B	-
	Feedwater heaters	-	A,B	-
	Moisture separators	-	A,B	-
	Condensers	-	A,B	-
	Cooling towers	-	A,B	-
	Reboilers	-	A,B	-
Electro-mechanical	Air handlers	B	B	-
	Refrigeration units	B	B	-
Electrical	Recombiners	B	-	-
	Heat tracing	B	-	-
	Heaters	B	B	-

F.4 Electrical Equipment

F.4.1 Module A

Instruction should enable the trainee to demonstrate the following:

- Removal and installation techniques
- Use of special purpose tools and equipment
- Assembly and disassembly methods
- Inspection and cleaning techniques
- Equipment repair.

F.4.2 Module B

In addition to the items in Module A, instruction should enable the trainee to demonstrate the following:

- Adjustment and calibration
- Testing methods.

F.4.3 Electrical Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Supply	Buses	A	-	-
	Cables	A	-	-
	Transformers			
	general	A	-	-
	station	A	-	-
	current	B	-	B
	potential	B	-	B
	Batteries	B	-	-
	Inverters	B	-	-
	Battery chargers	B	-	-
Control	Switchgear	B	-	-
	Breakers	B	-	-
	Relays	B	-	-
	Switches	B	-	B
	Disconnects	B	-	-
	High voltage breakers	B	-	-

F.5 Process Conditioning Equipment

F.5.1 Module A

Instruction should enable the trainee to demonstrate the methods for:

- Medium removal and replacement
- Handling and disposing of medium.

F.5.2 Module B

Instruction should enable the trainee to demonstrate the following:

- Assembly and disassembly methods
- Equipment repair
- Use of special purpose tools and equipment.

F.5.3 Process Conditioning Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Chemical	Ion exchangers	-	A,B	-
	Demineralizers	-	A,B	-
	Purifiers	-	A,B	-
	Absorbers	-	A,B	-
	Catalytic recombiners	-	A,B	-
Gaseous	Mechanical recombiners	-	A,B	-
	Ejectors	-	B	-
	Eductors	-	B	-
Mechanical	Filters	-	A,B	-
	Strainers	-	A,B	-
	Screens	-	A,B	-
	Centrifuges	-	A,B	-
	Traps	-	A,B	-

F.6 Control Elements

F.6.1 Module A

Instruction should enable the trainee to demonstrate proper adjustment of equipment.

F.6.2 Module B

- Assembly and disassembly methods
- Inspection and cleaning techniques
- Equipment repair
- Use of special purpose tools and equipment.

F.6.3 Control Elements Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Valves	Gate	-	B	-
	Globe	-	B	-
	Butterfly	-	B	-
	Diaphragm	-	B	A
	Ball	-	B	-
	Plug	-	B	-
	Check	-	B	-
	Stop-check	-	B	-
	Relief	-	B	-
Actuators	Electric	A	B	B
	Pneumatic	-	B	B
	Explosive	-	B	B
Dampers	Blade	A	B	A
	Vane	A	B	A
	Louver	A	B	A

F.7 Instrumentation and Control Equipment

F.7.1 Module A

Instruction should enable the trainee to demonstrate the ability to extract information from instrument scales accurately.

- Ability to remove equipment from service properly
- Assembly and disassembly methods

- Inspection and cleaning techniques
- Ability to troubleshoot defective equipment.

F.7.2 Module B

Instruction should enable the trainee to demonstrate the following:

- Equipment repair
- Adjustment and calibration
- Methods for returning equipment to service
- Use of special purpose tools and equipment.

F.7.3 Instrumentation and Control Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Instruments	Sensors	-	-	B
	Indicators	A,B	A	A,B
	Recorders	A	A	A,B
	Switches	B	-	B
	Controllers	B	-	B
	Positioners	B	A,B	B
	Transmitters	-	-	B
	Annunciators	A,B	A	A,B
	Detectors	-	-	A,B
Electronic equipment	Analyzers	A	A	A,B
	Signal converters	-	-	A,B
	Monitors	A	A	A,B
	Computers	A	A	A,B

F.8 Passive Components

F.8.1 Module A

Instruction should enable the trainee to demonstrate the following:

- Methods for opening a system/component/equipment
- Inspection and cleaning techniques
- Use of special purpose tools and equipment.

F.8.2 Passive Components Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Pressure Vessels	Confinement/containment Reactor Pressurizer	A - A	A A A	- - -
Volume	Tanks Reservoirs Pools Accumulators Piping Tubing	- - - - - A	A A A A A A	- - - - - A
Flow	Orifice	-	A	-

F.9 Miscellaneous Equipment

F.9.1 Module A

Instruction should enable the trainee to demonstrate the following:

- Assembly and disassembly methods
- Inspection and cleaning techniques
- Repair techniques
- Use of special purpose tools and equipment.

F.9.2 Module B

In addition to the items listed in Module A, instruction should enable the trainee to demonstrate the ability to lubricate designated equipment.

F.9.3 Miscellaneous Equipment Matrix

SUBJECT	TOPIC	ELEC	MECH	I&C
Auxiliary equipment	Hoists	B	B	-
	Elevators	B	-	-
	Cranes	B	B	-
	Boilers	-	A	-
Structural equipment	Mounts	A	B	-
	Bases	A	A	-
	Supports	-	B	-
	Hangers	-	B	-
	Cable trays	A	-	-
	Conduit	A	-	-
	Fire barriers	A	-	-
	Snubbers	-	B	-
	Anchor bolts	-	A	-

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APPENDIX G
SPECIALIZED SKILLS TRAINING

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APPENDIX G - SPECIALIZED SKILLS TRAINING

Some tasks or duties are typically performed by a few individuals who are specialists in these tasks or duties. Accordingly, training should be provided to an appropriate number of individuals to maintain an adequate number of trained specialists for each applicable task or duty. Depending on specific facility structure and responsibility assignments, some of these tasks may be performed by subcontractor personnel. The tasks listed in this Appendix are intended to serve as examples only. Other tasks may be added depending on the division of labor, results of facility-specific job analyses, and individual facility practices.

These skills and tasks are especially suited to laboratory, workshop, and On-the-Job training settings. Procedures, operating experience, vendor-supplied documents, and job analysis results should be used to develop training guides for use by instructors or evaluators. Training should also include the selection and use of any special tools or equipment.

G.1 Electrical

Instruction should enable the trainee to perform the following tasks:

- Battery load testing
- Breaker operation, setting, adjustment, and repair
- Cable splicing
- High pot testing
- Major motor overhaul
- Preparation of high voltage connections
- Relay setting, adjustment, calibration, and repair
- Special soldering
- Stress relieving of major components
- Switchgear testing.

G.2 Mechanical

Instruction should enable the trainee to perform the following tasks:

- Annealing
- Close tolerance machining
- Control rod drive mechanism overhaul and repair
- Control rod drive mechanism seal removal and replacement
- Crane inspections, maintenance, repair, and operation
- Emergency diesel overhaul
- Freeze sealing techniques
- Reactor coolant pump mechanical seal replacement
- Recirculation pump mechanical seal replacement
- Tempering
- Reactor cavity seal installation and removal
- Reactor pressure vessel stud tensioners - installation and use
- Reactor vessel head disassembly and reassembly
- Rigging equipment selection, inspection, and use
- Scaffolding installation, inspection, and removal
- Scavenging air blower overhaul
- Silver plating, electroplating
- Welding (electric arc)
- Welding (gas)
- Welding (inert gas)
- Metal spray welding.

G.3 Instrumentation and Control

Instruction should enable the trainee to perform the following tasks:

- Analytical equipment troubleshooting and repair
- Computer troubleshooting and repair
- Feedwater pump control troubleshooting and repair
- Nuclear instrumentation system troubleshooting and repair

- Reactor protection and engineered safety feature troubleshooting and repair
- Rod control and rod position indication equipment troubleshooting and repair
- Soldering techniques and circuit board repair.

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