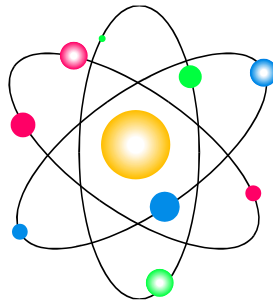


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# The Nuclear Mechanic Apprenticeship Process Study Report



**Rev. July 1999**

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# **I. Management Summary**

In anticipation of changes to nuclear training regulations, a group was formed and has developed a structured approach for the review of contractor craft journeyman qualifications (i.e. basic skills) for performing independent work activities in Commercial Nuclear Power Facilities.

- The group (named the Tripartite Committee) was made up of representatives from nuclear utilities, labor unions, and contractors.

Two different types of reviews were performed on the union apprenticeship programs depending on the nature of the particular unions' work. For the unions performing "Safety Related" type activities, a "detailed" review of the apprenticeship program was performed. A "general" review of the apprenticeship programs was performed on the unions outside of the above category.

The detailed review had two goals:

- The first goal was to determine if the scope of the craft union apprenticeship programs provide the appropriate basic skills for the types of maintenance and modification work normally assigned to contract craft labor.
- The second goal was to develop a method for the documentation of knowledge and skills information for each craftsperson employed in maintenance and modification work.

The union apprenticeship programs chosen for detailed review were:

- United Association of Journeyman and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada (UA)
- International Brotherhood of Electrical Workers (IBEW).
- International Brotherhood of Boilermakers - Ship Builders - Blacksmiths - Forgers & Helpers
- Millwrights - United Brotherhood of Carpenters and Joiners of America
- International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers
- Sheet Metal Workers' International Association (SMWIA)

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The union apprenticeship programs chosen for general review are listed below. Attachment A provides the justification for not performing a detailed review of these programs.

- Insulators
- Carpenters
- Roofers
- Bricklayers
- Concrete Finishers
- Teamsters
- Laborers
- Operating Engineers
- Painters

## *CONCLUSIONS:*

- The scope of all apprenticeship programs are appropriate for the type of work assigned to the unions
- All programs reviewed in detail exceed requirements for basic skill training.
- Verification of apprenticeship completion provides a method for the documentation of knowledge and skills information for each craftsperson employed in maintenance and modification work.

## **II. INTRODUCTION**

In anticipation of changes to nuclear industry training regulations, an EEI Construction Committee subcommittee developed a structured approach for the review of craft journeyman qualifications (e.g. fundamental knowledge/skills). Fundamental knowledge and skills are the entry level knowledge and skills that allow an employee to perform basic tasks within a trade without additional training. These skills also provide a reasonable expectation that an individual can successfully complete further detailed (advanced task) training.

In 1989 the EEI Construction Committee, Labor Relations subcommittee, and in conjunction with the AFL-CIO Building Trades Department, the Associated Maintenance Contractors Inc., and the National Maintenance Agreements Policy Committee formed a committee to propose a methodology for providing greater assurance of contracted craft entry level qualification. The committee, named the Tripartite Committee, consisted of representatives from:

- Utilities
  - Commonwealth Edison
  - Florida Power and Light
  - Duquesne Light Company
  - Southern California Edison Company
  - Northeast utilities
- Labor
  - Building and Construction Trades Department AFL-CIO
  - All unions involved in the General and Detailed Apprenticeship Program reviews
- Contractor Management
  - National Maintenance Agreement Policy Committee
  - Associated Maintenance Contractors Inc.
    - Stone & Webster Engineering Corporation
    - Bechtel
    - Fluor Constructors
    - Raytheon (United Engineers and Constructors)

The committee decided that the use of existing union apprenticeship training programs would provide the most economical solution. The objective set by the committee was to determine if the scope of the craft unions' apprenticeship programs provided the appropriate basic skills for the types of maintenance and modification work normally assigned to contract craft labor.

To accomplish this objective a study group was formed from representatives of the Tri-partite Committee to identify industry requirements and review the apprenticeship programs for compliance. The Study Group concluded that it was necessary to consider the requirements in the following regulatory documents.

- 10CFR 50, Appendix B, Criterion 2,
- INPO 92-001 (Conduct of Maintenance), Section VI.C.5
- ANSI 3.1

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- The April 1993 Revision addresses contractors doing maintenance and modification work. Section 3.2.2 requires that documented evidence exist which demonstrates that contractor personnel are qualified to perform their assigned tasks.

Two different types of reviews were performed on the union apprenticeship programs depending on the nature of the particular unions' work. For the unions performing "Safety Related" type activities, a detailed review of the apprenticeship program was performed. A general review of the apprenticeship programs was performed on the unions outside of the above category. This study report documents the detailed reviews.

The detailed reviews were in depth comparisons between the apprenticeship programs of the building trades and the base INPO 86-018 "Guidelines for Training and Qualification of Maintenance Personnel" requirements for the training and qualification of utility maintenance personnel. The significance of each item not addressed by the apprenticeship programs was documented and evaluated as described in the methodology section. Upon completion of this comparison, the Study Group evaluated whether additional training and/or testing was required to assure that fundamental knowledge/skills were acquired through apprenticeship.

The second objective was to develop a method for the documentation of knowledge and skills qualification information for each craftsperson employed in maintenance and modification work. This information is necessary in order to demonstrate compliance to the requirements of ANSI 3.1.

The Study Group reviewed the regulations that govern apprenticeship programs and also reviewed the internal processes of the unions that were reviewed in detail. There was sufficient information to indicate that the unions had acceptable control over their programs to verify an individual's completion of program requirements.

### **III. CONCLUSIONS**

The programs reviewed in detail provide the knowledge and skills required for working independently in a nuclear power facility. It is the opinion of the Tripartite Committee that those items which were not covered have no affect on the ability of craft personnel to perform basic tasks or receive site specific training normally given to them. In addition, hundreds of additional items are addressed by each of the programs. Most of these items are relevant to work assigned to these crafts but they were not specifically required by the INPO 86-018 document.

Verification that an individual craftsperson has completed a union apprenticeship program provides documentation that the individual has the skills and knowledge to perform certain identified tasks normally assigned to that union.



## **IV. DISCUSSION**

The first union apprenticeship programs chosen for review were the United Association of Journeyman and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada (UA), and the International Brotherhood of Electrical Workers (IBEW).

These two union organizations were chosen for initial review because of the scope and complexity of maintenance and modification activities assigned to them at operating nuclear stations. Work assigned to these crafts most directly correlates with the "normal" work of utility mechanical and electrical maintenance departments. After these initial reviews, four additional detailed apprenticeship program reviews were performed. The results of all six reviews are discussed in Section VI.

### **Methodology**

Meetings were held with the Tripartite Committee to discuss review methodology. Meeting discussions identified that the union apprenticeship programs are typically controlled by a joint committee made up of union and employer representatives. Often, a separate organization known as a "Training Fund" or "National Training Committee" exists. Since the union apprenticeship programs are controlled from a central source, a detailed review of each union's standard program would be the most efficient approach to take. The apprenticeship program review process was then flow charted and action plans for its implementation written.

First, a review was conducted to determine if there were minimum entrance and graduation requirements for the apprenticeship programs. Then sections 9 through 12 of INPO 86-018 were used as the standard for program content review:

- This document forms a basis for utility training programs.
- Sections 9 through 12 are the sections that correspond to the basic skill related subjects.

A matrix of subjects and topics from INPO 86-018 was developed. The craft unions, in conjunction with members of the Study Group, listed which section of their respective program documents addressed each subject and topic on the matrix. The comparison matrices are included in the Appendices.

The following is a summary of the results for the programs reviewed in detail. A low percentage of INPO 86-018 subjects/topics addressed by an apprenticeship program does not necessarily indicate a problem. INPO 86-018 is intended for the full range of maintenance activities while a union's workscope represents a limited portion of these activities.

IBEW - 83% of the subjects and 73% of the topics listed in INPO 86-018 are addressed. (86 of 103 subjects - 420 of 578 topics)

UA - 82% of the subjects and 77% of the topics listed in INPO 86-018 are addressed. (86 of 105 subjects - 414 of 540 topics)

Boilermakers- 70% of the subjects and 58% of the topics listed in INPO 86-018 are addressed. (73 of 105 subjects- 313 of 540 topics)

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Millwrights- 54% of the subjects and 47% of the topics listed in INPO 86-018 are addressed. (57 of 105 subjects- 254 of 540 topics)

Ironworkers- 35% of the subjects and 34% of the topics listed in INPO 86-018 are addressed. (37 of 105 subjects - 186 of 540 topics)

Sheet Metal Workers- 40% of the subjects and 27% of the topics listed in INPO 86-018 are addressed. (42 of 105 subjects - 140 of 540 topics)

## **Significance Scale**

A scale of 0 through 5 was used to indicate the relative significance of items not addressed in the apprenticeship program documents.

0 = no significance for reasons listed below:

- a. The material is covered sufficiently in other standard site training such as General Employee Training (GET)
- b. Training in this topic is not necessary to perform tasks normally assigned to this type of individual

1-2 = little significance as defined below:

- a. Training in the topic may be useful but is not necessary to perform tasks normally assigned to this type of individual
- b. This topic is sufficiently covered by other topics that are addressed under this subject or other subjects

3-4 = possible significance - further investigation is warranted

5 = definite significance. This material must be covered in other training or skill testing in this area may be necessary.

A summary of the number of subjects/topics addressed, the number of topics with a significance 0, and the average of the significant items for each section was also developed and is included in the Appendices.

## **Issuance of ACAD 92-008**

Subsequent to the program reviews, the Study Group discovered that ACAD 92-008 had been issued to replace INPO 86-018. A comparison of these two documents was performed to determine if the results of the reviews would be affected by the issuance of ACAD 92-008. This comparison indicated that the review results remain valid under the use of ACAD 92-008. This comparison is documented in Attachment B.

## **Identification of Task Skills and Knowledge**

Through the performance of the detailed reviews of the six union apprenticeship programs, the NMA Study Group found that these programs provide qualification for an extensive number of tasks in several different industries. The tasks that the nuclear power industry normally assigns to craft labor union personnel are merely a subset of those tasks addressed in the apprenticeship programs. Through discussions with utility, contractor, and union representatives a list of common tasks assigned to the building trades was developed. For each of these tasks the supporting skills and knowledge topics covered

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in the union apprenticeship program were identified and documented. The task listing for each union provides the trade specific tasks for which journeymen are capable of performing. The task lists are broken down into the categories of Generic, Fabrication/Installation, and Maintenance. This information concentrates on the tasks associated with the nuclear power industry and is not intended to be an all-inclusive list of task qualifications acquired through apprenticeship. The task listing and supporting skills and knowledge is documented in the Appendices.

## **V. Generic Issues**

This section addresses the issues that were generic to all programs reviewed. After this section, results for the specific apprenticeship programs are provided.

### **INPO 86-018 Sections 9 & 10**

Sections 9 & 10 stipulate two different modules for the training program. These are defined below:

#### **Module A (Typical)**

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

#### **Module B (Typical)**

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

### **INPO 86-018 Sections 9.7 & 9.9**

Each topic in these sections may not be specifically addressed in the training materials of the apprenticeship program by the titles used in the INPO document- which are:

1. Basic Atomic and Nuclear Physics
2. Reactor Plant Protection

Four of the programs reviewed (UA, IBEW, Boilermakers, and Millwrights) had sections addressing nuclear power. Successful completion of such a module gives the apprentice more than sufficient basic knowledge of nuclear power plants and their components to allow him/her to successfully receive further training in their skill area. Completion of the modules gives the student a solid understanding of the structure, arrangement, and basic operation of nuclear power plants. The NMAP Study Group believes these modules cover the topics in greater detail than utility "GET" programs for temporary contract employees. Details on how these sections are addressed can be found in the following union specific sections.

The remaining two programs (Iron Workers and Sheet Metal Workers) did not have sections addressing nuclear power. Training in this subject is not necessary considering the limited workscope of the Iron Workers (basic structural steel erection) and the Sheet Metal Workers (installation/modification of HVAC duct). The NMAP Study Group believes the craftsperson receives the appropriate information needed to perform the assigned tasks during the utility "GET" programs.

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## **INPO 86-018 Section 11**

"This section provides the trainee with the knowledge necessary to understand systems and components and apply that information to the job." Subject matrices in INPO 86-018 show the applicability of types of systems and components to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments. Section 11 stipulates up to four different modules for the training program. INPO 86-018 also states "It is expected that a one to two week basic systems and components course would cover the Module A & B recommendations for electricians and maintenance mechanics. A four week course would probably be necessary for instrumentation and control technicians."

- The Study Group feels that the basic system courses are not necessary for temporary contract (craft) employees. The types of work assignments given, and administrative controls exercised over their work, preclude the need for training in areas such as: knowledge of system interaction or unanalyzed safety conditions (50.59).

The extent of applicability of Module C and D definitions were also reviewed. It was determined that, for those topics which were addressed, the apprenticeship program covered the topics in sufficient detail for the types of work normally assigned and the type and amount of additional site specific training normally given.

## **INPO 86-018 Section 12**

This section provides the trainee with the skills necessary to perform maintenance on plant systems and components. This section utilizes up to three modules for the training program.

- These modules deal with training on physical models and mockups of plant equipment. Differences will exist in the amount of equipment available for training at each local and equipment that may be used by utility personnel. These differences are not considered significant because the trainee can still acquire the basic skills required for further training.
- Utilities provide site specific training when necessary by using components identical to actual plant components such as CRD's and specific valve types.

## **On-the-Job-Training (OJT)**

Apprenticeship OJT consists of working at actual jobsites under the direct supervision of a union journeyman. Each specific activity performed by an apprentice during OJT is not always formally documented on checklists, however as a minimum; the local union records the job locations that are assigned and the duration of the assignment.

## **VI. RESULTS OF DETAILED REVIEWS**

### **Pipefitters (UA)**

#### ***Apprenticeship completion requirements:***

United Association of Journeyman and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada (UA).

#### **Prerequisites:**

- High School graduate or GED
- Aptitude test (if required by local JATC)

#### **Program Details:**

- Class room/lab training - 216 hours per year for 5 years - total 1080 hours (min.)
- 8500 - 10000 hours of on the job training (OJT)
- Instructor training program- Certified Instructors

#### ***INPO 86-018 Review***

Results- 82% of the subjects and 77% of the topics listed in INPO 86-018 are addressed. (86 of 105 subjects - 414 of 540 topics)

The subjects and topics applicable to the Pipe Fitter scope of work were adequately addressed by the apprenticeship program.

#### ***Matrix Sections 9.7 & 9.9***

Knowledge and Skill Training for these subjects are addressed in the Nuclear Power Plants section (Information Sheet 74). This section covers areas such as:

1. Principles of Nuclear Energy
2. Basic System and Equipment

#### ***Concerns***

There were no concerns identified through the review of this apprenticeship program.

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## **Electricians (IBEW)**

### ***Apprenticeship completion requirements:***

International Brotherhood of Electrical Workers (IBEW).

### **Prerequisites:**

- High School graduate or GED
- Aptitude test

### **Program Details:**

- Class room/lab training -160 hours per year for 5 years - total 800 hours (min.)
- 8000 hours of on the job training (OJT)
- Instructor training program

### ***INPO 86-018 Review***

Results- 83% of the subjects and 73% of the topics listed in INPO 86-018 are addressed. (86 of 103 subjects - 420 of 578 topics)

The subjects and topics applicable to the Electricians scope of work were adequately addressed by the apprenticeship program.

### ***Matrix Sections 9.7 & 9.9***

Knowledge and Skill Training for these subjects are addressed in the Nuclear Safety section (4-4, 4-5, 4-6, and 4-7), The Structure Matter section (1-20), and Electron Theory section (1-23).

### ***Concerns***

There were no concerns identified through the review of this apprenticeship program.

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## **Boilermakers**

### ***Apprenticeship completion requirements:***

International Brotherhood of Boilermakers - Ship Builders - Blacksmiths - Forgers & Helpers.

### **Prerequisites:**

- High School graduate or GED

### **Program Details:**

- Class room/lab training - 144 hrs year for 4 years - total 576 hours (min.)
- Home Study courses given in addition to classroom hours
- 5200 to 8000 hours of on the job training (OJT)
- Instructor training program- Certified Instructors

### ***INPO 86-018 Review***

Results- 70% of the subjects and 58% of the topics listed in INPO 86-018 are addressed. (73 of 105 subjects- 313 of 542 topics)

The subjects and topics applicable to the Boilermakers scope of work were adequately addressed by the apprenticeship program. The following sections provide a basis for the topics and subjects that were not addressed in a straightforward manner.

### ***Matrix Sections 9.7 - 9.9***

Knowledge and Skill Training for these subjects are addressed in the Related Study Text "Nuclear Power" (Lesson 3-3). This document covers areas such as:

1. Principles of Nuclear Energy
2. Nuclear Fuels, Nuclear Reactors (types and structure)
3. Health Physics and Radiation Protection

***Concerns-*** During the review of the Boilermaker program, two areas of concern were identified. They are:

1. The fact that prior to 1985 the apprenticeship program was home study with no classroom component.
2. That the current program does not address torquing. A significant scope of work assigned to this craft involves torquing. Subsequent to the review we have been advised that a training module on this topic is being developed. (Ref. BNAP letter of 8/31/92) These concerns are being addressed by the committee.



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## **Millwrights**

### ***Apprenticeship completion requirements:***

United Brotherhood of Carpenters and Joiners of America.

### **Prerequisites:**

- High School or GED not required on a national basis, Locals may require

### **Program Details:**

- Class room/lab training - 144 hours per year for 4 years - total 576 hours (min.)
- 5200 to 8000 hours of on the job training (OJT)

Instructor training program

### ***INPO 86-018 Review***

Results- 54% of the subjects and 47% of the topics listed in INPO 86-018 are addressed. (57 of 105 subjects- 254 of 540 topics)

The subjects and topics applicable to the Millwrights scope of work were adequately addressed by the apprenticeship program. The following sections provide a basis for the topics and subjects that were not addressed in a straightforward manner and require an explanation.

### ***Matrix Sections 9.7 - 9.9***

Knowledge and Skill Training for these subjects are addressed in Unit 9, "Nuclear Reactors". This document covers areas such as:

1. Principles of Nuclear Energy
2. Plant System Components
3. Plant Safety Systems

### ***Concerns***

There were no concerns identified through the review of this apprenticeship program.

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## **Iron Workers**

### ***Apprenticeship completion requirements:***

International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers

#### **Prerequisites:**

- High School graduate or GED

#### **Program Details:**

- Class room/lab training - 144 hours per year for 4 years - total 576 hours (min.)
- 8000 hours of on the job training (OJT)
- Instructor training program

### ***INPO 86-018 Review***

Results- 35% of the subjects and 34% of the topics listed in INPO 86-018 are addressed. (37 of 105 subjects - 186 of 540 topics)

The subjects and topics applicable to the Iron Workers scope of work were adequately addressed by the apprenticeship program.

### ***Matrix Sections 9.7 - 9.9***

The apprenticeship program does not include a module that specifically addresses this subject.

### ***Concerns***

There were no concerns identified through the review of this apprenticeship program.

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## **Sheet Metal Workers**

### ***Apprenticeship completion requirements:***

Sheet Metal Workers' International Association (SMWIA) and the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

### **Prerequisites:**

- High School graduate or GED

### **Program Details:**

- Class room/lab training - 144 hours per year for 4 years - total 576 hours (min.) Locals may require more.
- 8000 hours of on the job training (OJT)
- Instructor training program

### ***INPO 86-018 Review***

Results- 40% of the subjects and 27% of the topics listed in INPO 86-018 are addressed. (42 of 105 subjects - 140 of 540 topics)

The subjects and topics applicable to the Sheet Metal Workers' scope of work were adequately addressed by the apprenticeship program.

### ***Matrix Sections 9.7 - 9.9***

The apprenticeship program does not include a module which specifically addresses this subject.

### ***Concerns***

There were no concerns identified through the review of this apprenticeship program.

## **ACKNOWLEDGMENTS**

Many organizations and individuals within those organizations contributed to the NMAP Study effort. The Tripartite Committee would like to identify those who diligently worked the hours necessary to assure the success of the study. This study was carried out over a five year period. As a result, turnover of participants was experienced during this period. The following list attempts to capture all of those involved through the years.

### **Tripartite Committee:**

Dan Shamblin	Commonwealth Edison Company
Len Petrie	Commonwealth Edison Company
Mike Dougherty	Commonwealth Edison Company
Stu Clark	Commonwealth Edison Company
Jim Roach	Florida Power and Light Company
Rich Swiderski	Duquesne Light Company
Kevin O'Connor	Southern California Edison Company
Frank Rothen	Northeast Utilities Company
Dave Ellenberger	Stone & Webster Construction Company
Jack Dakes	Fluor Constructors International, Inc.
Iz Cakrane	United Engineers & Constructors, Inc.
John Brock	Bechtel Construction Company
Tom Pagan	Assosiated Maintenance Contractors
Noel Borck	National Maintenance Agreements Policy Committee
Tom Owens	Building and Construction Trades Dept., AFL-CIO
Randall Gardner	United Association (Pipefitters)
Pat Reilly	International Brotherhood of Electrical Workers
Lew Pugh	United Brotherhood of Carpenters (Millwrights)
Henry Gertz	International Brotherhood of Boilermakers
Ed Pelger	Sheet Metal Workers International Association
Charles Hill	International Association of Bridge, Structural and Ornamental Iron Workers

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### **NMAP Study Group:**

Mike Dougherty	Commonwealth Edison Company
Stu Clark	Commonwealth Edison Company
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### **Primary Contacts for the Union Training Organizations:**

Al Parmenter	United Association (Pipefitters)
Don Ball	United Association (Pipefitters)
Tom Sweat	United Association (Pipefitters)
A.J. Pearson	National Joint Apprenticeship and Training Committee (IBEW)
James Boyd	National Joint Apprenticeship and Training Committee (IBEW)
Dale Shoemaker	United Brotherhood of Carpenters (Millwrights)
Dan Everett	International Brotherhood of Boilermakers
Dave Herrington	National Training Fund (Sheet Metal Workers)
Glen Gibson	International Training Institute (Sheet Metal Workers)
Ray Robertson	International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers
Michael White	International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers
Frank Migliaccio, Jr.	National Ironworkers and Employers Apprenticeship Training and Journeyman Upgrade Fund

The Tripartite Committee extends sincere appreciation to all of those involved in the NMAP Study. This group followed a vision, and can be proud that their efforts have left a mark in the Nuclear training industry.

NMAP

Study Report

Attachments

## **Justification for the Exemption of Apprenticeship Program Review**

### **Introduction**

The requirements of ANSI 3.1 apply to those contractor personnel performing maintenance activities that are considered "Safety Related" or are important to the safe operation of the nuclear plant. This document requires that contractor personnel performing such activities be qualified to the tasks that they perform. Union craft personnel are considered qualified when they hold the "basic skills" to perform the task and have received any Utility or Contractor specific training associated with these tasks.

Nuclear utilities and their associated Contractors use several different craft unions to accomplish the maintenance activities, however, not all of these craft unions perform work that is considered Safety Related or requires a Safety Related skill to perform. For this reason, the review of these craft apprenticeship programs is not necessary. The three categories that provide the basis for the exemption of the apprenticeship program review are indicated below:

Craft union does not perform work that is considered Safety Related.  
The tasks are not addressed by INPO 86-018 (No INPO equivalent task).  
Safety Related skills are verified by performance demonstration.

The following sections will place the craft unions that are exempt from the apprenticeship program review into one of these categories and provide the specific justification for the exemption.

### **Craft Union does not Perform Safety Related Work**

**Insulators-** The scope of their activities is the installation, repair and removal of insulating materials on both Safety Related and Non-safety Related components, piping, and equipment. Even though their activities may be associated with Safety Related systems or components, this work is not considered Safety Related.

**Carpenters-** The scope of their activities is the erection and tear down of scaffolding, and other miscellaneous architectural work. Since scaffolding is a temporary installation, this work is not considered Safety Related. Architectural installations erected by the carpenters also are not considered Safety Related installations for design reasons.

**Roofers-** The scope of their activities is the installation and repair of roofs for both Safety and Non-safety Related plant structure. The roofing activities associated with Safety Related structures are not considered Safety Related.

**Teamsters-** The scope of their activities is limited to the operation of vehicles for transporting materials, personnel, and equipment. These personnel do not directly perform any activities that affect the quality of Safety Related structures, systems or components.

**Laborers-** The scope of their activities is limited to manual labor such as transporting materials, plant cleaning, and plant decontamination work. These personnel do not directly perform any activities that affect the quality of Safety Related structures, systems or components. Additionally, Utilities provide training to these personnel for the plant decontamination activities.

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## *Attachment A*

### **No INPO Equivalent Task**

**Bricklayers-** The scope of their activities is the installation, repair, and removal of masonry block walls in both Safety Related and Non-safety Related plant areas. INPO 86-018 contains no work activities of this type. Additionally, even though their activities may be associated with Safety Related structures; this work is normally not considered Safety Related.

**Concrete Finishers-** The scope of their activities is the finishing work on concrete and grout installations of both Safety Related and Non-safety Related structures. INPO 86-018 contains no work activities of this type.

### **Skills Verified by Performance Demonstration**

**Operating Engineers-** The scope of their work is the operation of mobile or plant cranes and other construction machinery. The operation of cranes may be associated with the lifting of Safety Related components or structures. This activity is considered Safety Related, however, Utilities require craft union personnel to complete a performance demonstration for plant cranes to assure they are capable of performing this task. Therefore, the skills are demonstrated on a case by case basis.

**Painters-** The scope of their activities is the preparation and coating of both Safety Related and Non-safety Related surfaces. The coating of Safety Related surfaces is considered a Safety Related activity. Utilities require craft painters to complete training on Safety Related coating and to complete a performance demonstration to assure they are capable of performing this task. Therefore, the skills are demonstrated on a case by case basis.

Though a detailed review of the apprenticeship programs was not performed due to the reasons stated above, a general review of the union programs was performed to determine the length of the apprenticeship programs, and general requirements of the program. This information was gathered in 1993 and is provided in the attached matrix for each union.



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## Attachment A

### Apprenticeship/Training Program Profile Matrix

	Union		
	Teamsters	Roofers	Insulators
<b>Program Start Date</b>	September 1991	1979	1959
<b>Minimum Education Req'd</b>	None	Local Discretion Typ. High School/GED	High School/GED
<b>Aptitude Tests Req'd?</b>	No	In Some areas	Yes
<b>Program Length</b>	6 Days	3 years	4 years
<b>#Training Hours per year</b>	See comments	144	144
<b># OJT Hours</b>	None	1200-2000	2000
<b>Instructors Certified?</b>	Yes	Yes, some areas	Yes
<b>Certification Process:</b>	80 hours training. Annual Recertification. Brookview National Lab established program for Nuclear Radiation.	Varies with location	Instructors are given Train the Trainer classes.
<b>Home Study Courses Used?</b>	No	Yes, some remote areas	Yes
<b>Home Study Additional to Hours Provided Above?</b>	N/A	Yes	Homework is for class training.
<b>% Journeyman Completing Apprenticeship Program</b>	Unknown	80%	90%
<b>Comments:</b>	Training program is optional for members. Have 7 Stationary schools and 5 mobiles. 56hr. HazMat course given- 8 hr annual refresher. 24 hr. course for BA's position. Plan to set up a national trng program in Constr. and Pipeline div.	Curricula training materials are currently being revised. Estimated completion is for 1994.	Have a good training Program which the locals use to produce quailified journeymen.
<b>Contact:</b>	C. Gagnon- Eastern Conf.	Not provided	Not provided

# Nuclear Mechanic Apprenticeship Process Study Report

## Attachment A

### Apprenticeship/Training Program Profile Matrix

	Union		
	Painters	Plasterers/Cement Masons	Carpenters
<b>Program Start Date</b>	March 1937	Varies by local	1937
<b>Minimum Education Req'd</b>	Generally High School or GED	High School	High School/GED
<b>Aptitude Tests Req'd?</b>	In some areas	Yes	Yes
<b>Program Length</b>	3 years	3 Years	4 Years
<b>#Training Hours per year</b>	144	800	144
<b># OJT Hours</b>	2000	1200	8000
<b>Instructors Certified?</b>	Yes	Yes	Yes
<b>Certification Process:</b>	Initiated a formal 3 year cert. program in 1991. Training given by professors from various Universities. 100 hours training.	Each local has their own certification program.	Use an instructor selection process which validates skill competency and ability to instruct. Attend annual training workshops.
<b>Home Study Courses Used?</b>	Some areas	No	No
<b>Home Study Additional to Hours Provided Above?</b>	No	N/A	N/A
<b>% Journeyman Completing Apprenticeship Program</b>	50%	50%	65%
<b>Comments:</b>	Apprenticeship programs are National Standards registered with US Dept of Labor. Standard program acts as the pattern for local area programs. Curriculum components are nationally established and distributed to the local areas.		Carpenters program has been registered with DOL for many years. Through labor/management efforts, industry is provided with training standards which produce qualified workers. These standards will keep pace with new technology and industry requirements.
<b>Comments:</b>	A. Monroe-Gen'l President	J. Nasca-OP&CMIA	D. Scott-Appr & Trng dept.

# Nuclear Mechanic Apprenticeship Process Study Report

## Attachment A

### Apprenticeship/Training Program Profile Matrix

	Union		
	Bricklayers	Laborers	Operating Engineers
<b>Program Start Date</b>	Information not provided.	1969	1963
<b>Minimum Education Req'd</b>		Varies by local	High School/GED
<b>Aptitude Tests Req'd?</b>		No	Yes
<b>Program Length</b>		Varies- See comments	3 to 4 Years
<b>#Training Hours per year</b>		See comments	144
<b># OJT Hours</b>		0, 2000, 3200, & 4000 depending on trng taken	6000 to 8000
<b>Instructors Certified?</b>		Yes, for Certifying Licensed courses	Yes
<b>Certification Process:</b>		When license requirements exist, union complies (e.g., Kansas requires asbestos instructors to possess a state license).	Some states, instructors Have state vocational Credentials. Some also Certified for Hazardous Waste Removal/ Remediation training.
<b>Home Study Courses Used?</b>		Yes, Learn at home literacy course.	No
<b>Home Study Additional to Hours Provided Above?</b>		Yes	N/A
<b>% Journeyman Completing Apprenticeship Program</b>		75%	15%
<b>Comments:</b>		Most programs are voluntary. Do have a formal apprenticeship in 7 states that meet 29CFR29. Application to US BAT for a national apprenticeship program is pending.	Have 75 local union Training programs Located throughout US. Entry standards May vary due to Programs being under Either state or federal Jurisdiction.
<b>Contact:</b>		John Tippe- Trng Fund	Not provided

# *Nuclear Mechanic Apprenticeship Process Study Report*

## *Attachment B*

### **Comparison of INPO 86-018 with ACAD 92-008 Impact Review for NMAP Study**

As discussed in the Nuclear Mechanic Accreditation Study Report, INPO document INPO 86-018 dated July 1986 titled *Guidelines for Training and Qualification of Maintenance Personnel* was used as the standard in which the apprenticeship programs were measured against. INPO has updated this document and issued it as ACAD 92-008 dated September 1992 (titled the same as INPO 86-018). The NMAP Study Group felt that an evaluation of the new INPO document was necessary to determine if any changes in ACAD 92-008 impacted the results of the NMAP study. The results of this evaluation are provided herein.

When INPO 86-018 was used as the standard, Sections 9, 10, 11, and 12 of this document were used as the basis for the study since they were the sections which correspond to the basic skills related subjects. Therefore, a detailed review of these specific corresponding sections in ACAD 92-008 was reviewed to determine if significant differences existed. The format of ACAD 92-008 does not use the "Module" and "Matrix" approach which INPO 86-018 used. ACAD 92-008 replaces this approach with a simple list of objectives and subjects/topics. In general, ACAD 92-008 was found to be less detailed and did not list as many subjects and topics as INPO 86-018. The following paragraphs contain discussion on each of the sections reviewed.

#### **ACAD 92-008 Section 6- Tools and Equipment Skills Training**

##### **Section 6.1- Hand and Power Tools (INPO 86-018 Sections 10.1 & 10.2)**

There are no significant differences between these sections. INPO 86-018 Sections 10.1 and 10.2 actually contain more subjects/topics than ACAD 92-008.

##### **Section 6.2- Measuring and Test Equipment (INPO 86-018 Section 10.3)**

There are no significant additional requirements in this section. INPO 86-018 Section 10.3 actually contains more subjects/topics than ACAD 92-008.

##### **Section 6.3- Lifting and Handling Equipment (New- No INPO 86-018 Section exists)**

The subject of lifting and handling equipment did not exist in INPO 86-018. Through the NMAP study, it was observed that each union had this area adequately covered. Each union program was found to have extensive training modules on lifting, rigging, and handling. These modules more than satisfy the requirements of Section 6.3.

#### **ACAD 92-008 Section 7- Fundamentals Training (INPO 86-018 Section 9)**

The major subjects are similar and fewer topics are listed in ACAD 92-008. There are no significant differences between these sections.

# *Nuclear Mechanic Apprenticeship Process Study Report*

## *Attachment B*

### **ACAD 92-008 Section 8- Plant Systems and Components Knowledge Training (INPO 86-18 Section 11)**

The format of this section has changed to contain two major sections, General Systems and Component Functions and Advanced System and Component Training. The General Systems and Component Functions section includes eight general objectives that are meant to provide a basic understanding of nuclear plant systems related to the individuals job scope. The Advanced System and Component Training section includes many objectives and then has topics broken down by maintenance discipline (electrical, mechanical, I&C). Although the format is different, the same basic subjects and topics are addressed in ACAD 92-008 and no significant differences exist.

### **ACAD 92-008 Section 9- Plant Component Skills Training (INPO 86-18 Section 12)**

The format of this section is also different from INPO 86-018. This section includes 25 generic and discipline-specific examples of skills to be considered and then lists four main subjects under which additional topics are listed. The major emphasis is performing training on mockups of actual plant equipment. Considering the NMAP Study Group's position that the scope of each craft union is limited and specialized (mockup) training is provided to these personnel on-site when necessary, the differences between ACAD 92-008 and INPO 86-018 are not significant.

### **Conclusion:**

The Study Group feels that a significant difference between ACAD 92-008 and INPO 86-018 did not exist for the sections used as the basis for the NMAP Study. One minor difference did exist (Lifting and Handling Equipment), however, the apprenticeship program review process determined that this area was adequately covered as well. Therefore, the conclusions of the NMAP Study remain valid with the issuance of ACAD 92-008 for implementation by the nuclear industry.

## ANSI Experience Requirements

As previously mentioned, the two nuclear industry standards which establish the qualification requirements for maintenance personnel are ANSI 3.1 (ANSI N18.1) and ACAD 92-008 (INPO 86-018). The requirements from ANSI 3.1 have changed through time, therefore, it is important for a utility to know the specific revision of this document to which they are committed. A utility typically commits to this ANSI standard through their Final (or Updated) Safety Analysis Report, and their Technical Specifications which is considered a part of the nuclear operating license. The commitment may come in the form of a commitment to Regulatory Guide 1.8, *Personnel Selection and Training*, which directs the use of the ANSI standard. Table 1 is a summary of the qualification requirements from the different revisions of ANSI 3.1.

Requirement	ANSI 3.1- 1993	ANSI 3.1- 1987	ANSI 3.1- 1981	ANSI N18.1-1971 & ANSI 3.1- 1978
Education	High School or GED	High School or GED	Journeyman Level	High School or GED
Minimum Experience	<ul style="list-style-type: none"><li>• 1 year related</li><li>• .25 year On-site</li></ul>	<ul style="list-style-type: none"><li>• 2 years related</li><li>• 0.25 year On-site</li></ul>	<ul style="list-style-type: none"><li>• 3 years related</li><li>• Possess ability to perform tasks</li><li>• Understand significance of task on plant operations</li></ul>	<ul style="list-style-type: none"><li>• 3 years related</li><li>• Possess high degree of manual dexterity</li><li>• Capable of learning and applying fundamental skills to work operations</li></ul>

**Table 1-** *Summary of ANSI 3.1 Qualification Requirements*

The requirements of ANSI 3.1 are met through the combination of secondary education, apprenticeship program completion, on the job training, and related work experience. Attachment B provides a detailed explanation of how the ANSI 3.1 requirements are met.

Sections 6 through 9 of ACAD 92-008 provide the requisite knowledge and skills for maintenance personnel. The ACAD 92-008 requirements are met through the combination of the NMAP Study and the NMAP Equivalency process. Through the NMAP Study, it was determined that apprenticeship program completion adequately assured that the requisite knowledge and skills are acquired by union personnel, considering their normally assigned scope of work. The NMAP equivalency process was specifically designed to provide a reasonable level of assurance that the requisite knowledge and skills are help by non-apprentice journeyman. Section VI provides more detail on the equivalency process.

## Compliance with ANSI 3.1 Standard

The method of compliance to the ANSI 3.1 Standard is easiest to describe by making a distinction between three classifications of union personnel since the method is different for these classifications. The three classifications are: those union personnel who completed an apprenticeship program, those who are considered equivalent through experience, and those who are considered equivalent through testing. The

method for compliance to the education and experience requirements for each of these classifications is provided below.

### **Journeyman through Apprenticeship:**

**Education:** High School Graduate or GED- Five of the six union apprenticeship programs require High School Graduation or successful completion of the GED, with the Millwrights being the exception. The Millwright program does not require this at the national level, but local training centers may invoke this requirement. Union personnel from the five trades that require this education who arrive at a nuclear facility with the appropriate NMAP process paperwork satisfy this requirement. For Millwright personnel, additional documentation is needed to assure this education requirement is met. For utilities committed to ANSI3.1- 1981, section 4.5.3 does not require High School education, but rather that the individual be at a “journeyman level”.

**Experience:** From 1 to 3 years related- As identified in the NMAP Study Report, each apprenticeship program requires a specific amount of on the job training (OJT), which is also considered related experience. Since the NMAP process is most effective when satisfying the most stringent requirements, the following basis is for the 3-year experience requirement. The least amount of OJT required by the six programs is a range from 5200 to 8000 hours over the length of the programs. Typically, the OJT process results in 6000 to 7000 hours of OJT. The normal “work year” is not 52 weeks, but rather more like 48 weeks when vacation time, holidays, and training periods are factored in. Using 48 weeks per year as the norm, the number of related experience hours for 3 years is 5760 hours. The OJT process itself normally provides enough related experience to satisfy the ANSI requirement. In addition to this, ANSI 3.1 1987 (para. 4.1.2) and later revisions allow related technical training to be applied in place of experience at a rate of 2 years education for one year experience for a maximum of 2 years.

Earlier revisions of ANSI 3.1 also require that personnel possess a high degree of manual dexterity, and have the capability of learning and applying fundamental skills to work operations. The apprenticeship programs provide both class instruction and hands on instruction and evaluation. Through this process, manual dexterity and the application of fundamental skills to the work are verified.

For the above reasons, the NMAP process considers the ANSI experience requirement to be met through apprenticeship program completion.

### **Journeyman through Equivalency- Experience:**

**Education:** High School Graduate or GED- Since the union programs do not require personnel in this category to have a High School education or GED, additional documentation is needed on an individual by individual basis to assure this education requirement is met. Personnel who do not have the requisite education will be subject to equivalency testing, justification through other documented means, or not referred to a nuclear facility. For utilities committed to ANSI3.1- 1981, section 4.5.3 does not require High School education, but rather that the individual be at a “journeyman level”.

**Experience:** From 1 to 3 years related- The minimum amount of related experience held by an individual in this category is 7500 hours. As mentioned in the previous classification, the requisite hours to meet the 3-year requirement are 5760 hours.

Earlier revisions of ANSI 3.1 also require that personnel possess a high degree of manual dexterity, and have the capability of learning and applying fundamental skills to work operations. The apprenticeship programs provide both class instruction and hands on instruction and evaluation. Through this process, manual dexterity and the application of fundamental skills to the work are verified.

For the above reasons, the NMAP process complies with the ANSI experience requirement.

### **Journeyman through Equivalency- Testing:**

**Education:** High School Graduate or GED- Since the union programs do not require personnel in this category to have a High School education or GED, additional documentation is needed on an individual by individual basis to assure this education requirement is met. Personnel who do not have the requisite education must be justified through other documented means, or not referred to a nuclear facility. For utilities committed to ANSI3.1- 1981, section 4.5.3 does not require High School education, but rather that the individual be at a “journeyman level”.

**Experience:** From 1 to 3 years related- As mentioned in the previous classification, the requisite hours to meet the 3 year requirement is 5760 hours. For personnel within this category, the union must provide documentation that states that personnel meet the experience requirement. Personnel without the requisite experience must be justified through other documented means, or not referred to a nuclear facility.

Earlier revisions of ANSI 3.1 also require that personnel possess a high degree of manual dexterity, and have the capability of learning and applying fundamental skills to work operations. The equivalency testing process contains both knowledge and skills testing. Through this process, manual dexterity and the application of fundamental skills to the work are verified.

For the above reasons, the NMAP process complies with the ANSI experience requirement.



NMAP

Study Report

Appendices

Detailed Review Documents

NMAP

# Study Report

Detailed Review Documents  
Pipefitters

## UA EVALUATION SUMMARY

Title	Section	Number of Subjects	Number of Subjects Addressed	Number of Topics *	Number of Topics Addressed	Number of topics w/ 'S' > 0	Ave 'S'> 0
Mathematics	9.1	7	7	13	11	0	0
Classical Physics	9.2	2	2	35	34	1	2
Electrical Science	9.3	7	7	27	26	0	0
Instrument and Control	9.4	2	2	9	9	0	0
Principles of Radiation Detection	9.5	0	0	0	0	0	0
Properties of Reactor Plant Materials	9.6	7	7	26	26	0	0
Basic Atomic and Nuclear Physics	9.7	5	2	20	5	0	0
Heat transfer and Fluid Flow	9.8	3	3	26	26	0	0
Reactor Plant Protection	9.9	3	0	18	0	0	0
Chemistry	9.10	4	1	26	4	0	0
Hand Tools	10.1	9	9	74	74	0	0
Power Driven Hand Tools	10.2	2	2	16	16	0	0
Measuring and Test Equipment	10.3	4	4	14	12	0	0
<b>Plant Systems and Components</b>							
<b>Knowledge Training</b>							
<b>knowledge</b>							
plant systems matrix	11	5	4	37	27	1	2
rotating equipment matrix	11	5	5	21	19	2	2
heat transfer equipment matrix	11	3	3	12	10	2	2
process conditioning equipment matrix	11	3	1	13	5	4	1.5
electrical equipment matrix	11	2	2	14	12	0	0
control elements matrix	11	3	3	15	14	0	0
instrument and control equipment matrix	11	2	2	13	13	0	0
passive components matrix	11	3	2	10	4	0	0
miscellaneous equipment matrix	11	2	2	13	13	0	0
<b>skills</b>							
plant systems matrix	12	1	0	1	0	0	0
rotating equipment matrix	12	5	3	21	11	3	2
heat transfer equipment matrix	12	3	3	12	9	0	0
process conditioning equipment matrix	12	3	1	13	5	4	1.5
electrical equipment matrix	12	0	0	0	0	0	0
control elements matrix	12	3	3	15	14	0	0
instrument and control equipment matrix	12	2	2	7	3	0	0
passive components matrix	12	3	2	10	4	3	2
miscellaneous equipment matrix	12	2	2	9	8	0	0
totals		105	86	540	414		
<b>subject % addressed</b>		<b>82%</b>					
<b>topic % addressed</b>		<b>77%</b>					
* DOES NOT COUNT TOPICS NOT APPLICABLE TO THIS CRAFT AS DEFINED BY INPO 86-018							


## 9.1 Mathematics





### Module A

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

### Module B

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

 = Not Applicable To This Craft Mech.

Subject	Topic	
Basic Mathematical Concepts	Basic arithmetic functions	ADDRESSED
	Percentage	ADDRESSED
	Square root	ADDRESSED
	Averages	ADDRESSED
Scientific Notation	Conversion	ADDRESSED
	Application of scientific notation	
Dimensional Analysis	Unit conversions	ADDRESSED
	Unit modifiers	ADDRESSED
	Metric measurements	ADDRESSED
Algebra	Basic equation solving	ADDRESSED
	Quadratic equations	
Trigonometry	Basic relationships	ADDRESSED
Geometry	Basic relationships	ADDRESSED
	Vectors	0
Calculus	Concept of rate of change	ADDRESSED
	Concept of integration	ADDRESSED
Analysis of Graphs and Control Charts	Obtaining information from graphs	ADDRESSED
	Rectangular coordinate system	ADDRESSED
	Polar coordinate system	
	Logarithmic coordinate system	

INPO 86-018 COMPARISON PIPE FITTERS

Subject	Topic	
Nomograms	Obtaining information from nomograms	<div>0</div>
Exponents Base	"E" exponents (Natural/Napierian)	<div></div>
Numbering Systems	Binary numbering system	<div></div>
	Octal numbering system	<div></div>
	Hexidecimal numbering system	<div></div>
	Conversion of numbering systems	<div></div>

## 9.2 Classical Physics

### Module A

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

### Module B

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

Subject	Topic	
Units	Systems of units	ADDRESSED
	Units of pressure (vacuum/pressure, differential pressure) measurement	ADDRESSED
	Units of temperature measurement	ADDRESSED
	Units of periodic motion measurement	ADDRESSED
	Units of flow	ADDRESSED
	Units of volume	ADDRESSED
	Units of mass	ADDRESSED
	Units of weight	ADDRESSED
	Units of distance measurement	ADDRESSED
	Units of time measurement	ADDRESSED
Mechanical Principles Acceleration		
	Cams	ADDRESSED
	Conditions of equilibrium	ADDRESSED
	Conservation of energy	ADDRESSED
	Density, height, and temperature effects on process fluids	ADDRESSED
	Energy	ADDRESSED
	Fluid mechanics	ADDRESSED
	Force	ADDRESSED
	Friction	ADDRESSED
	Gear ratios	2
	Gravitation	ADDRESSED
	Heat	ADDRESSED
	Hydraulics	ADDRESSED
	Inclined planes	ADDRESSED

INPO 86-018 COMPARISON PIPE FITTERS

Subject	Topic	
Mechanical Principles Acceleration	Laws of motion	ADDRESSED
	Mass	ADDRESSED
	Momentum	ADDRESSED
	Power	ADDRESSED
	Pulleys	ADDRESSED
	Simple machines	ADDRESSED
	Temperature systems	ADDRESSED
	Temperature system conversions	ADDRESSED
	Translational and rotational motion	ADDRESSED
	Velocity	ADDRESSED
	Weight	ADDRESSED
	Work	ADDRESSED
	-	

### 9.3 Electrical Science

#### Module A

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

#### Module B

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

Subject	Topic	
Basic Electrical	Electron theory	ADDRESSED
	Insulators	ADDRESSED
	Conductors	ADDRESSED
	Static electricity	ADDRESSED
	Magnetism	ADDRESSED
	Direct current (DC)	ADDRESSED
	DC sources	ADDRESSED
	Units of electrical measurement	ADDRESSED
	Fundamental electrical laws	ADDRESSED
	Electrical hazards and safety	ADDRESSED
	Electrical grounds	ADDRESSED
	Basic electrical circuits	ADDRESSED
	Bistables	
	Relays	ADDRESSED
Alternating Current	Basic alternating current theory	ADDRESSED
	Sources	ADDRESSED
	Simple circuits	ADDRESSED
	AC waveforms	
	Inductance and inductive reactance	ADDRESSED
	Mutual inductance and transformers	ADDRESSED
	Capacitance and capacitive reactance	ADDRESSED
	Impedance	ADDRESSED
	Series, parallel and combination circuits	ADDRESSED
	Resonance	ADDRESSED



# INPO 86-018 COMPARISON PIPE FITTERS

Subject	Topic	
Alternating Current	Power factor	ADDRESSED
	Single-phase circuits	ADDRESSED
	Multi-phase circuits	ADDRESSED
Plant Electrical	Sources of electrical power	ADDRESSED
	Switchgear components	0
	Power distribution (AC and DC)	ADDRESSED
Power Transformers	Theory	ADDRESSED
	Internal construction	ADDRESSED
	Tap changers and hazards	ADDRESSED
	Effects of exceeding ratings	ADDRESSED
	Cooling systems	ADDRESSED
	Oil system air entrainment	ADDRESSED
	Safety precautions associated with cooling mediums	ADDRESSED
	Construction of terminal connections	
	Fault symptoms	ADDRESSED
	Fire protection systems	0
Current Transformers	Theory	ADDRESSED
	Use	ADDRESSED
	Hazards	
Potential Transformers	Theory	ADDRESSED
	Use	ADDRESSED
	Hazards	
Advanced Electrical	AC motors	ADDRESSED
	AC generators	ADDRESSED
	DC motors	ADDRESSED
	DC generators	ADDRESSED
	Control circuits	
	utility grid switchgear	0
	Synchrosopes	
	Voltage regulator	0
	Ground detection	0

INPO 86-018 COMPARISON PIPE FITTERS

Subject

Topic

Advanced Electrical

Control circuits for  
in-plant electrical  
switchgear  
Protective relaying  
Lightning arrestors  
Batteries

0
0
ADDRESSED
ADDRESSED

**9.4 Instrumentation and Control****Module A**

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

**Module B**

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

Subject	Topic	
Basic Electronics	Semiconductors	
	Diodes	
	Transistors	
	Amplifier basics	
	Operational amplifiers	
	Integrated circuits	
	Solid state circuitry	
	Wave-shaping circuits	
	Noise suppression techniques	
Digital Electronics	Boolean algebra	
	Combinational logic	
	Sequential logic	
	Logic circuit timing	
	Input/output methods	
	Programming	
Process Measurement	Pressure measurement	ADDRESSED
	Temperature measurement	ADDRESSED
	Fluid flow measurement	ADDRESSED
	Level measurement	ADDRESSED
	Analytical measurements	ADDRESSED
Process Control	Automatic control fundamentals	ADDRESSED
	Basic control circuits	
	Open-loop control	ADDRESSED
	Closed-loop control	ADDRESSED
	Two-position control	ADDRESSED
	Proportional control	
	Reset action	
	Rate action	
	Control loop tuning	

9.5 Principles of Radiation Detection

Module A

Instruction should enable the trainee to identify the location of and applications for each applicable instrument and detector.

Module B

Instruction should enable the trainee to explain the principles of operation for each instrument and detector.

Subject	Topic	
Detectors	Geiger-Mueller (G.M.)	
	Scintillation	
	Proportional counter	
	Ion chamber	
	Fission chamber	
	Self-powered neutron	

## 9.6 Properties of Reactor Plant Materials

### Module A

Instruction should enable the trainee to explain the terms, definitions, and basic concepts and to recognize conditions that are detrimental to reactor plant materials.

Subject	Topic	
Properties of Metals	Structure basics	ADDRESSED
	Changes in structure	ADDRESSED
	Expansion	ADDRESSED
	Embrittlement	ADDRESSED
Alloy	Definition	ADDRESSED
	Applications	ADDRESSED
Brittle Fracture	Characteristics	ADDRESSED
	Mechanisms	ADDRESSED
	Heatup/cooldown effects	ADDRESSED
	Heat treating	ADDRESSED
	Annealing	ADDRESSED
Plant Material Problems	Fatiguefailure/work hardening	ADDRESSED
	Corrosion	ADDRESSED
	Contamination	ADDRESSED
	Radiation-induced embrittlement	
Thermal Shock/Stress	Definition	ADDRESSED
	Causes and effects	ADDRESSED
Strength of Materials	Compressive strength	ADDRESSED
	Tensile strength	ADDRESSED
	Torque limits	ADDRESSED
Corrosion and Corrosion and Control	General	ADDRESSED
	Pit and crevice	ADDRESSED
	Galvanic	ADDRESSED
	Chloride stress	ADDRESSED
	Caustic stress	ADDRESSED
	Stress corrosion cracking	ADDRESSED

## 9.7 Basic Atomic and Nuclear Physics

### Module A

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

Subject	Topic	
Atomic Structure	Atomic mass unit	ADDRESSED
	Protons	ADDRESSED
	Neutrons	ADDRESSED
	Electrons	ADDRESSED
Nuclear Interactions	Ionization	0
	Radiation interactions	0
	Neutron interactions	0
	Radioactive decay process	0
Fission Process	Definition	0
	Theory of fission process	0
	Control of fission process	0
	Neutrons associated with fission	0
	Neutron flux effects on reactor power	0
	Neutron Leakage	
Residual Heat/Decay Heat	Sources of decay heat	ADDRESSED
Reactor Operation	Basic reactor types	0
	Reactor parameters	0
	Power-to-flow relationships	0
	Axial flux	
	Core imbalance	
	Core quadrant power tilt	
	Reactivity	
	Reactor response to control rods	0
	Reactor start-up and shutdown	0
	Reactivity accidents	0

**9.8 Heat Transfer and Fluid Flow****Module A**

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

**Module B**

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

Subject	Topic	
Basic Thermodynamics	Temperature	ADDRESSED
	Sensible heat	ADDRESSED
	Latent heat--vaporization, condensation	ADDRESSED
	Properties of water and steam	ADDRESSED
	Pressure/temperature relationship	ADDRESSED
	Specific volume	ADDRESSED
	Basic steam-water cycle	ADDRESSED
	Steam tables	ADDRESSED
	Specific heat	ADDRESSED
	Boiling	ADDRESSED
	Saturation	ADDRESSED
	Properties of gases, gas-liquid interfaces	ADDRESSED
	Heat transfer mechanisms	ADDRESSED
	Heat cycles (basic)	ADDRESSED
	Heat exchangers	ADDRESSED
Properties of Fluids	Flow rate	ADDRESSED
	Fluid statics	ADDRESSED
	Density	ADDRESSED
	Buoyancy	ADDRESSED
Principles of Fluid Flow	Pump theory	ADDRESSED
	Cavitation	ADDRESSED
	Fluid flow in a closed system	ADDRESSED
	Water hammer	ADDRESSED
	Heating a closed system	ADDRESSED
	Filling and Venting	ADDRESSED
	Draining a closed system	ADDRESSED

**9.9 Reactor Plant Protection****Module A**

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

**Module B**

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

Subject	Topic	
Reactor Plant Protection Concepts	Thermal-hydraulic operating	0
	Safety limits	0
	Limiting conditions for operation	0
	Administrative controls and procedural concepts	0
	Automatic reactor plant protection concepts	0
Design Basis Accident	Discussion	0
	Symptoms and indications	0
	Anticipated radiation levels	0
	Effect on work place	0
	Evacuation criteria	0
	Recovery process	0
Transient Prevention and Mitigation of Core Damage	Integrated plant transient response	0
	Core cooling mechanisms	0
	Potentially damaging operating conditions	0
	Core damage	0
	Hydrogen hazards during accidents	0
	Monitoring critical parameters during accident conditions	0
	Radiation hazards and radiation monitor response	0



**9.10 Chemistry****Module A**

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

**Module B**

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

Subject	Topic	
Fundamentals of Chemistry	Mixtures, solutions, compounds	0
	Properties and uses of gases	0
	oxygen	0
	nitrogen	0
	hydrogen	0
	noble gases	0
	Ideal gas law	0
	Conductivity	0
	Acids and bases	0
	Corrosion chemistry	0
	pH	0
	Ion exchangers	0
Water Chemistry Control	S/G chemistry	0
	Secondary chemistry control	0
	Water chemistry control methods	0
Reactor Water Chemistry	Types of impurities	0
	Sources of impurities	0
	Effects of impurities	0
	Control/removal of impurities	0
	Radiochemistry	0
	Analytical results and core conditions	
	Sampling methods	
	Radiolysis and recombination	0
	Hydrogen gas in reactor water	0

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Subject	Topic	
Principles of Water Treatment	Purpose	ADDRESSED
	Methods	ADDRESSED
	Water quality/purity	ADDRESSED
	Grades of water	ADDRESSED

**SECTION 10****TOOLS AND EQUIPMENT SKILLS TRAINING**

This section 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. Subject matrices show the applicability of types of tools and equipment to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

**10.1 Hand Tools****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

**Module B**

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
- \* explain the limitations of each tool
- \* explain the importance of maintaining tools in excellent condition
- \* describe the common failure mechanism(s) of each type of tool
- \* identify precursors 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., redressing 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 area 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.

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Subject	Topic	
Hammers	Machinist (ballpeen)	ADDRESSED
	Carpenter (claw)	ADDRESSED
	Sledge	ADDRESSED
	Chipping	ADDRESSED
	Slide	ADDRESSED
Mallets	Plastic	ADDRESSED
	Rubber	ADDRESSED
	Rawhide	ADDRESSED
	Brass	ADDRESSED
	Lead	ADDRESSED
Punches	Drift	ADDRESSED
	Center	ADDRESSED
	Pin	ADDRESSED
	Hole	ADDRESSED
	Alignment	ADDRESSED
Wrenches	Open-end	ADDRESSED
	Box-end	ADDRESSED
	Combination	ADDRESSED
	Socket	ADDRESSED
	Socket set attachments	ADDRESSED
	* handles	ADDRESSED
	* extensions	ADDRESSED
	* adapters	ADDRESSED
	Tubing	ADDRESSED
	Adjustable open-end	ADDRESSED
	Adjustable pipe	ADDRESSED
	* open Jaw	ADDRESSED
	* strap	ADDRESSED
	* chain	ADDRESSED
	Slugging	ADDRESSED
	Spanner	ADDRESSED
	* pin	ADDRESSED
	* hook	ADDRESSED
	* face	ADDRESSED
	Hexagonal (Allen)	ADDRESSED
	Splined (Bristol)	ADDRESSED
	Torque	ADDRESSED
Screwdrivers	Flat	ADDRESSED
	Phillips	ADDRESSED
	Reed-Prince	ADDRESSED
	Off set	ADDRESSED
	Holding/starting	ADDRESSED

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Subject	Topic	
Pliers	Slipjoint	ADDRESSED
	Lineman	ADDRESSED
	Needle-nose	ADDRESSED
	Diagonal	ADDRESSED
	Round nose	ADDRESSED
	Duckbill	ADDRESSED
	Snap ring	ADDRESSED
	Parallel jaw	ADDRESSED
	(channel/pump)	ADDRESSED
	Locking	ADDRESSED
	Lockwire	ADDRESSED
Vises and Clamps	Mechanics bench vise	ADDRESSED
	Pipe vise	ADDRESSED
	* yoke	ADDRESSED
	* bench	ADDRESSED
	Vise grips	ADDRESSED
	C-clamps	ADDRESSED
	V-clamps	ADDRESSED
	Spring clamps	ADDRESSED
	Table clamps	ADDRESSED
Cutting	Saws	ADDRESSED
	* wood cutting	ADDRESSED
	* metal cutting	ADDRESSED
	Knives	ADDRESSED
	Scissors/shears	ADDRESSED
	Bolt cutter	ADDRESSED
	Cable cutter	ADDRESSED
	Chisels	ADDRESSED
	Files	ADDRESSED
Other	Crimpers	ADDRESSED
	Nutdrivers	ADDRESSED
	Cable strippers	ADDRESSED
	Wire strippers	ADDRESSED
	Threaders	ADDRESSED
	Benders	ADDRESSED

## 10.2 Power-driven Hand Tools

### Module A

Instruction should enable the trainee to perform the following:

- \* describe administrative controls on power-driven 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 radiologically 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 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 attachments for each tool
- \* describe the function of each attachment
- \* identify power sources that may be connected to power-driven hand tools
- \* identify areas of the plant where power sources are not available
- \* identify power source connection equipment- air hoses, extension cords, connectors, adaptors
- \* explain the limitations of each tool

### Module B

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 precursors of 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 adaptors

### Module C

Instruction should enable the trainee to perform the following:

- \* demonstrate the proper procedure to assemble and disassemble each tool
- \* demonstrate the proper procedure to inspect and clean each tool
- \* demonstrate the proper procedure to adjust and repair each tool

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Subject	Topic	
Pneumatic	Hammer	ADDRESSED
	Drill	ADDRESSED
	Chisel	ADDRESSED
	Grinder	ADDRESSED
	Punch	ADDRESSED
	Wrench	ADDRESSED
	Screwdriver	ADDRESSED
	Saw	ADDRESSED
Electrical	Drill	ADDRESSED
	Grinder	ADDRESSED
	Wrench	ADDRESSED
	Screwdriver	ADDRESSED
	Saw	ADDRESSED
	Spot welder	ADDRESSED
	Heat gun	ADDRESSED
	Vacuum cleaner	ADDRESSED

### 10.3 Measuring and Test Equipment (M&TE)

#### Module A

Instruction should enable the trainee to perform the following:

- \* define calibration
- \* explain requirements for maintaining an audiable calibration program
- \* explain calibration cycle
- \* explain requirements for instruments and test equipment found out of calibration
- \* identify information displayed on calibration sticker
- \* explain use of information on 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
- \* demonstrate procedures for obtaini ng M&TE
- \* identify the types of M&TE
- \* explain the use of inventory lists or printouts in selection of M&TE
- \* define "or equivalent" as applied to M&TE
- \* describe procedures to determine equivalency

#### Module B

Instruction should enable the trainee to perform the following:

- \* explain the special handling procedures for each type of test equipment
  - \* demonstrate proper method of protecting M&TE
    - in a radiologically controlled area
    - in a confined space
    - when working from hights
    - 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
  - \* the proper procedure to connect and disconnect each type of equipment
  - \* the proper procedure to operate each type of equipment
  - \* the proper use of connectors, adaptors, and leads
- Module C Instruction should enable the trainee to demonstrate the following:
- \* the proper procedure to inspect and clean each type of equipment
  - \* the proper procedure to adjust and calibrate each type of equipment
  - \* the proper procedure to repair each type of equipment

Subject	Topic	
General M&TE	All	ADDRESSED
Sources	Current	ADDRESSED
	Frequency	
	Heat	ADDRESSED
	Pressure	ADDRESSED



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Subject	Topic	
Sources	Radiation	
	Resistance	ADDRESSED
	Vibration	
	Voltage	ADDRESSED
Measuring Devices	Capacitance	ADDRESSED
	Current	ADDRESSED
	Distance	ADDRESSED
	Frequency	
	Mass	ADDRESSED
	Pressure	ADDRESSED
	Differential pressure	ADDRESSED
	Resistance	ADDRESSED
	Speed	ADDRESSED
	Temperature	ADDRESSED
	Time	ADDRESSED
	Torque	ADDRESSED
	Vibration	ADDRESSED
	Voltage	ADDRESSED
	Scales	0
	Radiation	0
	Flow	ADDRESSED
Analytical Devices	Oscilloscope	
	Vibration analyzer	ADDRESSED
	Gas analyzer	ADDRESSED
Special Purpose Devices	Plant protection system test set	
	Hydrostatic test set	ADDRESSED
	Inverter test set	
	Leak-rate test set	ADDRESSED

**SECTION 11****PLANT SYSTEMS AND COMPONENTS KNOWLEDGE TRAINING**

This section provides the trainee with the knowledge necessary to understand systems and components and apply that information to the job. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments. It is expected that a one to two week basic systems and components course would cover the recommendations for electricians and maintenance mechanics. A four week course would probably be necessary for instrumentation and control technicians.

**11.1 Plant Systems (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \* explain the purpose
- \* identify the components
- \* identify the alarms and indications affected by maintenance
- \* describe each system at the block diagram level \* explain the importance to plant operations"
- \* identify conditions that preclude safe work in the vicinity of system components
- \* describe the effect of isolating system components on plant operation
- \* identify the basic the interrelationships with other plant systems

**Module B**

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

Subject	Topic	
Primary	NSSS	ADDRESSED
	Containment	ADDRESSED
	Fuel handling/storage	ADDRESSED
	Engineered safety features	ADDRESSED
	Sampling	ADDRESSED
	Reactor protection	ADDRESSED
	Auto control	ADDRESSED
	Steam (BWR)	ADDRESSED
Secondary	Steam (PWR)	ADDRESSED
	Feedwater	ADDRESSED
	Condensate	ADDRESSED
	Sampling	ADDRESSED
	Auto control	ADDRESSED
	Water treatment	ADDRESSED

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Subject	Topic	
Auxiliary	Component cooling	ADDRESSED
	Containment cooling	ADDRESSED
	Air supply	ADDRESSED
	Gas supply	ADDRESSED
	Water supply	ADDRESSED
	Oil	ADDRESSED
	HVAC	ADDRESSED
	Radwaste	0
	Bulk storage	0
	Waste treatment	ADDRESSED
Electrical	Switchyard	0
	Generator	ADDRESSED
	AC distribution	ADDRESSED
	DC distribution	ADDRESSED
	Heat tracing	ADDRESSED
	Grounding	ADDRESSED
Monitoring	Seismic	0
	Loose parts	2
	Radiation	0
	Environmental	0
	Neutron	0
	Plant computer	0
	Safety parameter	0

**11.2 ROTATING EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to identify the vibration limits.

Subject	Topic	
Prime Movers	Electrical	ADDRESSED
	* AC	ADDRESSED
	* DC	ADDRESSED
	Turbine	ADDRESSED
	* impulse	2
	* reaction	2
	Diesel	ADDRESSED
Electrical Generators	Main	ADDRESSED
	Auxiliary	ADDRESSED
	Emergency	ADDRESSED
Pumps	Centrifugal	ADDRESSED
	Positive displacement	ADDRESSED
	Jet	ADDRESSED
Compressors	Rotary vane	ADDRESSED
	Reciprocating	ADDRESSED
	Rotary screw	ADDRESSED
	Centrifugal	ADDRESSED

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Subject	Topic	
Fans	Vaneaxial	ADDRESSED
	Propeller	ADDRESSED
	Squirrel cage	ADDRESSED
	Centrifugal	ADDRESSED

**11.3 HEAT TRANSFER EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Mechanical	Heat exchangers	ADDRESSED
	Feedwater heaters	ADDRESSED
	Steam generator	ADDRESSED
	Moisture separator	2
	Condensers	ADDRESSED
	Cooling towers	ADDRESSED
	Reboilers	ADDRESSED
Electro-mechanical	Air handlers	ADDRESSED
	Refrigeration units	ADDRESSED
Electrical	Recombiners	0
	Heat tracing	ADDRESSED
	Heaters	ADDRESSED

**11.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	2
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	2
	Ejectors	1
	Eductors	1
Mechanical	Filters	ADDRESSED
	Strainers	ADDRESSED
	Screens	ADDRESSED
	Centrifuges	ADDRESSED
	Traps	ADDRESSED

**11.5 ELECTRICAL EQUIPMENT MATRIX (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols to interpret print information
- \*explain the purpose and use of applicable types of equipment

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify indications of normal and abnormal equipment operation during troubleshooting and testing
- \*identify the probable cause of abnormal indications
- identify abnormal conditions that preclude safe work in the vicinity of equipment

**Module C**

Instruction should enable the trainee to perform the following:

- \*locate equipment in panels and cabinets
- \*identify breaker, switch, and disconnect position indications

Subject	Topic	
Supply	Buses	ADDRESSED
	Cables	
	Transformers	ADDRESSED
	* general	ADDRESSED
	* station	0
	* current	ADDRESSED
	* potential	ADDRESSED
	Batteries	ADDRESSED
	Inverters	0
	Battery chargers	ADDRESSED
Control	Switchgear	ADDRESSED
	Breakers	ADDRESSED
	Relays	ADDRESSED
	Switches	ADDRESSED
	Disconnects	ADDRESSED
	High voltage breakers	ADDRESSED



**11.6 CONTROL ELEMENTS MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to explain the proper use of applicable lubricants.

Topic	Subject	
Valves	Gate	ADDRESSED
	Globe	ADDRESSED
	Butterfly	ADDRESSED
	Diaphragm	ADDRESSED
	Ball	ADDRESSED
	Plug	ADDRESSED
	Check	ADDRESSED
	Stop-check	ADDRESSED
	Relief	ADDRESSED
Actuators	Electric	ADDRESSED
	Pneumatic	ADDRESSED
	Explosive	0
Dampers	Blade	ADDRESSED
	Vane	ADDRESSED
	Louver	ADDRESSED

**11.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols
- \*explain the purpose of equipment

**Module B**

Instruction should enable the trainee to identify the following:

- \*the instrument range
- \*the instrument units

**Module C**

Instruction should enable the trainee to identify the following:

- \*the input and output ranges
- \*the input and output medium

**Module D**

Instruction should enable the trainee to identify the following:

- \*the power source(s)
- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Instruments	Sensors	ADDRESSED
	Indicators	ADDRESSED
	Recorders	ADDRESSED
	Switches	ADDRESSED
	Controllers	ADDRESSED
	Positioners	ADDRESSED
	Transmitters	ADDRESSED
	Annunciators	ADDRESSED
	Detectors	ADDRESSED
Electronic Equipment	Analyzers	ADDRESSED
	Signal converters	ADDRESSED
	Monitors	ADDRESSED
	Computers	ADDRESSED

**11.8 PASSIVE COMPONENTS MATRIX (Knowledge)****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

**Module B**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the pressure and volume capacity limits

**Module C**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the flow capacity limits

Subject	Topic	
Pressure Vessels	Containment	ADDRESSED
	Reactor	ADDRESSED
	Pressurize	ADDRESSED
Volume	Tanks	ADDRESSED
	Reservoirs	ADDRESSED
	Pools	ADDRESSED
	Accumulator	ADDRESSED
	Piping	ADDRESSED
	Tubing	ADDRESSED
Flow	Orifice	ADDRESSED

**11.9 MISCELLANEOUS EQUIPMENT MATRIX (Knowledge)****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

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify the load limits
- \*identify the major parts

**Module C**

Instruction should enable the trainee to perform the following:

- \*explain the principles of operation
- \*identify the normal and abnormal indications of equipment performance
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Auxiliary Equipment	Hoists	ADDRESSED
	Elevator	ADDRESSED
	Cranes	ADDRESSED
	Boiler	ADDRESSED
Structural Equipment	Mounts	ADDRESSED
	Bases	ADDRESSED
	Supports	ADDRESSED
	Hangers	ADDRESSED
	Cable trays	ADDRESSED
	Conduit	ADDRESSED
	Fire barriers	ADDRESSED
	Snubbers	ADDRESSED
	Anchor bolts	ADDRESSED

**SECTION 12****PLANT SYSTEMS AND COMPONENTS SKILLS TRAINING**

This section provides the trainee with the skills necessary to perform maintenance on systems and components. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The module indicates the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

**12.1 Plant Systems (Skills)****Module A**

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

Subject	Topic	
Primary	NSSS	
	Containment	
	Fuel Handling/storage	
	Engineered safety features	
	Sampling	
	Reactor protection	
	Auto control	
	Steam (BWR)	
Secondary	Steam (PWR)	ADDRESSED
	Feedwater	ADDRESSED
	Condensate	ADDRESSED
	Sampling	ADDRESSED
	Auto control	ADDRESSED
	Water treatment	ADDRESSED
Auxiliary	Component cooling	ADDRESSED
	Containment cooling	
	Air supply	ADDRESSED
	Gas supply	ADDRESSED
	Water supply	ADDRESSED
	Oil	ADDRESSED
	HVAC	ADDRESSED
	Radwaste	0
	Bulk storage	
Electrical	Switchyard	
	Generator	
	AC distribution	
	DC distribution	
	Heat tracing	ADDRESSED
	Grounding	

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Subject	Topic	
Monitoring	Seismic	
	Loose parts	
	Radiation	
	Environmental	
	Neutron	
	Plant computer	
	Safety parameter	

**12.2 ROTATING EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

**Module B**

Instruction should enable the trainee to demonstrate the ability to measure equipment vibration properly.

**Module C**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to install and remove couplings/belts
- \*the ability to align rotating equipment
- \*the ability to test rotating equipment for "soft feet"
- \*the ability to lubricate designated equipment

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	2
	* impulse	2
	* reaction	2
	Diesel	0
Electrical Generators	Main	0
	Auxiliary	0
	Emergency	0
Pumps	Centrifugal	ADDRESSED
	Positive displacement	ADDRESSED
	Jet	ADDRESSED
Compressors	Rotary vane	ADDRESSED
	Reciprocating	ADDRESSED
	Rotary screw	ADDRESSED
	Centrifugal	ADDRESSED
Fans	Vaneaxial	ADDRESSED
	Propeller	ADDRESSED
	Squirrel cage	ADDRESSED
	Centrifugal	ADDRESSED

**12.3 HEAT TRANSFER EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*methods for breaching equipment or system integrity
- \*techniques for testing tubes for leaks
- \*techniques to repair or plug leaking tubes

**Module B**

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

Subject	Topic	
Mechanical	Heat exchangers	ADDRESSED
	Feedwater heater	ADDRESSED
	Steam generator	2
	Moisture separator	2
	Condensers	ADDRESSED
	Cooling towers	ADDRESSED
	Reboilers	ADDRESSED
Electro-mechanical	Air handlers	ADDRESSED
	Refrigeration units	ADDRESSED
Electrical	Recombiners	0
	Heat tracing	ADDRESSED
	Heaters	ADDRESSED



**12.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*methods of medium removal and replacement
- \*methods for handling and disposing of medium

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	0
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	1
	Ejectors	1
	Eductors	1
Mechanical	Filters	ADDRESSED
	Strainers	ADDRESSED
	Screens	ADDRESSED
	Centrifuges	ADDRESSED
	Traps	ADDRESSED

**12.5 ELECTRICAL EQUIPMENT MATRIX (Skills)****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
- \*repair techniques

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*adjustment and calibration
- \*testing methods

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	
	* general	
	* station	
	* current	
	* potential	
	Batteries	
	Inverters	
	Battery chargers	
Control	Switchgear	
	Breakers	ADDRESSED
	Relays	ADDRESSED
	Switches	
	Disconnects	
	High voltage breakers	

**12.6 CONTROL ELEMENTS MATRIX (Skills)****Module A**

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

**Module B**

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

Subject	Topic	
Valves	Ball	ADDRESSED
	Butterfly	ADDRESSED
	Check	ADDRESSED
	Diaphragm	ADDRESSED
	Gate	ADDRESSED
	Globe	ADDRESSED
	Plug	ADDRESSED
	Stop-check	ADDRESSED
	Relief	ADDRESSED
Actuators	Electric	ADDRESSED
	Explosive	0
	Pneumatic	ADDRESSED
Dampers	Blade	ADDRESSED
	Louver	ADDRESSED
	Vane	ADDRESSED

**12.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Skills)****Module A**

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

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to remove equipment from service properly
- \*assembly and disassembly methods
- \*inspection and cleaning techniques
- \*the ability to logically troubleshoot defective equipment
- \*repair techniques
- \*adjustment and calibration
- \*methods for returning equipment to service
- \*use of special purpose tools and equipment

Subject	Topic	
Instruments	Annunciators	0
	Controllers	
	Indicators	ADDRESSED
	Positioners	ADDRESSED
	Recorders	ADDRESSED
	Sensors	ADDRESSED
	Switches	ADDRESSED
	Transmitters	ADDRESSED
	Detectors	ADDRESSED
Electronic Equipment	Analyzers	0
	Monitors	0
	Computers	0
	Signal converters	

**12.8 PASSIVE COMPONENTS MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*the ability for breaching equipment or system integrity
- \*inspection and cleaning techniques
- \*use of special purpose tools and equipment

Subject	Topic	
Pressure Vessels	Containment	0
	Pressurizer	2
	Reactor	0
Volume	Accumulators	2
	Piping	ADDRESSED
	Pools	0
	Reservoirs	2
	Tanks	ADDRESSED
	Tubing	ADDRESSED
Flow	Orifice	ADDRESSED

**12.9 MISCELLANEOUS EQUIPMENT MATRIX (Skills)****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

**Module B**

Instruction should enable the trainee to demonstrate the ability to lubricate designated equipment.

Subject	Topic	
Auxiliary Equipment	Boilers	ADDRESSED
	Cranes	0
	Elevators	
	Hoists	ADDRESSED
Structural Equipment	Anchor bolts	ADDRESSED
	Bases	ADDRESSED
	Cable trays	
	Conduit	
	Fire barrier	
	Hangers	ADDRESSED
	Mounts	ADDRESSED
	Snubbers	ADDRESSED
	Supports	ADDRESSED

**TRADE SPECIFIC JOB/TASK LISTING  
KNOWLEDGE AND SKILL REQUIREMENTS  
FOR  
PIPEFITTERS**

**GENERIC JOBS:**

**TASK-KNOWLEDGE AND SKILL**

Bolting and Torquing

Identify U.N.C. threads  
Identify U..N.F. threads  
Identify pipe threads  
Identify Metric threads  
Determine class of thread fit  
Identify ASTM and SAE grade marking for standard bolts  
Discuss types of screws, nuts, washers, pins  
Select correct bolts/fasteners for a given job  
Identify bolting sequence for a 4, 6, and 8 pattern  
Define tension, torque, break-away torque  
Demonstrate the use of assorted sizes of torque wrenches  
Discuss using torque wrench adaptors and extensions  
Describe care of torque wrenches

Precision measuring

Precision Level(s)  
Dial Indicator  
Outside Micrometer, 0 to 1”  
Outside Micrometer, 1 to 2”  
Inside Micrometer, 0 to 4”  
Depth Gages  
Telescoping Gages  
Inside Caliper, Small  
Inside Caliper, Large  
Outside Caliper, small  
Outside Caliper, large  
Inside-Outside Calipers  
Beveled protractor  
Surface comparator

Rigging of material/equipment

Follow OSHA Regs 1910/1926  
Inspect and identify rigging hardware  
Select rigging hardware  
Attaching rigging hardware

Tieing knots, splicing rope  
Cribbing machinery  
Determining Safe Working Load of rigging hardware  
Determine Safe Working Load of rigging hitches  
Calculating effective strain on slings  
Using chainfalls and come-alongs  
Using hand rigging signals  
Using voice rigging signals  
Interpreting crane capacity charts  
Splicing cable  
Weight calculations  
Interpreting sling capacity charts

Fabrication of special tools,  
Mock-ups, and parts for  
Support equipment

Describe the need for specialty tools  
Discuss fabrication methods (for specialty tooling)  
Design individual fittings using trigonometry  
Construct patterns for fitting layout and construction  
Layout system/component mock-up  
Design “jigs” to support weld fabrication  
Describe material handling for fabrication of specialty tools.  
Demonstrate ability to torch from sheet steel

Performance of welding activities

*Welding activities at a Nuclear Power Plant are controlled by utility Welding Certification Program. Presently these certifications (qualifications) are not always transferable from utility to utility.*

Operation and maintenance of  
welding and cutting equipment

Demonstrate knowledge of gas welding and soldering equipment  
Demonstrate knowledge of connecting hoses to gas bottles  
Demonstrate ability to properly clean and inspect gas-welding equipment

Reading/interpretation of mechanical  
prints, drawings and P & ID's

Identifying types of lines  
Identifying types of views



Identifying isometric drawings  
Determining dimensions of objects on drawings  
Determine scale of drawing  
Interpreting bill of materials  
Interpreting title block  
Identifying types of sections  
Identifying special views  
Identify piping symbols  
Interpret flow and spool sheets  
Interpreting tolerances  
Identifying exploded views  
Interpreting material designation  
Determine basic welding symbols  
Determine location and size of radii  
Reference specification  
Demonstrate field sketching  
Measurement take-offs

#### Core drilling

Demonstrate ability to lay out drilling position(s)  
Demonstrate use of rebar locating equipment  
Select proper drilling/cutting equipment for a core drilling test sample  
Demonstrate core sample testing

#### Pneumatic controls

Discuss elements of pneumatic system  
Describe how a pneumatic system works  
Discuss selecting control systems  
Discuss operator and final control elements  
Discuss function of controllers  
Discuss thermostats (type/capacity)  
Describe sensor control system  
Describe air supply systems and equipment  
Discuss miniature diaphragm, pneumatic relays and switches  
Discuss general maintenance of pneumatic control systems

#### Instrumentation and automated systems

Describe the following components of the mechanical instrument family:

- Pressure measuring instruments
- Liquid level instruments
- Density measuring instruments

- Temperature measuring instruments
- Humidity measuring instruments
- Speed and position transmitters
- Automatic force balance controllers
- Pneumatic control valves
- Control valve accessories
- Control valve instrumentation systems

## **FABRICATION/INSTALLATION**

### **Small bore piping installations**

Use of plant drawings, procedures and administration forms

Lay out gasket blowholes

Identification of piping components:

- Union            - Coupling
- Nipple           - Elbow
- Street elbow - Bell reducer
- Bushing        - Cross
- Pipe "T"        - Flanges
- Supports       - Hangers
- Spool pieces

Methods of inspecting pipe

Method of assembling piping joints

Determination of proper thread engagement for pipe fittings

Identification and use of trade hand tools

Determine cleanliness standard for material and equipment

### **Large bore piping installations**

Use of plant drawings, procedures and administration forms

Lay out gasket blowholes

Identification of piping components:

- Union            - Coupling
- Nipple           - Elbow
- Street elbow - Bell reducer
- Bushing        - Cross
- Pipe "T"        - Flanges
- Supports       - Hangers
- Spool pieces

Methods of inspecting pipe

Method of assembling piping joints

Inspect pipe threads for physical damage

	Lubricate pipe threads Determination of proper thread engagement for pipe fittings Identification and use of trade hand tools Determine cleanliness standard for material and equipment
<u>Instrument tubing and supports</u>	Knowledge of tools and equipment use for tubing installation Measure tubing for overall length required Manipulate/bend tubing Prepare/cut tubing ends for flaring/compression fittings Install tubing nuts and flair tubing ends/compression fittings Install tubing to existing fitting/compression fitting Install hangers to hold tubing in proper position
<u>Capped test connection</u>	Identify test connection from drawings Identify proper connection cap Clean connection Identify sealant requirements Install cap on test
<u>Bending of small bore process piping and instrument tubing</u>	Select proper piping/tubing IAW work plan Measure tubing length Make field sketch/template Using tools of the trade, make piping bends IAW piping code
<u>System components (valves, flowmeters, strainers, filters, steam traps, etc.)</u>	Select system components from work package approved parts list Verify system/component is cleared and released for work Assemble installation equipment Establish work boundaries Verify component to current drawing Verify form, fit, and function Document as found condition(s)

Install component  
Post installation test IAW work plan

### Expansion joints

Discuss expansion joint types  
Describe expansion joint uses  
Discuss expansion joint locations  
Discuss installation and position of guides  
Discuss installation of anchors  
Discuss movement of pipe in any direction  
Discuss proper pipe alignment  
Describe expansion “U” bend

### Concrete expansion anchors

Prepare layout of area for anchor bolt/stud installation  
Verify size and depth of hole to be drilled  
Measure desired hole depth on drill bit  
Insert drill bit into anchor installation device  
Drill hole for anchor bolt(s)  
Clean hole  
Install nut on stud  
Measure distance from top of nut to anchor bolt top  
Insert anchor bolt into hole  
Torque all anchor bolts  
Check nut for full engagement

### HVAC controls and supports

Describe the function of the following HVAC control components:

- Automatic expansion valves
- Thermostat controls
- Sensor controller systems
- Humidity sensor
- Pressure sensor
- Insertion and immersion temperature

Controllers

- Humidity controllers
- Pressure controllers

Describe the two general categories of HVAC Controls

- Operating controls
- Safety controls

Describe types of support use for HVAC Controls

- Rigid mounted
- Shock mounted

### Storage tanks

Discuss tank safety precaution  
 Discuss need for storage tank safety valves  
 Discuss storage tank testing  
 Discuss storage tank ventilation  
 Discuss confined space in relation to storage tank work

### Heat exchangers

Discuss types of heat exchangers  
 Discuss typical heat exchanger components  
 Using a P & I D  
 Discuss heat exchanger safety precaution  
 Discuss heat exchanger leak testing  
 Discuss heat exchanger mountings/positions  
 Discuss confined space in relation heat exchanger work

### Boilers

Discuss boiler safety  
 Discuss boiler code  
 Discuss code inspection requirements  
 Discuss boiler construction (low/high pressure)  
 Discuss boiler-piping accessories  
 Discuss steam/condensate system  
 High pressure relief  
 Low water causes/conditions  
 Low water protection

### Condensers

Discuss the following types of condensers

- Shell-and-tube condenser
- Double-pipe condenser
- Shell-and-coil condenser
- Induced-draft evaporative condenser

Describe condenser cleaning methods  
 Discuss condenser leak detection  
 Describe use of tube sheet map  
 Discuss safety precautions when performing any condenser work

### Air compressors

Discuss air compressor safety  
Discuss air compressor types  
Discuss air compressor components  
Describe air compressor installation criteria  
Discuss air compressor controls/mountings/supports  
Describe air compressor relief protection  
Describe post-installation acceptance testing

### Pumps

Discuss the following type pumps (installed in Nuclear Power Plant Systems)

- Reciprocating
- Centrifugal
- Rotary
- Peripheral

Discuss pump installation considerations

- Foundation
- Mounting
- Coupling alignment
- Grouting

### Core drilling

Drilling location precautions  
Concrete types  
Rebar locator  
Space integrity

### Valves (gate, globe, ball, butterfly, check)

Discuss valve installation considerations

- Valve position
- Adverse effects of different positions
- Proper assembly of valves
  - Threaded
  - Flanged
  - Welded
- Valve location
  - Hand-wheel location
  - Too high
  - To low
  - Exposed to danger

Discuss valve certification  
Discuss valve installation by welding

## **MAINTENANCE:**

### **Repair/replacement of damaged or degraded piping and tubing**

Establish work boundaries  
Verify components/parts match in form, fit, and function to ones being replaced  
Document “as found” condition  
Repair/replace damaged piping and/or tubing IAW work plan  
Demonstrate ‘bag & tag’ during work  
Discuss foreign material exclusion (FME)  
Conduct close-out inspection including FME  
Document FME inspection and “as-left” condition  
Clean work area, restore system to normal

### **Repair/replacement of damaged or degraded system components**

Establish work boundaries  
Obtain necessary tools and equipment to work the job  
Verify components/parts match in form, fit, and function to ones being replaced  
Document “as found” condition of component  
Repair/replace damaged component IAW work plan  
Demonstrate ‘bag & tag’ during work  
Discuss foreign material exclusion (FME)  
Conduct close-out inspection including FME  
Document FME inspection and “as-left” condition  
Dispose of removed components/parts IAW work package instructions  
Clean work area, restore system to normal

### **Removal/repair/replacement of piping supports**

Establish work boundaries  
Verify need for weld/flame cut documents  
Obtain proper work authorization  
Verify components/parts match in form, fit, and function to ones being replaced  
Document “as found” condition  
Repair/replace damaged piping supports IAW work plan  
Demonstrate ‘bag & tag’ during work  
Document “as-left” condition  
Clean work area, restore system to normal

## Valve repacking

Discuss valve packing materials

- Vegetable fibers
- Asbestos
- Carbon and Graphite
- TFE (teflon)
- Metals

Discuss packing design and construction

- Fiber packing
  - Twisted
  - Braid-over-braid
  - Braid-over-core
  - Square braid
  - Diagonal braid
- Metal packing
  - Folding
  - Twisting
  - Spirally wrapping
- Plastic packing
  - Homogeneous mixture of materials
- Ribbon packing
  - Normally pure graphite
  - Corrugated construction
  - Die-molded
  - Shape by compression
- Packing lubricants
  - Primary purpose (reduce friction)
  - Easier installation and removal of packing
  - Easier valve operation
  - Minimize dry-out

Establish work boundaries

Verify all replacement packing is listed  
on parts page of work package

Document “as found” condition of valve

Discuss packing removal and installation

- Removal all old packing
- No damage to stem or stuffing box
- Clean all components

Discuss packing configurations

- Standard bulk
- Combination sets of bulk packing
- Die-molded packing sets
- Graphite ribbon packing



- Live loading
- Demonstrate 'bag & tag' during work
- Discuss foreign material exclusion (FME)
- Conduct close-out inspection including FME

Installation of Hilti concrete expansion anchors

Drilling layout  
 Rebar locator  
 Drill bit depth marked/verified  
 Drill hole for Hilti  
 Set Hilti anchor  
 Clean work area

Repair HVAC supports

Verify components/parts match in form, fit, and function to ones being replaced  
 Document "as found" condition  
 Repair/replace damaged HVAC supports  
 Demonstrate 'bag & tag' during work  
 Document "as-left" condition

Installation of temporary components (equipment) to support testing

Establish work boundaries  
 Verify all test equipment meets calibration standards  
 Observe all applicable safety precautions  
 Install test equipment as required  
 Document exact installation sequence  
 Verify operability of installed test equipment  
 Remove test equipment when directed  
 Re-verify test equipment calibration and operability  
 Document calibration and operability

**Note:** This listing of tasks is intended to be used in determining the training requirements for contracted craft labor personnel at a Nuclear Power Plant. The list *is not* designed or intended for determining jurisdictional work assignments. The contractor is responsible for supplying the utility with qualified craft. He is also responsible for making appropriate work assignments based on the applicable work agreement.

NMAP

# Study Report

Detailed Review Documents  
Electricians

IBEW EVALUATION SUMMARY

Title	Section	Number of Subjects	Number of Subjects Addressed	Number of Topics	Number of Topics * Addressed	Number of topics w/ 'S' > 0	Ave 'S'> 0
Mathematics	9.1	8	8	16	16	0	0
Classical Physics	9.2	2	2	35	22	5	1.2
Electrical Science	9.3	7	7	57	54	2	1
Instrument and Control	9.4	4	4	19	19	0	0
Principles of Radiation Detection	9.5	0	0	0	0	0	0
Properties of Reactor Plant Materials	9.6	6	6	17	6	0	0
Basic Atomic and Nuclear Physics	9.7	5	5	19	15	0	0
Heat transfer and Fluid Flow	9.8	3	3	21	13	0	0
Reactor Plant Protection	9.9	3	3	18	15	0	0
Chemistry	9.1	4	4	26	8	0	0
Hand Tools	10.1	9	9	76	72	3	2
Power Driven Hand Tools	10.2	2	2	16	16	0	0
Measuring and Test Equipment	10.3	4	4	32	30	1	2
<b>Plant Systems and Components</b>							
<b>Knowledge Training</b>							
<b>knowledge</b>							
plant systems matrix	11	5	5	37	13	1	2
rotating equipment matrix	11	5	1	21	14	7	1.3
heat transfer equipment matrix	11	3	3	11	5	0	0
process conditioning equipment matrix	11	3	1	12	0	0	0
electrical equipment matrix	11	2	2	16	16	0	0
control elements matrix	11	3	1	28	16	0	0
instrument and control equipment matrix	11	2	1	13	2	0	0
passive components matrix	11	3	0	9	2	0	0
miscellaneous equipment matrix	11	2	2	13	13	0	0
<b>skills</b>							
plant systems matrix	12	3	3	9	9	0	0
rotating equipment matrix	12	3	3	11	6	0	0
heat transfer	12	2	0	5	0	0	0
process conditioning equipment	12	0	0	0	0	0	0
electrical equipment matrix	12	2	2	16	15	0	0
control elements matrix	12	2	1	4	4	0	0
instrument and control equipment matrix	12	2	2	9	9	0	0
passive components matrix	12	2	0	3	1	0	0
miscellaneous equipment matrix	12	2	2	9	9	0	0
totals		103	86	578	420		
subject % addressed		83%					
topic % addressed		73%					
* DOES NOT COUNT TOPICS NOT APPLICABLE TO THIS CRAFT AS DEFINED BY INPO 86-018							

**9.1 Mathematics****Module A**

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

- Not Applicable  
To This Craft  
Mech.

**Module B**

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

Subject	Topic	
Basic Mathematical Concepts	Basic arithmetic functions	ADDRESSED
	Percentage	ADDRESSED
	Square root	ADDRESSED
	Averages	ADDRESSED
Scientific Notation	Conversion	ADDRESSED
	Application of scientific notation	ADDRESSED
Dimensional Analysis	Unit conversions	ADDRESSED
	Unit modifiers	ADDRESSED
	Metric measurements	ADDRESSED
Algebra	Basic equation solving	ADDRESSED
	Quadratic equations	ADDRESSED
Trigonometry	Basic relationships	ADDRESSED
Geometry	Basic relationships	ADDRESSED
	Vectors	ADDRESSED
Calculus	Concept of rate of change	ADDRESSED
	Concept of integration	ADDRESSED
Analysis of Graphs and Control Charts	Obtaining information from graphs	ADDRESSED
	Rectangular coordinate system	ADDRESSED
	Polar coordinate system	ADDRESSED
	Logarithmic coordinate system	

# INPO 86-018 COMPARISON ELECTRICIANS

Subject	Topic	
Nomograms	Obtaining information from nomograms	ADDRESSED
Exponents Base	"E" exponents (Natural/Napierian)	
Numbering Systems	Binary numbering system	ADDRESSED
	Octal numbering system	ADDRESSED
	Hexidecimal numbering system	ADDRESSED
	Conversion of numbering systems	ADDRESSED

## 9.2 Classical Physics

### Module A

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

### Module B

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

Subject	Topic	
Units	Systems of units	ADDRESSED
	Units of pressure (vacuum/pressure, differential pressure) measurement	ADDRESSED
	Units of temperature measurement	ADDRESSED
	Units of periodic motion measurement	ADDRESSED
	Units of flow	ADDRESSED
	Units of volume	ADDRESSED
	Units of mass	ADDRESSED
	Units of weight	ADDRESSED
	Units of distance measurement	ADDRESSED
	Units of time measurement	ADDRESSED
Mechanical Principles Acceleration	Cams	1
	Conditions of equilibrium	1
	Conservation of energy	1
	Density, height, and temperature effects on process fluids	ADDRESSED
	Energy	ADDRESSED
	Fluid mechanics	0
	Force	ADDRESSED
	Friction	ADDRESSED
	Gear ratios	ADDRESSED
	Gravitation	ADDRESSED
	Heat	ADDRESSED
	Hydraulics	0
	Inclined planes	2

# INPO 86-018 COMPARISON ELECTRICIANS

Subject

Topic

Mechanical Principles  
Acceleration

Laws of motion  
Mass  
Momentum  
Power  
Pulleys  
Simple machines  
Temperature systems  
Temperature system  
conversions  
Translational and  
rotational motion  
Velocity  
Weight  
Work

0
0
0
ADDRESSED
ADDRESSED
0
ADDRESSED
ADDRESSED
ADDRESSED
1
0
0

### 9.3 Electrical Science

#### Module A

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

#### Module B

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

Subject	Topic	
Basic Electrical	Electron theory	ADDRESSED
	Insulators	ADDRESSED
	Conductors	ADDRESSED
	Static electricity	ADDRESSED
	Magnetism	ADDRESSED
	Direct current (DC)	ADDRESSED
	DC sources	ADDRESSED
	Units of electrical measurement	ADDRESSED
	Fundamental electrical laws	ADDRESSED
	Electrical hazards and safety	ADDRESSED
	Electrical grounds	ADDRESSED
	Basic electrical circuits	ADDRESSED
	Bistables	ADDRESSED
	Relays	ADDRESSED
Alternating Current	Basic alternating current theory	ADDRESSED
	Sources	ADDRESSED
	Simple circuits	ADDRESSED
	AC waveforms	ADDRESSED
	Inductance and inductive reactance	ADDRESSED
	Mutual inductance and transformers	ADDRESSED
	Capacitance and capacitive reactance	ADDRESSED
	Impedance	ADDRESSED
	Series, parallel and combination circuits	ADDRESSED
	Resonance	ADDRESSED



# INPO 86-018 COMPARISON ELECTRICIANS

Subject	Topic	
Alternating Current	Power factor	ADDRESSED
	Single-phase circuits	ADDRESSED
	Multi-phase circuits	ADDRESSED
Plant Electrical	Sources of electrical power	ADDRESSED
	Switchgear components	ADDRESSED
	Power distribution (AC and DC)	ADDRESSED
Power Transformers	Theory	ADDRESSED
	Internal construction	ADDRESSED
	Tap changers and hazards	ADDRESSED
	Effects of exceeding ratings	ADDRESSED
	Cooling systems	ADDRESSED
	Oil system air entrainment	1
	Safety precautions associated with cooling mediums	ADDRESSED
	Construction of terminal connections	ADDRESSED
	Fault symptoms	ADDRESSED
	Fire protection systems	ADDRESSED
Current Transformers	Theory	ADDRESSED
	Use	ADDRESSED
	Hazards	ADDRESSED
Potential Transformers	Theory	ADDRESSED
	Use	ADDRESSED
	Hazards	ADDRESSED
Advanced Electrical	AC motors	ADDRESSED
	AC generators	ADDRESSED
	DC motors	ADDRESSED
	DC generators	ADDRESSED
	Control circuits	
	utility grid switchgear	0
	Synchrosopes	ADDRESSED
	Voltage regulator	ADDRESSED
	Ground detection	ADDRESSED

INPO 86-018 COMPARISON ELECTRICIANS

Subject

Topic

Advanced Electrical

Control circuits for  
in-plant electrical  
switchgear  
Protective relaying  
Lightning arrestors  
Batteries

ADDRESSED
ADDRESSED
1
ADDRESSED

## 9.4 Instrumentation and Control

### Module A

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

### Module B

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

Subject	Topic	
Basic Electronics	Semiconductors	ADDRESSED
	Diodes	ADDRESSED
	Transistors	ADDRESSED
	Amplifier basics	ADDRESSED
	Operational amplifiers	ADDRESSED
	Integrated circuits	ADDRESSED
	Solid state circuitry	ADDRESSED
	Wave-shaping circuits	ADDRESSED
	Noise suppression techniques	ADDRESSED
Digital Electronics	Boolean algebra	ADDRESSED
	Combinational logic	ADDRESSED
	Sequential logic	ADDRESSED
	Logic circuit timing	
	Input/output methods	ADDRESSED
	Programming	ADDRESSED
Process Measurement	Pressure measurement	ADDRESSED
	Temperature measurement	ADDRESSED
	Fluid flow measurement	ADDRESSED
	Level measurement	ADDRESSED
	Analytical measurements	ADDRESSED
Process Control	Automatic control fundamentals	ADDRESSED
	Basic control circuits	ADDRESSED
	Open-loop control	ADDRESSED
	Closed-loop control	ADDRESSED
	Two-position control	ADDRESSED
	Proportional control	ADDRESSED
	Reset action	ADDRESSED
	Rate action	ADDRESSED
	Control loop tuning	ADDRESSED

9.5 Principles of Radiation Detection

Module A

Instruction should enable the trainee to identify the location of and applications for each applicable instrument and detector.

Module B

Instruction should enable the trainee to explain the principles of operation for each instrument and detector.

Subject	Topic	
Detectors	Geiger-Mueller (G.M.)	ADDRESSED
	Scintillation	ADDRESSED
	Proportional counter	ADDRESSED
	Ion chamber	ADDRESSED
	Fission chamber	
	Self-powered neutron	

## 9.6 Properties of Reactor Plant Materials

### Module A

Instruction should enable the trainee to explain the terms, definitions, and basic concepts and to recognize conditions that are detrimental to reactor plant materials.

Subject	Topic	
Properties of Metals	Structure basics	0
	Changes in structure	0
	Expansion	0
	Embrittlement	0
Alloy	Definition	0
	Applications	0
Brittle Fracture	Characteristics	
	Mechanisms	
	Heatup/cooldown effects	
	Heat treating	
	Annealing	
Plant Material Problems	Fatiguefailure/work hardening	ADDRESSED
	Corrosion	ADDRESSED
	Contamination	0
	Radiation-induced embrittlement	
Thermal Shock/Stress	Definition	0
	Causes and effects	0
Strength of Materials	Compressive strength	0
	Tensile strength	0
	Torque limits	ADDRESSED
Corrosion and Corrosion and Control	General	ADDRESSED
	Pit and crevice	ADDRESSED
	Galvanic	ADDRESSED
	Chloride stress	
	Caustic stress	
	Stress corrosion cracking	

## 9.7 Basic Atomic and Nuclear Physics

### Module A

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

Subject	Topic	
Atomic Structure	Atomic mass unit	ADDRESSED
	Protons	ADDRESSED
	Neutrons	ADDRESSED
	Electrons	ADDRESSED
Nuclear Interactions	Ionization	ADDRESSED
	Radiation interactions	ADDRESSED
	Neutron interactions	0
	Radioactive decay process	ADDRESSED
Fission Process	Definition	ADDRESSED
	Theory of fission process	ADDRESSED
	Control of fission process	ADDRESSED
	Neutrons associated with fission	ADDRESSED
	Neutron flux effects on reactor power	0
	Neutron Leakage	
Residual Heat/Decay Heat	Sources of decay heat	0
Reactor Operation	Basic reactor types	ADDRESSED
	Reactor parameters	ADDRESSED
	Power-to-flow relationships	0
	Axial flux	
	Core imbalance	
	Core quadrant power tilt	
	Reactivity	ADDRESSED
	Reactor response to control rods	ADDRESSED
	Reactor start-up and shutdown	ADDRESSED
	Reactivity accidents	ADDRESSED

## 9.8 Heat Transfer and Fluid Flow

### Module A

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

### Module B

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

Subject	Topic	
Basic Thermodynamics	Temperature	ADDRESSED
	Sensible heat	ADDRESSED
	Latent heat--vaporization, condensation	ADDRESSED
	Properties of water and steam	ADDRESSED
	Pressure/temperature relationship	ADDRESSED
	Specific volume	ADDRESSED
	Basic steam-water cycle	
	Steam tables	
	Specific heat	ADDRESSED
	Boiling	ADDRESSED
	Saturation	ADDRESSED
	Properties of gases, gas-liquid interfaces	ADDRESSED
	Heat transfer mechanisms	ADDRESSED
	Heat cycles (basic)	ADDRESSED
	Heat exchangers	ADDRESSED
Properties of Fluids	Flow rate	ADDRESSED
	Fluid statics	ADDRESSED
	Density	ADDRESSED
	Buoyancy	0
Principles of Fluid Flow	Pump theory	0
	Cavitation	0
	Fluid flow in a closed system	0
	Water hammer	0
	Heating a closed system	ADDRESSED
	Filling and Venting	0
	Draining a closed system	0

## 9.9 Reactor Plant Protection

### Module A

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

### Module B

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

Subject	Topic	
Reactor Plant Protection Concepts	Thermal-hydraulic operating	ADDRESSED
	Safety limits	ADDRESSED
	Limiting conditions for operation	ADDRESSED
	Administrative controls and procedural concepts	ADDRESSED
	Automatic reactor plant protection concepts	ADDRESSED
Design Basis Accident	Discussion	ADDRESSED
	Symptoms and indications	ADDRESSED
	Anticipated radiation levels	ADDRESSED
	Effect on work place	ADDRESSED
	Evacuation criteria	ADDRESSED
	Recovery process	0
Transient Prevention and Mitigation of Core Damage	Integrated plant transient response	0
	Core cooling mechanisms	ADDRESSED
	Potentially damaging operating conditions	ADDRESSED
	Core damage	ADDRESSED
	Hydrogen hazards during accidents	0
	Monitoring critical parameters during accident conditions	ADDRESSED
	Radiation hazards and radiation monitor response	ADDRESSED



## 9.10 Chemistry

### Module A

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

### Module B

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

Subject	Topic	
Fundamentals of Chemistry	Mixtures, solutions, compounds	ADDRESSED
	Properties and uses of gases	ADDRESSED
	oxygen	ADDRESSED
	nitrogen	ADDRESSED
	hydrogen	ADDRESSED
	noble gases	0
	Ideal gas law	ADDRESSED
	Conductivity	ADDRESSED
	Acids and bases	0
	Corrosion chemistry	ADDRESSED
	pH	0
	Ion exchangers	0
Water Chemistry Control	S/G chemistry	0
	Secondary chemistry control	0
	Water chemistry control methods	
Reactor Water Chemistry	Types of impurities	0
	Sources of impurities	0
	Effects of impurities	0
	Control/removal of impurities	0
	Radiochemistry	0
	Analytical results and core conditions	
	Sampling methods	0
	Radiolysis and recombination	0
	Hydrogen gas in reactor water	0

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Subject	Topic	
Principles of Water Treatment	Purpose	0
	Methods	0
	Water quality/purity	0
	Grades of water	0

## SECTION 10

### TOOLS AND EQUIPMENT SKILLS TRAINING

This section 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. Subject matrices show the applicability of types of tools and equipment to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

#### 10.1 Hand Tools

##### 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

##### Module B

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
- \* explain the limitations of each tool
- \* explain the importance of maintaining tools in excellent condition
- \* describe the common failure mechanism(s) of each type of tool
- \* identify precursors 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., redressing 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 area 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.

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Subject	Topic	
Hammers	Machinist (ballpeen)	ADDRESSED
	Carpenter (claw)	ADDRESSED
	Sledge	ADDRESSED
	Chipping	ADDRESSED
	Slide	ADDRESSED
Mallets	Plastic	ADDRESSED
	Rubber	ADDRESSED
	Rawhide	ADDRESSED
	Brass	ADDRESSED
	Lead	ADDRESSED
Punches	Drift	ADDRESSED
	Center	ADDRESSED
	Pin	ADDRESSED
	Hole	ADDRESSED
	Alignment	ADDRESSED
Wrenches	Open-end	ADDRESSED
	Box-end	ADDRESSED
	Combination	ADDRESSED
	Socket	ADDRESSED
	Socket set attachments	ADDRESSED
	* handles	ADDRESSED
	* extensions	ADDRESSED
	* adapters	ADDRESSED
	Tubing	ADDRESSED
	Adjustable open-end	ADDRESSED
	Adjustable pipe	ADDRESSED
	* open Jaw	ADDRESSED
	* strap	ADDRESSED
	* chain	ADDRESSED
	Slugging	ADDRESSED
	Spanner	ADDRESSED
	* pin	ADDRESSED
	* hook	ADDRESSED
	* face	
	Hexagonal (Allen)	ADDRESSED
	Splined (Bristol)	ADDRESSED
	Torque	ADDRESSED
Screwdrivers	Flat	ADDRESSED
	Phillips	ADDRESSED
	Reed-Prince	2
	Off set	ADDRESSED
	Holding/starting	ADDRESSED

# INPO 86-018 COMPARISON ELECTRICIANS

Subject	Topic	
Pliers	Slipjoint	ADDRESSED
	Lineman	ADDRESSED
	Needle-nose	ADDRESSED
	Diagonal	ADDRESSED
	Round nose	ADDRESSED
	Duckbill	ADDRESSED
	Snap ring	2
	Parallel jaw	ADDRESSED
	(channel/pump)	ADDRESSED
	Locking	ADDRESSED
	Lockwire	2
Vises and Clamps	Mechanics bench vise	ADDRESSED
	Pipe vise	ADDRESSED
	* yoke	ADDRESSED
	* bench	ADDRESSED
	Vise grips	ADDRESSED
	C-clamps	ADDRESSED
	V-clamps	ADDRESSED
	Spring clamps	ADDRESSED
	Table clamps	ADDRESSED
Cutting	Saws	ADDRESSED
	* wood cutting	0
	* metal cutting	ADDRESSED
	Knives	ADDRESSED
	Scissors/shears	ADDRESSED
	Bolt cutter	ADDRESSED
	Cable cutter	ADDRESSED
	Chisels	ADDRESSED
	Files	ADDRESSED
Other	Crimpers	ADDRESSED
	Nutdrivers	ADDRESSED
	Cable strippers	ADDRESSED
	Wire strippers	ADDRESSED
	Threaders	ADDRESSED
	Benders	ADDRESSED

## 10.2 Power-driven Hand Tools

### Module A

Instruction should enable the trainee to perform the following:

- \* describe administrative controls on power-driven 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 radiologically 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 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 attachments for each tool
- \* describe the function of each attachment
- \* identify power sources that may be connected to power-driven hand tools
- \* identify areas of the plant where power sources are not available
- \* identify power source connection equipment- air hoses, extension cords, connectors, adaptors
- \* explain the limitations of each tool

### Module B

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 precursors of 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 adaptors

### Module C

Instruction should enable the trainee to perform the following:

- \* demonstrate the proper procedure to assemble and disassemble each tool
- \* demonstrate the proper procedure to inspect and clean each tool
- \* demonstrate the proper procedure to adjust and repair each tool

# INPO 86-018 COMPARISON ELECTRICIANS

Subject

Topic

Pneumatic

Hammer

ADDRESSED

Drill

ADDRESSED

Chisel

ADDRESSED

Grinder

ADDRESSED

Punch

ADDRESSED

Wrench

ADDRESSED

Screwdriver

ADDRESSED

Saw

ADDRESSED

Electrical

Drill

ADDRESSED

Grinder

ADDRESSED

Wrench

ADDRESSED

Screwdriver

ADDRESSED

Saw

ADDRESSED

Spot welder

ADDRESSED

Heat gun

ADDRESSED

Vacuum cleaner

ADDRESSED

### 10.3 Measuring and Test Equipment (M&TE)

#### Module A

Instruction should enable the trainee to perform the following:

- \* define calibration
- \* explain requirements for maintaining an audiable calibration program
- \* explain calibration cycle
- \* explain requirements for instruments and test equipment found out of calibration
- \* identify information displayed on calibration sticker
- \* explain use of information on 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
- \* demonstrate procedures for obtaini ng M&TE
- \* identify the types of M&TE
- \* explain the use of inventory lists or printouts in selection of M&TE
- \* define "or equivalent" as applied to M&TE
- \* describe procedures to determine equivalency

#### Module B

Instruction should enable the trainee to perform the following:

- \* explain the special handling procedures for each type of test equipment
  - \* demonstrate proper method of protecting M&TE
    - in a radiologically controlled area
    - in a confined space
    - when working from hights
    - 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
  - \* the proper procedure to connect and disconnect each type of equipment
  - \* the proper procedure to operate each type of equipment
  - \* the proper use of connectors, adaptors, and leads
- Module C Instruction should enable the trainee to demonstrate the following:
- \* the proper procedure to inspect and clean each type of equipment
  - \* the proper procedure to adjust and calibrate each type of equipment
  - \* the proper procedure to repair each type of equipment

Subject	Topic	
General M&TE	All	ADDRESSED
Sources	Current	ADDRESSED
	Frequency	ADDRESSED
	Heat	ADDRESSED
	Pressure	ADDRESSED



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Subject	Topic	
Sources	Radiation	ADDRESSED
	Resistance	ADDRESSED
	Vibration	ADDRESSED
	Voltage	ADDRESSED
Measuring Devices	Capacitance	ADDRESSED
	Current	ADDRESSED
	Distance	ADDRESSED
	Frequency	ADDRESSED
	Mass	0
	Pressure	ADDRESSED
	Differential pressure	ADDRESSED
	Resistance	ADDRESSED
	Speed	ADDRESSED
	Temperature	ADDRESSED
	Time	ADDRESSED
	Torque	ADDRESSED
	Vibration	ADDRESSED
	Voltage	ADDRESSED
	Scales	2
	Radiation	ADDRESSED
	Flow	ADDRESSED
Analytical Devices	Oscilloscope	ADDRESSED
	Vibration analyzer	ADDRESSED
	Gas analyzer	ADDRESSED
Special Purpose Devices	Plant protection system test set	ADDRESSED
	Hydrostatic test set	
	Inverter test set	ADDRESSED
	Leak-rate test set	ADDRESSED

**SECTION 11****PLANT SYSTEMS AND COMPONENTS KNOWLEDGE TRAINING**

This section provides the trainee with the knowledge necessary to understand systems and components and apply that information to the job. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments. It is expected that a one to two week basic systems and components course would cover the recommendations for electricians and maintenance mechanics. A four week course would probably be necessary for instrumentation and control technicians.

**11.1 Plant Systems (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \* explain the purpose
- \* identify the components
- \* identify the alarms and indications affected by maintenance
- \* describe each system at the block diagram level \* explain the importance to plant operations"
- \* identify conditions that preclude safe work in the vicinity of system components
- \* describe the effect of isolating system components on plant operation
- \* identify the basic the interrelationships with other plant systems

**Module B**

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

Subject	Topic	
Primary	NSSS	0
	Containment	0
	Fuel handling/storage	0
	Engineered safety features	0
	Sampling	0
	Reactor protection	0
	Auto control	ADDRESSED
	Steam (BWR)	0
Secondary	Steam (PWR)	0
	Feedwater	0
	Condensate	0
	Sampling	0
	Auto control	ADDRESSED
	Water treatment	0

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Subject	Topic	
Auxiliary	Component cooling	0
	Containment cooling	0
	Air supply	0
	Gas supply	0
	Water supply	0
	Oil	0
	HVAC	ADDRESSED
	Radwaste	ADDRESSED
	Bulk storage	0
	Waste treatment	0
Electrical	Switchyard	ADDRESSED
	Generator	ADDRESSED
	AC distribution	ADDRESSED
	DC distribution	ADDRESSED
	Heat tracing	ADDRESSED
	Grounding	ADDRESSED
Monitoring	Seismic	0
	Loose parts	2
	Radiation	0
	Environmental	ADDRESSED
	Neutron	0
	Plant computer	ADDRESSED
	Safety parameter	ADDRESSED

## 11.2 ROTATING EQUIPMENT MATRIX (Knowledge)

### 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

### Module B

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

### Module C

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

### Module D

Instruction should enable the trainee to identify the vibration limits.

Subject	Topic	
Prime Movers	Electrical	ADDRESSED
	* AC	ADDRESSED
	* DC	ADDRESSED
	Turbine	2
	* impulse	2
	* reaction	2
	Diesel	2
Electrical Generators	Main	ADDRESSED
	Auxiliary	ADDRESSED
	Emergency	ADDRESSED
Pumps	Centrifugal	1
	Positive displacement	1
	Jet	1
Compressors	Rotary vane	ADDRESSED
	Reciprocating	ADDRESSED
	Rotary screw	ADDRESSED
	Centrifugal	ADDRESSED

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Subject

Topic

Fans

Vaneaxial  
Propeller  
Squirrel cage  
Centrifugal

ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED

**11.3 HEAT TRANSFER EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Mechanical	Heat exchangers	0
	Feedwater heaters	0
	Steam generator	0
	Moisture separator	0
	Condensers	0
	Cooling towers	0
	Reboilers	
Electro-mechanical	Air handlers	ADDRESSED
	Refrigeration units	ADDRESSED
Electrical	Recombiners	ADDRESSED
	Heat tracing	ADDRESSED
	Heaters	ADDRESSED

#### 11.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Knowledge)

##### 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

##### Module B

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

##### Module C

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	0
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	0
	Ejectors	0
	Eductors	0
Mechanical	Filters	0
	Strainers	0
	Screens	0
	Centrifuges	0
	Traps	0

**11.5 ELECTRICAL EQUIPMENT MATRIX (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols to interpret print information
- \*explain the purpose and use of applicable types of equipment

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify indications of normal and abnormal equipment operation during troubleshooting and testing
- \*identify the probable cause of abnormal indications
- identify abnormal conditions that preclude safe work in the vicinity of equipment

**Module C**

Instruction should enable the trainee to perform the following:

- \*locate equipment in panels and cabinets
- \*identify breaker, switch, and disconnect position indications

Subject	Topic	
Supply	Buses	ADDRESSED
	Cables	ADDRESSED
	Transformers	ADDRESSED
	* general	ADDRESSED
	* station	ADDRESSED
	* current	ADDRESSED
	* potential	ADDRESSED
	Batteries	ADDRESSED
	Inverters	ADDRESSED
Control	Battery chargers	ADDRESSED
	Switchgear	ADDRESSED
	Breakers	ADDRESSED
	Relays	ADDRESSED
	Switches	ADDRESSED
	Disconnects	ADDRESSED
	High voltage breakers	ADDRESSED



**11.6 CONTROL ELEMENTS MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to explain the proper use of applicable lubricants.

Topic	Subject	
Valves	Gate	0
	Globe	0
	Butterfly	0
	Diaphragm	0
	Ball	0
	Plug	0
	Check	0
	Stop-check	0
	Relief	0
Actuators	Electric	ADDRESSED
	Pneumatic	ADDRESSED
	Explosive	ADDRESSED
Dampers	Blade	0
	Vane	0
	Louver	0

## 11.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Knowledge)

### Module A

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols
- \*explain the purpose of equipment

### Module B

Instruction should enable the trainee to identify the following:

- \*the instrument range
- \*the instrument units

### Module C

Instruction should enable the trainee to identify the following:

- \*the input and output ranges
- \*the input and output medium

### Module D

Instruction should enable the trainee to identify the following:

- \*the power source(s)
- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Instruments	Sensors	ADDRESSED
	Indicators	ADDRESSED
	Recorders	ADDRESSED
	Switches	ADDRESSED
	Controllers	ADDRESSED
	Positioners	ADDRESSED
	Transmitters	ADDRESSED
	Annunciators	ADDRESSED
	Detectors	ADDRESSED
Electronic Equipment	Analyzers	ADDRESSED
	Signal converters	ADDRESSED
	Monitors	ADDRESSED
	Computers	ADDRESSED

## 11.8 PASSIVE COMPONENTS MATRIX (Knowledge)

### 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

### Module B

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the pressure and volume capacity limits

### Module C

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the flow capacity limits

Subject	Topic	
Pressure Vessels	Containment	0
	Reactor	0
	Pressurize	0
Volume	Tanks	0
	Reservoirs	0
	Pools	0
	Accumulator	0
	Piping	ADDRESSED
	Tubing	ADDRESSED
Flow	Orifice	

## 11.9 MISCELLANEOUS EQUIPMENT MATRIX (Knowledge)

### 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

### Module B

Instruction should enable the trainee to perform the following:

- \*identify the load limits
- \*identify the major parts

### Module C

Instruction should enable the trainee to perform the following:

- \*explain the principles of operation
- \*identify the normal and abnormal indications of equipment performance
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Auxiliary Equipment	Hoists	ADDRESSED
	Elevator	ADDRESSED
	Cranes	ADDRESSED
	Boiler	ADDRESSED
Structural Equipment	Mounts	ADDRESSED
	Bases	ADDRESSED
	Supports	ADDRESSED
	Hangers	ADDRESSED
	Cable trays	ADDRESSED
	Conduit	ADDRESSED
	Fire barriers	ADDRESSED
	Snubbers	ADDRESSED
	Anchor bolts	ADDRESSED

**SECTION 12****PLANT SYSTEMS AND COMPONENTS SKILLS TRAINING**

This section provides the trainee with the skills necessary to perform maintenance on systems and components. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The module indicates the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

**12.1 Plant Systems (Skills)****Module A**

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

Subject	Topic	
Primary	NSSS	
	Containment	
	Fuel Handling/storage	
	Engineered safety features	ADDRESSED
	Sampling	
	Reactor protection	
	Auto control	ADDRESSED
	Steam (BWR)	
Secondary	Steam (PWR)	
	Feedwater	
	Condensate	
	Sampling	
	Auto control	ADDRESSED
	Water treatment	
Auxiliary	Component cooling	
	Containment cooling	
	Air supply	
	Gas supply	
	Water supply	
	Oil	
	HVAC	ADDRESSED
	Radwaste	
	Bulk storage	
Electrical	Switchyard	ADDRESSED
	Generator	ADDRESSED
	AC distribution	ADDRESSED
	DC distribution	ADDRESSED
	Heat tracing	ADDRESSED
	Grounding	ADDRESSED

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Subject	Topic	
Monitoring	Seismic	
	Loose parts	
	Radiation	
	Environmental	
	Neutron	
	Plant computer	
	Safety parameter	

## 12.2 ROTATING EQUIPMENT MATRIX (Skills)

### Module A

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

### Module B

Instruction should enable the trainee to demonstrate the ability to measure equipment vibration properly.

### Module C

Instruction should enable the trainee to demonstrate the following:

- \*the ability to install and remove couplings/belts
- \*the ability to align rotating equipment
- \*the ability to test rotating equipment for "soft feet"
- \*the ability to lubricate designated equipment

Subject	Topic	
Prime Movers	Electrical	ADDRESSED
	* AC	ADDRESSED
	* DC	ADDRESSED
	Turbine	0
	* impulse	
	* reaction	
	Diesel	
Electrical Generators	Main	ADDRESSED
	Auxiliary	ADDRESSED
	Emergency	ADDRESSED
Pumps	Centrifugal	
	Positive displacement	
	Jet	
Compressors	Rotary vane	ADDRESSED
	Reciprocating	ADDRESSED
	Rotary screw	ADDRESSED
	Centrifugal	ADDRESSED
Fans	Vaneaxial	0
	Propeller	0
	Squirrel cage	0
	Centrifugal	0

### 12.3 HEAT TRANSFER EQUIPMENT MATRIX (Skills)

#### Module A

Instruction should enable the trainee to demonstrate the following:

- \*methods for breaching equipment or system integrity
- \*techniques for testing tubes for leaks
- \*techniques to repair or plug leaking tubes

#### Module B

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

Subject	Topic	
Mechanical	Heat exchangers	
	Feedwater heater	
	Steam generator	
	Moisture separator	
	Condensers	
	Cooling towers	
	Reboilers	
Electro-mechanical	Air handlers	0
	Refrigeration units	0
Electrical	Recombiners	0
	Heat tracing	0
	Heaters	0



## 12.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Skills)

### Module A

Instruction should enable the trainee to demonstrate the following:

- \*methods of medium removal and replacement
- \*methods for handling and disposing of medium

### Module B

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

Subject	Topic	
Chemical	Ion exchangers	
	Demineralizers	
	Purifiers	
	Absorbers	
	Catalytic recombiners	
Gaseous	Mechanical recombiners	
	Ejectors	
	Eductors	
Mechanical	Filters	
	Strainers	
	Screens	
	Centrifuges	
	Traps	

## 12.5 ELECTRICAL EQUIPMENT MATRIX (Skills)

### 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
- \*repair techniques

### Module B

Instruction should enable the trainee to demonstrate the following:

- \*adjustment and calibration
- \*testing methods

Subject	Topic	
Supply	Buses	ADDRESSED
	Cables	ADDRESSED
	Transformers	ADDRESSED
	* general	ADDRESSED
	* station	ADDRESSED
	* current	ADDRESSED
	* potential	ADDRESSED
	Batteries	ADDRESSED
	Inverters	ADDRESSED
Control	Battery chargers	ADDRESSED
	Switchgear	ADDRESSED
	Breakers	ADDRESSED
	Relays	ADDRESSED
	Switches	ADDRESSED
	Disconnects	ADDRESSED
	High voltage breakers	ADDRESSED

**12.6 CONTROL ELEMENTS MATRIX (Skills)****Module A**

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

**Module B**

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

Subject	Topic	
Valves	Ball	
	Butterfly	
	Check	
	Diaphragm	
	Gate	
	Globe	
	Plug	
	Stop-check	
	Relief	
Actuators	Electric	ADDRESSED
	Explosive	
	Pneumatic	
Dampers	Blade	ADDRESSED
	Louver	ADDRESSED
	Vane	ADDRESSED

**12.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Skills)****Module A**

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

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to remove equipment from service properly
- \*assembly and disassembly methods
- \*inspection and cleaning techniques
- \*the ability to logically troubleshoot defective equipment
- \*repair techniques
- \*adjustment and calibration
- \*methods for returning equipment to service
- \*use of special purpose tools and equipment

Subject	Topic	
Instruments	Annunciators	ADDRESSED
	Controllers	ADDRESSED
	Indicators	ADDRESSED
	Positioners	ADDRESSED
	Recorders	ADDRESSED
	Sensors	ADDRESSED
	Switches	ADDRESSED
	Transmitters	ADDRESSED
	Detectors	ADDRESSED
Electronic Equipment	Analyzers	ADDRESSED
	Monitors	0
	Computers	0
	Signal converters	ADDRESSED

12.8 PASSIVE COMPONENTS MATRIX (Skills)

Module A

Instruction should enable the trainee to demonstrate the following:

- \*the ability for breaching equipment or system integrity
- \*inspection and cleaning techniques
- \*use of special purpose tools and equipment

Subject	Topic	
Pressure Vessels	Containment	0
	Pressurizer	0
	Reactor	
Volume	Accumulators	
	Piping	
	Pools	
	Reservoirs	
	Tanks	
	Tubing	ADDRESSED
Flow	Orifice	

## 12.9 MISCELLANEOUS EQUIPMENT MATRIX (Skills)

### 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

### Module B

Instruction should enable the trainee to demonstrate the ability to lubricate designated equipment.

Subject	Topic	
Auxiliary Equipment	Boilers	ADDRESSED
	Cranes	ADDRESSED
	Elevators	ADDRESSED
	Hoists	ADDRESSED
Structural Equipment	Anchor bolts	ADDRESSED
	Bases	ADDRESSED
	Cable trays	ADDRESSED
	Conduit	ADDRESSED
	Fire barrier	ADDRESSED
	Hangers	ADDRESSED
	Mounts	ADDRESSED
	Snubbers	ADDRESSED
	Supports	ADDRESSED

**TRADE SPECIFIC JOB/TASK LISTING  
KNOWLEDGE AND SKILL REQUIREMENTS  
FOR  
ELECTRICIANS**

**GENERIC JOBS:**

**TASK-KNOWLEDGE AND SKILL**

Bolting and Torquing

Identify U..N.C. threads  
Identify U..N.F. threads  
Identify pipe threads  
Identify Metric threads  
Determine class of thread fit  
Identify ASTM and SAE grade marking for standard bolts  
Select correct bolts/fasteners for a given job  
Demonstrate the use of assorted sizes of torque wrenches

Rigging of material/equipment

Discuss rigging Safety

- Planning
- Supply and Care of Rigging Equipment
- Rigging Operation and Responsibility
- OSHA Regs 1910/1926

Inspect and identify rigging hardware  
Select rigging hardware  
Attaching rigging hardware  
Tieing knots, splicing rope  
Cribbing machinery  
Determining Safe Working Load of rigging hardware  
Determine Safe Working Load of rigging hitches  
Calculating effective strain on slings  
Using chainfalls and come-alongs  
Using hand rigging signals  
Using voice rigging signals  
Interpreting crane capacity charts  
Splicing cable  
Weight calculations  
Interpreting sling capacity charts  
Fabricate series LCR Circuit practice boards  
Fabricate parallel LCR Circuit practice boards

Fabrication of specialty tools,  
mock-ups, and parts for

support equipment

Fabricate Delta and Wye connection training boards

Discuss specialty tools for special job(s), (i.e. high voltage insulator cleaning )

Demonstrate field fabrication per job specification

Performance of welding activities

(Must be a site qualified welder before allowed to do any type welding at a Nuclear Power Plant.)

Weld machine set-up

Fabrication

Welding to site specification

Grinding

Finishing

Maintenance welding and cutting

Same qualifications for Maintenance welders as for Construction welders

Reading/interpretation of electrical schematics, prints, drawings

Describe the relationship between a *wiring diagram (prints)* and *line diagram (schematic)*

Identify common electrical symbols used in electrical diagrams (drawings)

Identify common terminal markings

Read and use target tables

Convert a wiring diagram to an elementary diagram

Read/interpretation of instrumentation control system and loop diagrams

Define the following instrumentation terms:

Symbol

Identification

Flow plan

Identify instrumentation on a flow plan

Identify pressure instruments symbols

Identify temperature instrument symbols

Identify flow instrument symbols

Read/interpretation of *National Electrical Code*

Describe, IAW the *National Electrical Code*, the following:

- Wiring methods
- Wiring materials-raceways and boxes
- Switches, switchboards and panelboards
- Conductors and overcurrent protection
- Branch circuits and feeders
- Grounding
- Transformers
- Services
- Motors and generators



- Air conditioning and refrigeration
- Fire pumps
- Equipment for general use
- Special locations
- Calculations

#### Core drilling

Drilling location precautions  
Concrete type  
Rebar location  
Space integrity

### **FABRICATION/INSTALLATION**

#### Rigid steel conduit

Select rigid conduit per job specifications  
Measure for conduit run  
Lay out conduit  
Bend/Cut conduit  
Install rigid conduit

#### Conduit supports & auxiliary steel

Select proper size conduit support  
Identify installation points  
Describe methods to bend, cut, and install rigid conduit  
Determine from drawings the type of mounting to be used  
Determine from drawings the auxiliary steel requirements  
Fabricate supports as required by installation package

#### Flexible conduit

Discuss code requirements relating to flexible conduit  
Demonstrate proper cutting method for flexible conduit  
Demonstrate installing end connectors on flexible conduit

#### Junction boxes (including mountings or supports)

Standard types  
Standard sizes  
Connection standards  
Number allowed per run

### Cable trays and covers

Cable tray layout  
Cable segregation requirements  
Fire barriers  
Cover requirement  
Cover construction  
Cover installation

### Cable tray supports and auxiliary steel

Standard support configuration  
Auxiliary steel requirements  
Support fabrication requirements

### Electrical duct and other raceways

Discuss electrical duct construction and use  
Define electrical raceways

### Cable

Discuss cable sizes  
Describe different properties of cable insulation  
Describe cable-pulling methods  
Discuss differences between control, distribution and transmission cable  
Identify cable markings  
Describe the purpose of cable markings  
Discuss cable tracking from manufacture to installation

### Cable terminations

High voltage terminations  
Medium voltage terminations  
Low voltage terminations  
Calibrated crimper use

### Electrical equipment

Motor control centers  
Switchboards  
Feeder panels  
Branch panels  
Distribution panels  
Service panels  
Lighting panels

### Motor installation and alignment

Electrical service  
Motor size  
Operating characteristics of controller  
Environment of installation  
Types of alignment  
Alignment method selection

### Electrically operated valve Assemblies

For solenoid valves:

- Describe proper terminations methods
- Method for removing housing cover
- Recognition of yoke on solenoid valve
- Method of inspecting/installing solenoid valve base sub-assembly
- Recognition of torque values and - - torquing procedure for solenoid valves
- Method for replacing housing cover
- Method of returning solenoid valve to service

### Electrical instruments

Electrical Measurement and Test Equipment  
use/calibration  
Electrical panel metering  
Portable electrical instruments

### Systems

Site fire system  
Special plant fire systems  
Site security system  
Special plant security systems  
Site communications including fiber optics  
Site grounding system

## **MAINTENANCE**

### Verify circuits de-energized prior to work

Demonstrate using electrical one-line drawing to identify electrically isolating a component, panel, and a complete bus  
Using the appropriate test equipment, verify A designated circuit is totally de-energized

#### Repair/replacement of cable and conduit

Discuss cable and conduit safety precautions  
Test cable for faults using megger or appropriate test equipment  
If engineering approved, make cable repair IAW site engineering specifications and work plan  
Replace cable IAW approved engineering specifications  
Record cable data  
Measure length of faulty cable run  
Cut cable to appropriate length  
Test cable prior to installing  
Install new cable  
Check cable for continuity and grounds  
Terminate cable as per work plan  
Retest for continuity and grounds  
Record all data  
Restore effected system to operability  
Conduit replacement IAW site engineering and work plan  
Identify and select appropriate conduit  
Measure and field sketch for forming replacement conduit  
Mark, cut, shape (bend), clean and install conduit  
Verify all connection meet NEC Code

#### Repair/replace cable tray

Review work package for completeness  
Discuss safety precautions related to cable trays  
Identify barrier (fire, water tight, energized cables)  
Inspect cable tray grounds  
Identify method to install cable tray anchors  
Describe method for repairing cable tray hangers or supports  
Identify torquing requirements for anchors and fittings  
Make repairs IAW work package  
Inspect for proper torque or tightening of all fasteners  
Verify cable trays are clean  
Install covers  
Verify grounds properly reinstalled  
Complete documentation

#### Repair/replacement of electrical

Repair/replace supports and auxiliary steel IAW

supports and auxiliary steel

approved work package  
Use approved materials that meet the form, fit and function requirements  
When welding/cutting, used approved procedure  
Verify seismic requirements  
Make required repairs/replacement  
Complete documentation

Inspect and clean storage batteries

Identify the basic components of a power plant main storage battery  
Discuss battery safety and cleaning equipment  
Inspect battery cell for corrosion buildup  
Inspect cell jar(s) for cracks and cleanliness  
Demonstrate application of oxide grease on cell post and interconnectors  
Demonstrate installation and removal of cell interconnectors  
Clean battery cell post and interconnectors  
Demonstrate ability to install and/or remove a battery cell jumper  
For Nuclear applications, identify “*Tech Spec Batteries*”

Repair/replace permanent lighting

Discuss safety precautions relating to plant lighting  
Identify different type permanent lighting fixtures  
Identify incandescent lighting fixture components  
Identify fluorescent lighting fixture components  
Identify gaseous discharge light fixture components  
Identify lamps for incandescent light fixtures  
Identify lamps for fluorescent light fixtures  
Identify lamps for gaseous discharge light fixtures  
Identify lamp wattage for light fixtures  
Identify power supply for light fixtures  
Identify lamp voltage for light fixtures  
Troubleshoot light fixtures  
Replace lighting fixture ballast  
Replace fluorescent lighting starter  
Replace lighting lamp holder/starter socket  
Use plant drawings to locate light fixtures and power supplies  
Use plant drawings to determine voltage and wattage requirements  
Discuss precautions associated with climbing and working from ladders

Replace circuit breakers and panels  
(molded-case circuit breakers)

Discuss why molded-case circuit breakers are replaced-vs-repaired  
Replace molded-case circuit breaker IAW manufacture's specifications  
Functionally field test circuit breaker  
Discuss circuit breaker and electrical panel board safety precautions  
Discuss panel board replacement for size, voltage, phases, seismic requirement.  
Panel bus rating  
Type/size of circuit breakers

Rack breakers in and out of switchgear

Discuss methods of racking breakers in/out using procedure guidance

- Molded case
- 600V LC breakers
- DC breakers
- 4160 breakers

Replace fuses and overloads

Precautions when checking and replacing fuses

- Check top of fuse for voltage
- Check bottom of fuse for voltage
- Remove fuse
- Check ohm value of fuse
- Check control drawing for proper replacement
- Obtain proper fuse
- Install fuse

Discuss methods for testing overloads  
Identify faulty overload  
Remove overload  
Check control document for proper replacement  
Replace overload IAW work package  
Perform postmaintenance test

Test and troubleshoot electrical circuits

Prepare to troubleshoot control circuitry and equipment

- Study applicable electrical drawing(s)
- Verify on drawing the points to use for voltage and resistance readings
- Identify on drawing all equipment and location
- Identify all components in the control circuit

	<p>Using approved test equipment, locate trouble, document “as-found” trouble.</p> <p>Return work package to supervisor/planner for repair/rework instructions</p>
<u>Check for equipment rotation and phase connections</u>	<p>Identify rotation on equipment or identify rotation from vendor drawing</p> <p>Connect phase rotation meter to check phase rotation</p> <p>Compare phase rotation to lead markings</p> <p>Change lead connections if required</p> <p>Jog motor, check rotation</p> <p>Reverse a phase lead if rotation is not correct</p>
<u>Perform continuity checks on cable</u>	<p>Identify and isolate cable to be checked</p> <p>Verify circuit is deenergized</p> <p>Using approved (utility) procedure and proper test equipment, check cable for open, ground or short</p>
<u>Perform resistance checks on cable Insulation</u>	<p>Isolate power to cable</p> <p>Perform operational check of megger</p> <p>Connect temporary grounds to cable (per procedural guidance time period)</p> <p>Remove temporary grounds</p> <p>Install megger to cable to be tested</p> <p>Perform test per procedural guidance</p> <p>Place megger to discharge</p> <p>Connect temporary grounds to cable</p> <p>Remove temporary grounds and test leads</p> <p>Return cable(s) back to service</p>
<u>Control panel maintenance/modification</u>	<p>Electrically isolate control panel</p> <p>Observe all safety precautions</p> <p>Conduct maintenance IAW plant procedures</p> <p>Inspect control panel relays</p> <p>Inspect control panel switches</p> <p>Inspect control panel accessories</p> <p>Clean panel relays</p> <p>Clean panel switches and panel accessories</p> <p>Document findings with recommendations</p>
<u>Installation of temporary lighting</u>	<p>Discuss electrical safety related to temporary power and lighting</p>

Using plant electrical drawings, locate power supplies for temporary lighting  
Determine lighting required  
Determine lighting environment  
Select appropriate lighting fixtures, lamps stringers, shields and support equipment  
Install temporary lights.  
Test temporary lights  
Place temporary lights in-service

Installation of temporary power to trailers or plant areas

Discuss electrical safety related to temporary power  
Using plant electrical drawings, locate power supplies for temporary power  
Determine power required  
Determine environment in trailer or plant area  
Select appropriate cable, fixtures, and support equipment  
Install temporary power to selected location(s)  
Test temporary power  
Place temporary power in-service

Clean and inspect Motor Control Center (MCC)

Use approved plant procedure  
Observe plant safety precautions  
Verify MCC is electrically isolated  
Verify MCC exterior has no physical damage  
Inspect electrical enclosure for oil, water and chemical damage  
Verify the foundations has no deterioration  
Inspect all incoming conduits and cable tray mountings and connections  
Replace indicating light bulbs and lenses where necessary  
Clean and replace air filters as necessary  
Open access panels and clean the interior of the motor control center  
Verify all foreign material removed when cleaning complete  
Replace all covers and access plates  
Verify all bolts/fasteners are installed and torqued or tighten as per work package



**Note:** This listing of tasks is intended to be used in determining the training requirements for contracted craft labor personnel at a Nuclear Power Plant. The list is not designed or intended for determining jurisdictional work assignments. The contractor is responsible for supplying the utility with qualified craft. He is also responsible for making appropriate work assignments based on the applicable work agreement.

NMAP

# Study Report

Detailed Review Documents  
Boilermakers

# BOILERMAKER EVALUATION SUMMARY


Title	Section	Number of Subjects	Number of Subjects Addressed	Number of Topics *	Number of Topics Addressed	Number of topics w/ 'S' > 0	Ave 'S'>0
Mathematics	9.1	7	7	13	12	0	0
Classical Physics	9.2	2	2	35	16	15	1
Electrical Science	9.3	7	5	27	11	0	0
Instrument and Control	9.4	2	0	9	0	5	1
Principles of Radiation Detection	9.5	0	0	0	0	0	0
Properties of Reactor Plant Materials	9.6	7	7	26	20	1	5
Basic Atomic and Nuclear Physics	9.7	5	5	20	16	0	0
Heat transfer and Fluid Flow	9.8	3	3	26	17	3	1
Reactor Plant Protection	9.9	3	3	20	20	0	0
Chemistry	9.10	4	0	26	0	0	0
Hand Tools	10.1	9	9	74	58	2	3.5
Power Driven Hand Tools	10.2	2	2	16	14	0	0
Measuring and Test Equipment	10.3	4	2	14	4	1	5
<b>Plant Systems and Components</b>							
<b>Knowledge Training</b>							
<b>knowledge</b>							
plant systems matrix	11	5	4	37	31	0	0
rotating equipment matrix	11	5	4	21	14	0	0
heat transfer equipment matrix	11	3	2	12	9	0	0
process conditioning equipment matrix	11	3	3	13	13	0	0
electrical equipment matrix	11	2	0	14	0	0	0
control elements matrix	11	3	0	15	0	9	1
instrument and control equipment matrix	11	2	0	13	0	0	0
passive components matrix	11	3	3	10	10	0	0
miscellaneous equipment matrix	11	2	1	13	4	5	1
<b>skills</b>							
plant systems matrix	12	1	0	1	0	1	1
rotating equipment matrix	12	5	0	21	0	0	0
heat transfer equipment matrix	12	3	3	12	12	0	0
process conditioning equipment matrix	12	3	3	13	13	0	0
electrical equipment matrix	12	0	0	0	0	0	0
control elements matrix	12	3	0	15	0	9	1
instrument and control equipment matrix	12	2	0	7	0	0	0
passive components matrix	12	3	3	10	10	0	0
miscellaneous equipment matrix	12	2	2	9	9	0	0
totals		105	73	542	313		
<b>subject % addressed</b>		<b>70%</b>					
<b>topic % addressed</b>		<b>58%</b>					
* DOES NOT COUNT TOPICS NOT APPLICABLE TO THIS CRAFT AS DEFINED BY INPO 86-018							








**9.1 Mathematics****Module A**

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

**Module B**

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

 = Not Applicable  
To This Craft  
Mech.

Subject	Topic	
Basic Mathematical Concepts	Basic arithmetic functions	ADDRESSED
	Percentage	ADDRESSED
	Square root	ADDRESSED
	Averages	0
Scientific Notation	Conversion	
	Application of scientific notation	
Dimensional Analysis	Unit conversions	ADDRESSED
	Unit modifiers	
	Metric measurements	ADDRESSED
Algebra	Basic equation solving	ADDRESSED
	Quadratic equations	
Trigonometry	Basic relationships	ADDRESSED
Geometry	Basic relationships	ADDRESSED
	Vectors	ADDRESSED
Calculus	Concept of rate of change	
	Concept of integration	
Analysis of Graphs and Control Charts	Obtaining information from graphs	ADDRESSED
	Rectangular coordinate system	ADDRESSED
	Polar coordinate system	
	Logarithmic coordinate system	

INPO 86-018 COMPARISON BOILERMAKERS

Subject	Topic	
Nomograms	Obtaining information from nomograms	ADDRESSED
Exponents Base	"E" exponents (Natural/Napierian)	
Numbering Systems	Binary numbering system	
	Octal numbering system	
	Hexidecimal numbering system	
	Conversion of numbering systems	

## 9.2 Classical Physics

### Module A

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

### Module B

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

Subject	Topic	
Units	Systems of units	ADDRESSED
	Units of pressure (vacuum/pressure, differential pressure) measurement	1
	Units of temperature measurement	1
	Units of periodic motion measurement	0
	Units of flow	0
	Units of volume	ADDRESSED
	Units of mass	0
	Units of weight	ADDRESSED
	Units of distance measurement	ADDRESSED
	Units of time measurement	ADDRESSED
Mechanical Principles Acceleration	Cams	1
	Conditions of equilibrium	ADDRESSED
	Conservation of energy	0
	Density, height, and temperature effects on process fluids	1
	Energy	ADDRESSED
	Fluid mechanics	1
	Force	ADDRESSED
	Friction	ADDRESSED
	Gear ratios	1
	Gravitation	ADDRESSED
	Heat	1
	Hydraulics	ADDRESSED
	Inclined planes	ADDRESSED

## INPO 86-018 COMPARISON BOILERMAKERS

Subject	Topic	
Mechanical Principles	Acceleration	1
	Laws of motion	1
	Mass	1
	Momentum	1
	Power	ADDRESSED
	Pulleys	ADDRESSED
	Simple machines	1
	Temperature systems	1
	Temperature system	
	- conversions	1
	Translational and rotational motion	1
	Velocity	1
	Weight	ADDRESSED
	Work	ADDRESSED

### 9.3 Electrical Science

#### Module A

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

#### Module B

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

Subject	Topic	
Basic Electrical	Electron theory	
	Insulators	
	Conductors	
	Static electricity	
	Magnetism	
	Direct current (DC)	
	DC sources	
	Units of electrical measurement	
	Fundamental electrical laws	
	Electrical hazards and safety	ADDRESSED
	Electrical grounds	ADDRESSED
	Basic electrical circuits	ADDRESSED
	Bistables	
	Relays	
Alternating Current	Basic alternating current theory	
	Sources	ADDRESSED
	Simple circuits	0
	AC waveforms	
	Inductance and inductive reactance	
	Mutual inductance and transformers	
	Capacitance and capacitive reactance	
	Impedance	
	Series, parallel and combination circuits	
	Resonance	0



# INPO 86-018 COMPARISON BOILERMAKERS

Subject	Topic	
Alternating Current	Power factor	
	Single-phase circuits	
	Multi-phase circuits	
Plant Electrical	Sources of electrical power	ADDRESSED
	Switchgear components	0
	Power distribution (AC and DC)	ADDRESSED
Power Transformers	Theory	
	Internal construction	0
	Tap changers and hazards	
	Effects of exceeding ratings	
	Cooling systems	0
	Oil system air entrainment	0
	Safety precautions associated with cooling mediums	0
	Construction of terminal connections	
	Fault symptoms	0
	Fire protection systems	0
Current Transformers	Theory	ADDRESSED
	Use	
	Hazards	
Potential Transformers	Theory	0
	Use	
	Hazards	
Advanced Electrical	AC motors	ADDRESSED
	AC generators	ADDRESSED
	DC motors	ADDRESSED
	DC generators	ADDRESSED
	Control circuits	
	utility grid switchgear	0
	Synchrosopes	
	Voltage regulator	0
	Ground detection	0

INPO 86-018 COMPARISON BOILERMAKERS

Subject

Topic

Advanced Electrical

Control circuits for  
in-plant electrical  
switchgear  
Protective relaying  
Lightning arrestors  
Batteries

0
0
0
0

## 9.4 Instrumentation and Control

### Module A

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

### Module B

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

Subject	Topic	
Basic Electronics	Semiconductors	
	Diodes	
	Transistors	
	Amplifier basics	
	Operational amplifiers	
	Integrated circuits	
	Solid state circuitry	
	Wave-shaping circuits	
	Noise suppression techniques	
Digital Electronics	Boolean algebra	
	Combinational logic	
	Sequential logic	
	Logic circuit timing	
	Input/output methods	
	Programming	
Process Measurement	Pressure measurement	1
	Temperature measurement	1
	Fluid flow measurement	1
	Level measurement	1
	Analytical measurements	1
Process Control	Automatic control fundamentals	0
	Basic control circuits	
	Open-loop control	0
	Closed-loop control	0
	Two-position control	0
	Proportional control	
	Reset action	
	Rate action	
	Control loop tuning	

9.5 Principles of Radiation Detection

Module A

Instruction should enable the trainee to identify the location of and applications for each applicable instrument and detector.

Module B

Instruction should enable the trainee to explain the principles of operation for each instrument and detector.

Subject	Topic	
Detectors	Geiger-Mueller (G.M.)	ADDRESSED
	Scintillation	ADDRESSED
	Proportional counter	ADDRESSED
	Ion chamber	
	Fission chamber	
	Self-powered neutron	

## 9.6 Properties of Reactor Plant Materials

### Module A

Instruction should enable the trainee to explain the terms, definitions, and basic concepts and to recognize conditions that are detrimental to reactor plant materials.

Subject	Topic	
Properties of Metals	Structure basics	ADDRESSED
	Changes in structure	ADDRESSED
	Expansion	ADDRESSED
	Embrittlement	ADDRESSED
Alloy	Definition	ADDRESSED
	Applications	ADDRESSED
Brittle Fracture	Characteristics	ADDRESSED
	Mechanisms	ADDRESSED
	Heatup/cooldown effects	ADDRESSED
	Heat treating	ADDRESSED
	Annealing	ADDRESSED
Plant Material Problems	Fatiguefailure/work hardening	ADDRESSED
	Corrosion	ADDRESSED
	Contamination	ADDRESSED
	Radiation-induced embrittlement	
Thermal Shock/Stress	Definition	ADDRESSED
	Causes and effects	ADDRESSED
Strength of Materials	Compressive strength	ADDRESSED
	Tensile strength	ADDRESSED
	Torque limits	5
Corrosion and Corrosion and Control	General	ADDRESSED
	Pit and crevice	ADDRESSED
	Galvanic	0
	Chloride stress	0
	Caustic stress	0
	Stress corrosion cracking	0

## 9.7 Basic Atomic and Nuclear Physics

### Module A

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

Subject	Topic	
Atomic Structure	Atomic mass unit	ADDRESSED
	Protons	ADDRESSED
	Neutrons	ADDRESSED
	Electrons	ADDRESSED
Nuclear Interactions	Ionization	ADDRESSED
	Radiation interactions	ADDRESSED
	Neutron interactions	ADDRESSED
	Radioactive decay process	ADDRESSED
Fission Process	Definition	ADDRESSED
	Theory of fission process	ADDRESSED
	Control of fission process	ADDRESSED
	Neutrons associated with fission	ADDRESSED
	Neutron flux effects on reactor power	0
	Neutron Leakage	
Residual Heat/Decay Heat	Sources of decay heat	ADDRESSED
Reactor Operation	Basic reactor types	ADDRESSED
	Reactor parameters	ADDRESSED
	Power-to-flow relationships	0
	Axial flux	
	Core imbalance	
	Core quadrant power tilt	
	Reactivity	
	Reactor response to control rods	ADDRESSED
	Reactor start-up and shutdown	0
	Reactivity accidents	0

**9.8 Heat Transfer and Fluid Flow****Module A**

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

**Module B**

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

Subject	Topic	
Basic Thermodynamics	Temperature	ADDRESSED
	Sensible heat	0
	Latent heat--vaporization, condensation	
	Properties of water and steam	ADDRESSED
	Pressure/temperature relationship	ADDRESSED
	Specific volume	ADDRESSED
	Basic steam-water cycle	ADDRESSED
	Steam tables	ADDRESSED
	Specific heat	ADDRESSED
	Boiling	ADDRESSED
	Saturation	ADDRESSED
	Properties of gases, gas-liquid interfaces	0
	Heat transfer mechanisms	ADDRESSED
	Heat cycles (basic)	ADDRESSED
	Heat exchangers	ADDRESSED
Properties of Fluids	Flow rate	1
	Fluid statics	1
	Density	ADDRESSED
	Buoyancy	1
Principles of Fluid Flow	Pump theory	0
	Cavitation	0
	Fluid flow in a closed system	ADDRESSED
	Water hammer	0
	Heating a closed system	ADDRESSED
	Filling and Venting	ADDRESSED
	Draining a closed system	ADDRESSED

## 9.9 Reactor Plant Protection

### Module A

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

### Module B

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

Subject	Topic	
Reactor Plant Protection Concepts	Thermal-hydraulic operating	See Report
	Safety limits	See Report
	Limiting conditions for operation	See Report
	Administrative controls and procedural concepts	See Report
	Automatic reactor plant protection concepts	See Report
Design Basis Accident	Discussion	See Report
	Symptoms and indications	See Report
	Anticipated radiation levels	See Report
	Effect on work place	See Report
	Evacuation criteria	See Report
	Recovery process	See Report
Transient Prevention and Mitigation of Core Damage	Integrated plant transient response	See Report
	Core cooling mechanisms	See Report
	Potentially damaging operating conditions	See Report
	Core damage	See Report
	Hydrogen hazards during accidents	See Report
	Monitoring critical parameters during accident conditions	See Report
	Radiation hazards and radiation monitor response	See Report



## 9.10 Chemistry

### Module A

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

### Module B

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

Subject	Topic	
Fundamentals of Chemistry	Mixtures, solutions, compounds	0
	Properties and uses of gases	0
	oxygen	0
	nitrogen	0
	hydrogen	0
	noble gases	0
	Ideal gas law	0
	Conductivity	0
	Acids and bases	0
	Corrosion chemistry	0
	pH	0
	Ion exchangers	0
Water Chemistry Control	S/G chemistry	0
	Secondary chemistry control	0
	Water chemistry control methods	0
Reactor Water Chemistry	Types of impurities	0
	Sources of impurities	0
	Effects of impurities	0
	Control/removal of impurities	0
	Radiochemistry	0
	Analytical results and core conditions	
	Sampling methods	
	Radiolysis and recombination	0
	Hydrogen gas in reactor water	0

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Subject	Topic	
Principles of Water Treatment	Purpose	0
	Methods	0
	Water quality/purity	0
	Grades of water	0

## SECTION 10

### TOOLS AND EQUIPMENT SKILLS TRAINING

This section 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. Subject matrices show the applicability of types of tools and equipment to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

#### 10.1 Hand Tools

##### 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

##### Module B

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
- \* explain the limitations of each tool
- \* explain the importance of maintaining tools in excellent condition
- \* describe the common failure mechanism(s) of each type of tool
- \* identify precursors 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., redressing 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 area 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.

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Subject	Topic	
Hammers	Machinist (ballpeen)	ADDRESSED
	Carpenter (claw)	ADDRESSED
	Sledge	ADDRESSED
	Chipping	ADDRESSED
	Slide	ADDRESSED
Mallets	Plastic	ADDRESSED
	Rubber	ADDRESSED
	Rawhide	ADDRESSED
	Brass	ADDRESSED
	Lead	ADDRESSED
Punches	Drift	ADDRESSED
	Center	ADDRESSED
	Pin	ADDRESSED
	Hole	ADDRESSED
	Alignment	ADDRESSED
Wrenches	Open-end	ADDRESSED
	Box-end	ADDRESSED
	Combination	ADDRESSED
	Socket	ADDRESSED
	Socket set attachments	ADDRESSED
	* handles	ADDRESSED
	* extensions	ADDRESSED
	* adapters	ADDRESSED
	Tubing	ADDRESSED
	Adjustable open-end	ADDRESSED
	Adjustable pipe	ADDRESSED
	* open Jaw	ADDRESSED
	* strap	ADDRESSED
	* chain	ADDRESSED
	Slugging	ADDRESSED
	Spanner	0
	* pin	0
	* hook	0
	* face	0
	Hexagonal (Allen)	ADDRESSED
	Splined (Bristol)	2
	Torque	5
Screwdrivers	Flat	ADDRESSED
	Phillips	ADDRESSED
	Reed-Prince	0
	Off set	ADDRESSED
	Holding/starting	ADDRESSED

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Subject	Topic	
Pliers	Slipjoint	ADDRESSED
	Lineman	ADDRESSED
	Needle-nose	ADDRESSED
	Diagonal	ADDRESSED
	Round nose	ADDRESSED
	Duckbill	0
	Snap ring	0
	Parallel jaw	0
	(channel/pump)	ADDRESSED
	Locking	0
	Lockwire	0
Vises and Clamps	Mechanics bench vise	ADDRESSED
	Pipe vise	ADDRESSED
	* yoke	ADDRESSED
	* bench	ADDRESSED
	Vise grips	ADDRESSED
	C-clamps	ADDRESSED
	V-clamps	0
	Spring clamps	0
	Table clamps	0
Cutting	Saws	ADDRESSED
	* wood cutting	ADDRESSED
	* metal cutting	ADDRESSED
	Knives	0
	Scissors/shears	ADDRESSED
	Bolt cutter	ADDRESSED
	Cable cutter	ADDRESSED
	Chisels	ADDRESSED
	Files	ADDRESSED
Other	Crimpers	
	Nutdrivers	ADDRESSED
	Cable strippers	
	Wire strippers	
	Threaders	ADDRESSED
	Benders	ADDRESSED

## 10.2 Power-driven Hand Tools

### Module A

Instruction should enable the trainee to perform the following:

- \* describe administrative controls on power-driven 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 radiologically 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 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 attachments for each tool
- \* describe the function of each attachment
- \* identify power sources that may be connected to power-driven hand tools
- \* identify areas of the plant where power sources are not available
- \* identify power source connection equipment- air hoses, extension cords, connectors, adaptors
- \* explain the limitations of each tool

### Module B

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 precursors of 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 adaptors

### Module C

Instruction should enable the trainee to perform the following:

- \* demonstrate the proper procedure to assemble and disassemble each tool
- \* demonstrate the proper procedure to inspect and clean each tool
- \* demonstrate the proper procedure to adjust and repair each tool

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Subject	Topic	
Pneumatic	Hammer	ADDRESSED
	Drill	ADDRESSED
	Chisel	ADDRESSED
	Grinder	ADDRESSED
	Punch	ADDRESSED
	Wrench	ADDRESSED
	Screwdriver	ADDRESSED
	Saw	ADDRESSED
Electrical	Drill	ADDRESSED
	Grinder	ADDRESSED
	Wrench	ADDRESSED
	Screwdriver	ADDRESSED
	Saw	ADDRESSED
	Spot welder	ADDRESSED
	Heat gun	0
	Vacuum cleaner	0

### 10.3 Measuring and Test Equipment (M&TE)

#### Module A

Instruction should enable the trainee to perform the following:

- \* define calibration
- \* explain requirements for maintaining an audiable calibration program
- \* explain calibration cycle
- \* explain requirements for instruments and test equipment found out of calibration
- \* identify information displayed on calibration sticker
- \* explain use of information on 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
- \* demonstrate procedures for obtaini ng M&TE
- \* identify the types of M&TE
- \* explain the use of inventory lists or printouts in selection of M&TE
- \* define "or equivalent" as applied to M&TE
- \* describe procedures to determine equivalency

#### Module B

Instruction should enable the trainee to perform the following:

- \* explain the special handling procedures for each type of test equipment
  - \* demonstrate proper method of protecting M&TE
    - in a radiologically controlled area
    - in a confined space
    - when working from hights
    - 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
  - \* the proper procedure to connect and disconnect each type of equipment
  - \* the proper procedure to operate each type of equipment
  - \* the proper use of connectors, adaptors, and leads
- Module C Instruction should enable the trainee to demonstrate the following:
- \* the proper procedure to inspect and clean each type of equipment
  - \* the proper procedure to adjust and calibrate each type of equipment
  - \* the proper procedure to repair each type of equipment

Subject	Topic	
General M&TE	All	ADDRESSED
Sources	Current	
	Frequency	
	Heat	
	Pressure	



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Subject	Topic	
Sources	Radiation	
	Resistance	
	Vibration	
	Voltage	
Measuring Devices	Capacitance	
	Current	
	Distance	ADDRESSED
	Frequency	
	Mass	0
	Pressure	0
	Differential pressure	0
	Resistance	
	Speed	0
	Temperature	
	Time	0
	Torque	5
	Vibration	0
	Voltage	
	Scales	0
	Radiation	ADDRESSED
	Flow	ADDRESSED
Analytical Devices	Oscilloscope	
	Vibration analyzer	0
	Gas analyzer	
Special Purpose Devices	Plant protection system test set	
	Hydrostatic test set	ADDRESSED
	Inverter test set	
	Leak-rate test set	0

## SECTION 11

### PLANT SYSTEMS AND COMPONENTS KNOWLEDGE TRAINING

This section provides the trainee with the knowledge necessary to understand systems and components and apply that information to the job. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments. It is expected that a one to two week basic systems and components course would cover the recommendations for electricians and maintenance mechanics. A four week course would probably be necessary for instrumentation and control technicians.

#### 11.1 Plant Systems (Knowledge)

##### Module A

Instruction should enable the trainee to perform the following:

- \* explain the purpose
- \* identify the components
- \* identify the alarms and indications affected by maintenance
- \* describe each system at the block diagram level \* explain the importance to plant operations"
- \* identify conditions that preclude safe work in the vicinity of system components
- \* describe the effect of isolating system components on plant operation
- \* identify the basic the interrelationships with other plant systems

##### Module B

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

Subject	Topic	
Primary	NSSS	See Report
	Containment	See Report
	Fuel handling/storage	See Report
	Engineered safety features	See Report
	Sampling	See Report
	Reactor protection	See Report
	Auto control	See Report
	Steam (BWR)	See Report
Secondary	Steam (PWR)	See Report
	Feedwater	See Report
	Condensate	See Report
	Sampling	See Report
	Auto control	See Report
	Water treatment	See Report

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Subject	Topic	
Auxiliary	Component cooling	See Report
	Containment cooling	See Report
	Air supply	See Report
	Gas supply	See Report
	Water supply	See Report
	Oil	See Report
	HVAC	See Report
	Radwaste	See Report
	Bulk storage	See Report
	Waste treatment	See Report
Electrical	Switchyard	0
	Generator	0
	AC distribution	0
	DC distribution	0
	Heat tracing	0
	Grounding	0
Monitoring	Seismic	See Report
	Loose parts	See Report
	Radiation	See Report
	Environmental	See Report
	Neutron	See Report
	Plant computer	See Report
	Safety parameter	See Report

**11.2 ROTATING EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to identify the vibration limits.

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	0
	* impulse	0
	* reaction	0
	Diesel	0
Electrical Generators	Main	See Report
	Auxiliary	See Report
	Emergency	See Report
Pumps	Centrifugal	See Report
	Positive displacement	See Report
	Jet	See Report
Compressors	Rotary vane	See Report
	Reciprocating	See Report
	Rotary screw	See Report
	Centrifugal	See Report

Subject	Topic	
Fans	Vaneaxial	See Report
	Propeller	See Report
	Squirrel cage	See Report
	Centrifugal	See Report

**11.3 HEAT TRANSFER EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Mechanical	Heat exchangers	See Report
	Feedwater heater	See Report
	Steam generator	See Report
	Moisture separator	See Report
	Condensers	See Report
	Cooling towers	See Report
	Reboilers	See Report
Electro-mechanical	Air handlers	See Report
	Refrigeration units	See Report
Electrical	Recombiners	0
	Heat tracing	0
	Heaters	0

**11.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Chemical	Ion exchangers	See Report
	Demineralizers	See Report
	Purifiers	See Report
	Absorbers	See Report
	Catalytic recombiners	See Report
Gaseous	Mechanical recombiners	See Report
	Ejectors	See Report
	Eductors	See Report
Mechanical	Filters	See Report
	Strainers	See Report
	Screens	See Report
	Centrifuges	See Report
	Traps	See Report

**11.5 ELECTRICAL EQUIPMENT MATRIX (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols to interpret print information
- \*explain the purpose and use of applicable types of equipment

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify indications of normal and abnormal equipment operation during troubleshooting and testing
- \*identify the probable cause of abnormal indications
- identify abnormal conditions that preclude safe work in the vicinity of equipment

**Module C**

Instruction should enable the trainee to perform the following:

- \*locate equipment in panels and cabinets
- \*identify breaker, switch, and disconnect position indications

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	0
	* general	0
	* station	0
	* current	0
	* potential	0
	Batteries	0
	Inverters	0
	Battery chargers	0
Control	Switchgear	0
	Breakers	0
	Relays	0
	Switches	0
	Disconnects	0
	High voltage breakers	0



**11.6 CONTROL ELEMENTS MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to explain the proper use of applicable lubricants.

Topic	Subject	
Valves	Gate	1
	Globe	1
	Butterfly	1
	Diaphragm	1
	Ball	1
	Plug	1
	Check	1
	Stop-check	1
	Relief	1
Actuators	Electric	0
	Pneumatic	0
	Explosive	0
Dampers	Blade	0
	Vane	0
	Louver	0

**11.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols
- \*explain the purpose of equipment

**Module B**

Instruction should enable the trainee to identify the following:

- \*the instrument range
- \*the instrument units

**Module C**

Instruction should enable the trainee to identify the following:

- \*the input and output ranges
- \*the input and output medium

**Module D**

Instruction should enable the trainee to identify the following:

- \*the power source(s)
- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Instruments	Sensors	0
	Indicators	0
	Recorders	0
	Switches	0
	Controllers	0
	Positioners	0
	Transmitters	0
	Annunciators	0
	Detectors	0
Electronic Equipment	Analyzers	0
	Signal converters	0
	Monitors	0
	Computers	0

**11.8 PASSIVE COMPONENTS MATRIX (Knowledge)****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

**Module B**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the pressure and volume capacity limits

**Module C**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the flow capacity limits

Subject	Topic	
Pressure Vessels	Containment	See Report
	Reactor	See Report
	Pressurize	See Report
Volume	Tanks	See Report
	Reservoirs	See Report
	Pools	See Report
	Accumulator	See Report
	Piping	See Report
	Tubing	See Report
Flow	Orifice	See Report

**11.9 MISCELLANEOUS EQUIPMENT MATRIX (Knowledge)****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

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify the load limits
- \*identify the major parts

**Module C**

Instruction should enable the trainee to perform the following:

- \*explain the principles of operation
- \*identify the normal and abnormal indications of equipment performance
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Auxiliary Equipment	Hoists	See Report
	Elevator	See Report
	Cranes	See Report
	Boiler	See Report
Structural Equipment	Mounts	1
	Bases	1
	Supports	1
	Hangers	1
	Cable trays	0
	Conduit	0
	Fire barriers	0
	Snubbers	0
	Anchor bolts	1

## SECTION 12

**PLANT SYSTEMS AND COMPONENTS SKILLS TRAINING**

This section provides the trainee with the skills necessary to perform maintenance on systems and components. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The module indicates the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

**12.1 Plant Systems (Skills)****Module A**

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

Subject	Topic	
Primary	NSSS	
	Containment	
	Fuel Handling/storage	
	Engineered safety features	
	Sampling	
	Reactor protection	
	Auto control	
	Steam (BWR)	
Secondary	Steam (PWR)	
	Feedwater	
	Condensate	
	Sampling	
	Auto control	
	Water treatment	
Auxiliary	Component cooling	
	Containment cooling	
	Air supply	
	Gas supply	
	Water supply	
	Oil	
	HVAC	
	Radwaste	1
	Bulk storage	
Electrical	Switchyard	
	Generator	
	AC distribution	
	DC distribution	
	Heat tracing	
	Grounding	

Subject	Topic	
Monitoring	Seismic	
	Loose parts	
	Radiation	
	Environmental	
	Neutron	
	Plant computer	
	Safety parameter	

**12.2 ROTATING EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

**Module B**

Instruction should enable the trainee to demonstrate the ability to measure equipment vibration properly.

**Module C**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to install and remove couplings/belts
- \*the ability to align rotating equipment
- \*the ability to test rotating equipment for "soft feet"
- \*the ability to lubricate designated equipment

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	0
	* impulse	0
	* reaction	0
	Diesel	0
Electrical Generators	Main	0
	Auxiliary	0
	Emergency	0
Pumps	Centrifugal	0
	Positive displacement	0
	Jet	0
Compressors	Rotary vane	0
	Reciprocating	0
	Rotary screw	0
	Centrifugal	0
Fans	Vaneaxial	0
	Propeller	0
	Squirrel cage	0
	Centrifugal	0

**12.3 HEAT TRANSFER EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*methods for breaching equipment or system integrity
- \*techniques for testing tubes for leaks
- \*techniques to repair or plug leaking tubes

**Module B**

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

Subject	Topic	
Mechanical	Heat exchangers	See Report
	Feedwater heater	See Report
	Steam generator	See Report
	Moisture separator	See Report
	Condensers	See Report
	Cooling towers	See Report
	Reboilers	See Report
Electro-mechanical	Air handlers	See Report
	Refrigeration units	See Report
Electrical	Recombiners	See Report
	Heat tracing	See Report
	Heaters	See Report



**12.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

\*methods of medium removal and replacement

\*methods for handling and disposing of medium

**Module B**

Instruction should enable the trainee to demonstrate the following:

\*assembly and disassembly methods

\*repair techniques

\*use of special purpose tools and equipment

Subject	Topic	
Chemical	Ion exchangers	See Report
	Demineralizers	See Report
	Purifiers	See Report
	Absorbers	See Report
	Catalytic recombiners	See Report
Gaseous	Mechanical recombiners	See Report
	Ejectors	See Report
	Eductors	See Report
Mechanical	Filters	See Report
	Strainers	See Report
	Screens	See Report
	Centrifuges	See Report
	Traps	See Report

12.5 ELECTRICAL EQUIPMENT MATRIX (Skills)

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
- \*repair techniques

Module B

Instruction should enable the trainee to demonstrate the following:

- \*adjustment and calibration
- \*testing methods

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	
	* general	
	* station	
	* current	
	* potential	
	Batteries	
	Inverters	
	Battery chargers	
Control	Switchgear	
	Breakers	
	Relays	
	Switches	
	Disconnects	
	High voltage breakers	

**12.6 CONTROL ELEMENTS MATRIX (Skills)****Module A**

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

**Module B**

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

Subject	Topic	
Valves	Ball	1
	Butterfly	1
	Check	1
	Diaphragm	1
	Gate	1
	Globe	1
	Plug	1
	Stop-check	1
	Relief	1
Actuators	Electric	0
	Explosive	0
	Pneumatic	0
Dampers	Blade	0
	Louver	0
	Vane	0

**12.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Skills)****Module A**

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

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to remove equipment from service properly
- \*assembly and disassembly methods
- \*inspection and cleaning techniques
- \*the ability to logically troubleshoot defective equipment
- \*repair techniques
- \*adjustment and calibration
- \*methods for returning equipment to service
- \*use of special purpose tools and equipment

Subject	Topic	
Instruments	Annunciators	0
	Controllers	
	Indicators	0
	Positioners	0
	Recorders	0
	Sensors	
	Switches	
	Transmitters	
	Detectors	
Electronic Equipment	Analyzers	0
	Monitors	0
	Computers	0
	Signal converters	

**12.8 PASSIVE COMPONENTS MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

\*the ability for breaching equipment or system integrity

\*inspection and cleaning techniques

\*use of special purpose tools and equipment

Subject	Topic	
Pressure Vessels	Containment	See Report
	Pressurizer	See Report
	Reactor	See Report
Volume	Accumulators	See Report
	Piping	See Report
	Pools	See Report
	Reservoirs	See Report
	Tanks	See Report
	Tubing	See Report
Flow	Orifice	See Report

**12.9 MISCELLANEOUS EQUIPMENT MATRIX (Skills)****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

**Module B**

Instruction should enable the trainee to demonstrate the ability to lubricate designated equipment.

Subject	Topic	
Auxiliary Equipment	Boilers	See Report
	Cranes	See Report
	Elevators	
	Hoists	See Report
Structural Equipment	Anchor bolts	See Report
	Bases	See Report
	Cable trays	
	Conduit	
	Fire barrier	
	Hangers	See Report
	Mounts	See Report
	Snubbers	See Report
	Supports	See Report

**TRADE SPECIFIC JOB/TASK LISTING  
KNOWLEDGE AND SKILL REQUIREMENTS  
FOR  
BOILERMAKERS**

**GENERIC JOBS:**

**TASK-KNOWLEDGE AND SKILL**

Bolting and Torquing

Identify U.N.C. threads  
Identify U..N.F. threads  
Identify pipe threads  
Identify Metric threads  
Determine class of thread fit  
Identify ASTM and SAE grade marking for standard bolts  
Select correct bolts/fasteners for a given job  
Identify bolting sequence for a 4, 6, and 8 pattern  
Demonstrate the use of assorted sizes of torque wrenches

Rigging of material/equipment

Follow OSHA Regs 1910/1926  
Inspect and identify rigging hardware  
Select rigging hardware  
Attaching rigging hardware  
Tieing knots, splicing rope  
Cribbing machinery  
Determining Safe Working Load of rigging hardware  
Determine Safe Working Load of rigging hitches  
Calculating effective strain on slings  
Using chainfalls and come-alongs  
Using hand rigging signals  
Using voice rigging signals  
Interpreting crane capacity charts  
Splicing cable  
Weight calculations  
Interpreting sling capacity charts

Fabrication of special tools,  
Mock-ups, and parts for

Material handling  
Off-set line development

Support equipment

Operating power shears  
Operating sheetmetal break  
Preparing welds  
Layout chutes  
Layout spiral chutes  
Layout guards

Performance of welding activities

Qualify for specific process IAW  
utility weld program

Maintenance of welding/cutting  
Equipment

Maintain equipment IAW manufacturer's  
recommendations

Mechanical blueprint reading

Title Block  
Scale  
Contract number  
Drawing sections  
Revisions  
Parts identification  
Standard abbreviations and symbols  
Identifying types of lines  
Identifying types of views  
Identifying isometric drawings  
Determining dimensions of objects on  
drawings  
Determine scale of drawing  
Interpreting bill of materials  
Interpreting title block  
Identifying types of sections  
Identifying special views  
Interpreting assembly drawings  
Interpreting tolerances  
Identifying exploded views  
Interpreting material designation  
Determining location and size of holes  
Determine basic welding symbols  
Determine location and size of radii  
Reference specification  
Measurement take-offs

**FABRICATION /INSTALLATION (including internal components)**



- Pressure vessel (tanks)

Review work package and applicable Tank Codes  
 Install pressure vessel (tank) IAW work package specifications  
 Perform weld inspections as required  
 Perform tank flushes as required  
 Perform tank hydro(s)  
 Test safety valve  
 Assist in acceptance testing
- Heat exchangers

Review work package and applicable Codes  
 Install heat exchanger IAW work package specifications  
 Perform weld inspections as required  
 Perform heat exchanger flushes as required  
 Perform heat exchanger hydro(s)  
 Assist in acceptance testing
- Boilers/steam drums

Review work package and applicable Codes  
 Install boiler IAW work package specifications  
 Perform weld inspections as required  
 Perform boiler flushes as required  
 Perform boiler hydro(s)  
 Install boiler safety valve(s)  
 Assist in acceptance testing
- Condensers

Review work package and applicable Codes  
 Install condenser IAW work package specifications  
 Perform condenser inspections as required  
 Perform condenser flushes as required  
 Perform condenser hydro(s)  
 Assist in acceptance testing
- Galleries on tanks and vessels

Review work package and applicable Codes  
 Install galleries IAW work package specifications  
 Perform gallery inspections as required  
 Assist in acceptance testing of galleries
- Tube rolling and installation

Use Rolling motors  
 Use Expanders  
 Use of lubricants

Cleaning of tubes  
Cleaning of tube sheets  
Gear drives  
Tube beveling and bending  
Tube removal

- Tank erection

Identify types of tanks  
Erection work IAW Tank Codes  
Use of tank construction prints

## **MAINTENANCE:**

- Remove and install manway covers and gaskets

Matchmark cover  
Detention cover stud nuts (or bolts) IAW procedure or work plan  
Remove manway cover while protecting threads  
Verify gasket material, remove gasket  
measure and record gasket thickness  
Clean seating surfaces  
Conduct closeout inspection (FME)  
Select and install new gasket  
Set cover IAW matchmarks  
Torque/tighten IAW procedure/work plan

- Replace rupture discs

Matchmark ring flange  
Remove flange nuts  
Remove ring flange  
Remove rupture disc  
Clean fasteners  
Clean ring flange and body flange  
Inspect fasteners  
Inspect ring flange and body seating flange seating surfaces  
Install rupture disc  
Install Ring Flange  
Install fasteners

- Repair heat exchanger tubing

Identification of heat exchanger components  
Identification of types of heat exchangers  
Identification of heat exchanger plug  
Method of installing heat exchanger plug  
Use of tube sealing plug  
Precautions associated with hitting tube

- sealing plug with hammer

  - Tank repair
    - Applicable tank code
    - Tank cleaning
    - Tank ventilation
    - Approved welding procedures
    - Repair IAW work plan
    - Post maintenance NDE testing
  - Boiler repair
    - Applicable boiler code
    - Identify high or low pressure
    - Boiler cleaning
    - Boiler ventilation
    - Approved welding procedures
    - Repair IAW work plan
    - Post maintenance NDE testing
  - Heat exchanger shell/structure repair
    - Clean and inspect heat exchanger shell
    - Repair IAW work plan
    - Closeout inspection
    - Post maintenance NDE testing
    - Component hydro
  - Expansion joint replacement
    - Remove identified expansion joint
    - Ensure proper position of guides
    - Ensure proper placement of anchors
    - Considerations to pipe movement
    - Install replacement joint
    - Post maintenance NDE testing
    - Component/system hydro as required
  - Condenser component repair
    - Remove waterbox covers
    - Install ventilation
    - Test for safe atmosphere
    - Swipe for contamination
    - Check for loose or missing plugs
    - Check for leaks using hand
    - Check for leaks using plastic wrap
    - Make repairs IAW work plan
    - Clean waterbox and tube sheet
    - Conduct closeout inspection (FME)
    - Remove ventilation
    - Install manway covers
    - Post maintenance testing as required
  - Grid layout for erosion/corrosion
    - Work from plant Drawings, layout

repairs

repair grid  
Mark erosion/corrosion areas  
Identify interference  
Assist developing repair plan

- Flange and closure connections

Select and use proper cleaning solvent  
Clean flange and closure connection  
Check physical condition of mating surfaces  
Verify proper gasket(s)  
Makeup connection IAW work plan  
Post maintenance testing as required

- Removal/Replacement of galleries on tanks and vessels

Identify tank or vessel contents  
Develop/follow safety plan  
Identify obstructions  
Set up safe work and load path  
Remove galleries IAW work plan  
Set safety barriers as required

**Note:** This listing of tasks is intended to be used in determining the training requirements for contracted craft labor personnel at a Nuclear Power Plant. The list *is not* designed or intended for determining jurisdictional work assignments. The contractor is responsible for supplying the utility with qualified craft. He is also responsible for making appropriate work assignments based on the applicable work agreement.

NMAP

# Study Report


Detailed Review Documents  
Millwrights

MILLWRIGHT EVALUATION SUMMARY

Title	Section	Number of Subjects	Number of Subjects Addressed	Number of Topics *	Number of Topics Addressed	Number of topics w/ 'S' > 0	Ave 'S'>0
Mathematics	9.1	7	6	13	11	0	0
Classical Physics	9.2	2	2	35	19	0	0
Electrical Science	9.3	7	0	28	0	0	0
Instrument and Control	9.4	2	0	9	0	0	0
Principles of Radiation Detection	9.5	0	0	0	0	0	0
Properties of Reactor Plant Materials	9.6	7	6	25	16	0	0
Basic Atomic and Nuclear Physics	9.7	5	0	20	0	0	0
Heat transfer and Fluid Flow	9.8	3	2	26	3	0	0
Reactor Plant Protection	9.9	3	0	18	0	0	0
Chemistry	9.10	4	0	26	0	0	0
Hand Tools	10.1	9	9	74	72	0	0
Power Driven Hand Tools	10.2	2	2	16	11	0	0
Measuring and Test Equipment	10.3	4	3	14	6	0	0
<b>Plant Systems and Components</b>							
<b>Knowledge Training</b>							
<b>knowledge</b>							
plant systems matrix	11	5	5	37	37	0	0
rotating equipment matrix	11	5	3	21	7	0	0
heat transfer equipment matrix	11	3	1	12	6	0	0
process conditioning equipment matrix	11	3	0	13	0	0	0
electrical equipment matrix	11	2	0	14	0	0	0
control elements matrix	11	3	1	15	1	0	0
instrument and control equipment matrix	11	2	0	13	0	0	0
passive components matrix	11	3	1	10	3	0	0
miscellaneous equipment matrix	11	2	2	13	7	0	0
<b>skills</b>							
plant systems matrix	12	1	0	1	0	0	0
rotating equipment matrix	12	5	5	21	21	0	0
heat transfer equipment matrix	12	3	3	12	12	0	0
process conditioning equipment matrix	12	3	3	13	13	0	0
electrical equipment matrix	12	0	0	0	0	0	0
control elements matrix	12	3	1	15	1	0	0
instrument and control equipment matrix	12	2	0	7	0	0	0
passive components matrix	12	3	0	10	0	0	0
miscellaneous equipment matrix	12	2	2	9	8	0	0
totals		105	57	540	254		
<b>subject % addressed</b>		<b>54%</b>					
<b>topic % addressed</b>		<b>47%</b>					
* DOES NOT COUNT TOPICS NOT APPLICABLE TO THIS CRAFT AS DEFINED BY INPO 86-018							






**9.1 Mathematics****Module A**

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

 = Not Applicable  
To This Craft  
Mech.

**Module B**

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

Subject	Topic	
Basic Mathematical Concepts	Basic arithmetic functions	ADDRESSED
	Percentage	0
	Square root	ADDRESSED
	Averages	ADDRESSED
Scientific Notation	Conversion	
	Application of scientific notation	ADDRESSED
Dimensional Analysis	Unit conversions	ADDRESSED
	Unit modifiers	ADDRESSED
	Metric measurements	ADDRESSED
Algebra	Basic equation solving	ADDRESSED
	Quadratic equations	
Trigonometry	Basic relationships	ADDRESSED
Geometry	Basic relationships	ADDRESSED
	Vectors	ADDRESSED
Calculus	Concept of rate of change	
	Concept of integration	
Analysis of Graphs and Control Charts	Obtaining information from graphs	ADDRESSED
	Rectangular coordinate system	ADDRESSED
	Polar coordinate system	ADDRESSED
	Logarithmic coordinate system	

INPO 86-018 COMPARISON MILLWRIGHTS

Subject	Topic	
Nomograms	Obtaining information from nomograms	<div>0</div>
Exponents Base	"E" exponents (Natural/Napierian)	<div></div>
Numbering Systems	Binary numbering system	<div></div>
	Octal numbering system	<div></div>
	Hexidecimal numbering system	<div></div>
	Conversion of numbering systems	<div></div>



## 9.2 Classical Physics

### Module A

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

### Module B

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

Subject	Topic	
Units	Systems of units	0
	Units of pressure (vacuum/pressure, differential pressure) measurement	0
	Units of temperature measurement	0
	Units of periodic motion measurement	0
	Units of flow	0
	Units of volume	ADDRESSED
	Units of mass	ADDRESSED
	Units of weight	ADDRESSED
	Units of distance measurement	ADDRESSED
	Units of time measurement	0
Mechanical Principles Acceleration	Cams	0
	Conditions of equilibrium	0
	Conservation of energy	0
	Density, height, and temperature effects on process fluids	0
	Energy	0
	Fluid mechanics	0
	Force	ADDRESSED
	Friction	ADDRESSED
	Gear ratios	ADDRESSED
	Gravitation	0
	Heat	0
	Hydraulics	0
	Inclined planes	ADDRESSED

# INPO 86-018 COMPARISON MILLWRIGHTS

Subject

Topic

Mechanical Principles

Acceleration

Laws of motion

ADDRESSED

Mass

ADDRESSED

Momentum

ADDRESSED

Power

ADDRESSED

Pulleys

ADDRESSED

Simple machines

ADDRESSED

Temperature systems

0

Temperature system

conversions

ADDRESSED

Translational and

rotational motion

ADDRESSED

Velocity

ADDRESSED

Weight

ADDRESSED

Work

ADDRESSED

### 9.3 Electrical Science

#### Module A

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

#### Module B

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

Subject	Topic	
Basic Electrical	Electron theory	
	Insulators	
	Conductors	
	Static electricity	
	Magnetism	
	Direct current (DC)	
	DC sources	
	Units of electrical measurement	
	Fundamental electrical laws	
	Electrical hazards and safety	0
	Electrical grounds	0
	Basic electrical circuits	0
	Bistables	
	Relays	
Alternating Current	Basic alternating current theory	
	Sources	0
	Simple circuits	0
	AC waveforms	
	Inductance and inductive reactance	
	Mutual inductance and transformers	
	Capacitance and capacitive reactance	
	Impedance	
	Series, parallel and combination circuits	
	Resonance	0

## INPO 86-018 COMPARISON MILLWRIGHTS

Subject	Topic	
Alternating Current	Power factor	
	Single-phase circuits	
	Multi-phase circuits	
Plant Electrical	Sources of electrical power	0
	Switchgear components	0
	Power distribution (AC and DC)	0
Power Transformers	Theory	
	Internal construction	0
	Tap changers and hazards	
	Effects of exceeding ratings	
	Cooling systems	0
	Oil system air entrainment	0
	Safety precautions associated with cooling mediums	0
	Construction of terminal connections	
	Fault symptoms	0
	Fire protection systems	0
Current Transformers	Theory	0
	Use	
	Hazards	
Potential Transformers	Theory	0
	Use	
	Hazards	
Advanced Electrical	AC motors	0
	AC generators	0
	DC motors	0
	DC generators	0
	Control circuits	
	utility grid switchgear	0
	Synchrosopes	
	Voltage regulator	0
	Ground detection	0

INPO 86-018 COMPARISON MILLWRIGHTS

Subject

Topic

Advanced Electrical

Control circuits for  
in-plant electrical  
switchgear  
Protective relaying  
Lightning arrestors  
Batteries

0
0
0
0

## 9.4 Instrumentation and Control

### Module A

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

### Module B

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

Subject	Topic	
Basic Electronics	Semiconductors	
	Diodes	
	Transistors	
	Amplifier basics	
	Operational amplifiers	
	Integrated circuits	
	Solid state circuitry	
	Wave-shaping circuits	
	Noise suppression techniques	
Digital Electronics	Boolean algebra	
	Combinational logic	
	Sequential logic	
	Logic circuit timing	
	Input/output methods	
	Programming	
Process Measurement	Pressure measurement	0
	Temperature measurement	0
	Fluid flow measurement	0
	Level measurement	0
	Analytical measurements	0
Process Control	Automatic control fundamentals	0
	Basic control circuits	
	Open-loop control	0
	Closed-loop control	0
	Two-position control	0
	Proportional control	
	Reset action	
	Rate action	
	Control loop tuning	

## 9.5 Principles of Radiation Detection

### Module A

Instruction should enable the trainee to identify the location of and applications for each applicable instrument and detector.

### Module B

Instruction should enable the trainee to explain the principles of operation for each instrument and detector.

Subject

Topic

Detectors

Geiger-Mueller (G.M.)  
Scintillation  
Proportional counter  
Ion chamber  
Fission chamber  
Self-powered neutron


## 9.6 Properties of Reactor Plant Materials

### Module A

Instruction should enable the trainee to explain the terms, definitions, and basic concepts and to recognize conditions that are detrimental to reactor plant materials.

Subject	Topic	
Properties of Metals	Structure basics	ADDRESSED
	Changes in structure	ADDRESSED
	Expansion	ADDRESSED
	Embrittlement	ADDRESSED
Alloy	Definition	ADDRESSED
	Applications	ADDRESSED
Brittle Fracture	Characteristics	0
	Mechanisms	0
	Heatup/cooldown effects	ADDRESSED
	Heat treating	ADDRESSED
	Annealing	ADDRESSED
Plant Material Problems	Fatiguefailure/work hardening	ADDRESSED
	Corrosion	0
	Contamination	0
	Radiation-induced embrittlement	
Thermal Shock/Stress	Definition	0
	Causes and effects	0
Strength of Materials	Compressive strength	ADDRESSED
	Tensile strength	ADDRESSED
	Torque limits	ADDRESSED
Corrosion and Corrosion and Control	General	ADDRESSED
	Pit and crevice	ADDRESSED
	Galvanic	0
	Chloride stress	0
	Caustic stress	0
	Stress corrosion cracking	ADDRESSED



## 9.7 Basic Atomic and Nuclear Physics

### Module A

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

Subject	Topic	
Atomic Structure	Atomic mass unit	0
	Protons	0
	Neutrons	0
	Electrons	0
Nuclear Interactions	Ionization	0
	Radiation interactions	0
	Neutron interactions	0
	Radioactive decay process	0
Fission Process	Definition	0
	Theory of fission process	0
	Control of fission process	0
	Neutrons associated with fission	0
	Neutron flux effects on reactor power	0
	Neutron Leakage	
Residual Heat/Decay Heat	Sources of decay heat	0
Reactor Operation	Basic reactor types	0
	Reactor parameters	0
	Power-to-flow relationships	0
	Axial flux	
	Core imbalance	
	Core quadrant power tilt	
	Reactivity	
	Reactor response to control rods	0
	Reactor start-up and shutdown	0
	Reactivity accidents	0

**9.8 Heat Transfer and Fluid Flow****Module A**

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

**Module B**

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

Subject	Topic	
Basic Thermodynamics	Temperature	0
	Sensible heat	0
	Latent heat--vaporization, condensation	
	Properties of water and steam	0
	Pressure/temperature relationship	0
	Specific volume	0
	Basic steam-water cycle	0
	Steam tables	0
	Specific heat	0
	Boiling	0
	Saturation	0
	Properties of gases, gas-liquid interfaces	0
	Heat transfer mechanisms	ADDRESSED
	Heat cycles (basic)	0
	Heat exchangers	0
Properties of Fluids	Flow rate	0
	Fluid statics	0
	Density	0
	Buoyancy	0
Principles of Fluid Flow	Pump theory	ADDRESSED
	Cavitation	ADDRESSED
	Fluid flow in a closed system	0
	Water hammer	0
	Heating a closed system	0
	Filling and Venting	0
	Draining a closed system	0

## 9.9 Reactor Plant Protection

### Module A

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

### Module B

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

Subject	Topic	
Reactor Plant Protection Concepts	Thermal-hydraulic operating	0
	Safety limits	0
	Limiting conditions for operation	0
	Administrative controls and procedural concepts	0
	Automatic reactor plant protection concepts	0
Design Basis Accident	Discussion	0
	Symptoms and indications	0
	Anticipated radiation levels	0
	Effect on work place	0
	Evacuation criteria	0
	Recovery process	0
Transient Prevention and Mitigation of Core Damage	Integrated plant transient response	0
	Core cooling mechanisms	0
	Potentially damaging operating conditions	0
	Core damage	0
	Hydrogen hazards during accidents	0
	Monitoring critical parameters during accident conditions	0
	Radiation hazards and radiation monitor response	0

## 9.10 Chemistry

### Module A

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

### Module B

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

Subject	Topic	
Fundamentals of Chemistry	Mixtures, solutions, compounds	0
	Properties and uses of gases	0
	oxygen	0
	nitrogen	0
	hydrogen	0
	noble gases	0
	Ideal gas law	0
	Conductivity	0
	Acids and bases	0
	Corrosion chemistry	0
	pH	0
	Ion exchangers	0
Water Chemistry Control	S/G chemistry	0
	Secondary chemistry control	0
	Water chemistry control methods	0
Reactor Water Chemistry	Types of impurities	0
	Sources of impurities	0
	Effects of impurities	0
	Control/removal of impurities	0
	Radiochemistry	0
	Analytical results and core conditions	
	Sampling methods	
	Radiolysis and recombination	0
	Hydrogen gas in reactor water	0

Subject

Topic

Principles of Water  
Treatment

Purpose  
Methods  
Water quality/purity  
Grades of water

0
0
0
0

## SECTION 10

### TOOLS AND EQUIPMENT SKILLS TRAINING

This section 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. Subject matrices show the applicability of types of tools and equipment to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

#### 10.1 Hand Tools

##### 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

##### Module B

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
- \* explain the limitations of each tool
- \* explain the importance of maintaining tools in excellent condition
- \* describe the common failure mechanism(s) of each type of tool
- \* identify precursors 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., redressing 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 area 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.

# INPO 86-018 COMPARISON MILLWRIGHTS

Subject	Topic	
Hammers	Machinist (ballpeen)	ADDRESSED
	Carpenter (claw)	ADDRESSED
	Sledge	ADDRESSED
	Chipping	ADDRESSED
	Slide	ADDRESSED
Mallets	Plastic	ADDRESSED
	Rubber	ADDRESSED
	Rawhide	ADDRESSED
	Brass	ADDRESSED
	Lead	ADDRESSED
Punches	Drift	ADDRESSED
	Center	ADDRESSED
	Pin	ADDRESSED
	Hole	ADDRESSED
	Alignment	ADDRESSED
Wrenches	Open-end	ADDRESSED
	Box-end	ADDRESSED
	Combination	ADDRESSED
	Socket	ADDRESSED
	Socket set attachments	ADDRESSED
	* handles	ADDRESSED
	* extensions	ADDRESSED
	* adapters	ADDRESSED
	Tubing	ADDRESSED
	Adjustable open-end	ADDRESSED
	Adjustable pipe	ADDRESSED
	* open Jaw	ADDRESSED
	* strap	ADDRESSED
	* chain	ADDRESSED
	Slugging	ADDRESSED
	Spanner	ADDRESSED
	* pin	ADDRESSED
	* hook	ADDRESSED
	* face	ADDRESSED
	Hexagonal (Allen)	ADDRESSED
	Splined (Bristol)	ADDRESSED
	Torque	ADDRESSED
Screwdrivers	Flat	ADDRESSED
	Phillips	ADDRESSED
	Reed-Prince	ADDRESSED
	Off set	ADDRESSED
	Holding/starting	ADDRESSED

# INPO 86-018 COMPARISON MILLWRIGHTS

Subject	Topic	
Pliers	Slipjoint	ADDRESSED
	Lineman	ADDRESSED
	Needle-nose	ADDRESSED
	Diagonal	ADDRESSED
	Round nose	ADDRESSED
	Duckbill	ADDRESSED
	Snap ring	ADDRESSED
	Parallel jaw	ADDRESSED
	(channel/pump)	ADDRESSED
	Locking	ADDRESSED
	Lockwire	ADDRESSED
Vises and Clamps	Mechanics bench vise	ADDRESSED
	Pipe vise	ADDRESSED
	* yoke	ADDRESSED
	* bench	ADDRESSED
	Vise grips	ADDRESSED
	C-clamps	ADDRESSED
	V-clamps	ADDRESSED
	Spring clamps	ADDRESSED
	Table clamps	ADDRESSED
Cutting	Saws	ADDRESSED
	* wood cutting	0
	* metal cutting	ADDRESSED
	Knives	ADDRESSED
	Scissors/shears	ADDRESSED
	Bolt cutter	ADDRESSED
	Cable cutter	ADDRESSED
	Chisels	ADDRESSED
	Files	ADDRESSED
Other	Crimpers	
	Nutdrivers	0
	Cable strippers	
	Wire strippers	
	Threaders	ADDRESSED
	Benders	ADDRESSED



## 10.2 Power-driven Hand Tools

### Module A

Instruction should enable the trainee to perform the following:

- \* describe administrative controls on power-driven 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 radiologically 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 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 attachments for each tool
- \* describe the function of each attachment
- \* identify power sources that may be connected to power-driven hand tools
- \* identify areas of the plant where power sources are not available
- \* identify power source connection equipment- air hoses, extension cords, connectors, adaptors
- \* explain the limitations of each tool

### Module B

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 precursors of 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 adaptors

### Module C

Instruction should enable the trainee to perform the following:

- \* demonstrate the proper procedure to assemble and disassemble each tool
- \* demonstrate the proper procedure to inspect and clean each tool
- \* demonstrate the proper procedure to adjust and repair each tool

# INPO 86-018 COMPARISON MILLWRIGHTS

Subject

Topic

Pneumatic

Hammer

ADDRESSED

Drill

ADDRESSED

Chisel

ADDRESSED

Grinder

ADDRESSED

Punch

ADDRESSED

Wrench

ADDRESSED

Screwdriver

0

Saw

0

Electrical

Drill

ADDRESSED

Grinder

ADDRESSED

Wrench

0

Screwdriver

ADDRESSED

Saw

ADDRESSED

Spot welder

ADDRESSED

Heat gun

0

Vacuum cleaner

0

### 10.3 Measuring and Test Equipment (M&TE)

#### Module A

Instruction should enable the trainee to perform the following:

- \* define calibration
- \* explain requirements for maintaining an audiable calibration program
- \* explain calibration cycle
- \* explain requirements for instruments and test equipment found out of calibration
- \* identify information displayed on calibration sticker
- \* explain use of information on 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
- \* demonstrate procedures for obtaini ng M&TE
- \* identify the types of M&TE
- \* explain the use of inventory lists or printouts in selection of M&TE
- \* define "or equivalent" as applied to M&TE
- \* describe procedures to determine equivalency

#### Module B

Instruction should enable the trainee to perform the following:

- \* explain the special handling procedures for each type of test equipment
  - \* demonstrate proper method of protecting M&TE
    - in a radiologically controlled area
    - in a confined space
    - when working from hights
    - 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
  - \* the proper procedure to connect and disconnect each type of equipment
  - \* the proper procedure to operate each type of equipment
  - \* the proper use of connectors, adaptors, and leads
- Module C Instruction should enable the trainee to demonstrate the following:
- \* the proper procedure to inspect and clean each type of equipment
  - \* the proper procedure to adjust and calibrate each type of equipment
  - \* the proper procedure to repair each type of equipment

Subject

Topic

General M&TE

All

ADDRESSED

Sources

Current

Frequency

Heat

Pressure

ADDRESSED

ADDRESSED

## INPO 86-018 COMPARISON MILLWRIGHTS

Subject	Topic	
Sources	Radiation	ADDRESSED
	Resistance	ADDRESSED
	Vibration	ADDRESSED
	Voltage	
Measuring Devices	Capacitance	
	Current	
	Distance	ADDRESSED
	Frequency	ADDRESSED
	Mass	0
	Pressure	0
	Differential pressure	0
	Resistance	
	Speed	ADDRESSED
	Temperature	ADDRESSED
	Time	0
	Torque	ADDRESSED
	Vibration	ADDRESSED
	Voltage	
	Scales	0
	Radiation	0
	Flow	0
Analytical Devices	Oscilloscope	
	Vibration analyzer	ADDRESSED
	Gas analyzer	
Special Purpose Devices	Plant protection system	
	test set	
	Hydrostatic test set	
	Inverter test set	
	Leak-rate test set	0

**SECTION 11****PLANT SYSTEMS AND COMPONENTS KNOWLEDGE TRAINING**

This section provides the trainee with the knowledge necessary to understand systems and components and apply that information to the job. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments. It is expected that a one to two week basic systems and components course would cover the recommendations for electricians and maintenance mechanics. A four week course would probably be necessary for instrumentation and control technicians.

**11.1 Plant Systems (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \* explain the purpose
- \* identify the components
- \* identify the alarms and indications affected by maintenance
- \* describe each system at the block diagram level \* explain the importance to plant operations"
- \* identify conditions that preclude safe work in the vicinity of system components
- \* describe the effect of isolating system components on plant operation
- \* identify the basic the interrelationships with other plant systems

**Module B**

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

Subject	Topic	
Primary	NSSS	See Report
	Containment	See Report
	Fuel handling/storage	See Report
	Engineered safety features	See Report
	Sampling	See Report
	Reactor protection	See Report
	Auto control	See Report
	Steam (BWR)	See Report
Secondary	Steam (PWR)	See Report
	Feedwater	See Report
	Condensate	See Report
	Sampling	See Report
	Auto control	See Report
	Water treatment	See Report

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Subject	Topic	
Auxiliary	Component cooling	See Report
	Containment cooling	See Report
	Air supply	See Report
	Gas supply	See Report
	Water supply	See Report
	Oil	See Report
	HVAC	See Report
	Radwaste	See Report
	Bulk storage	See Report
	Waste treatment	See Report
Electrical	Switchyard	See Report
	Generator	See Report
	AC distribution	See Report
	DC distribution	See Report
	Heat tracing	See Report
	Grounding	See Report
Monitoring	Seismic	See Report
	Loose parts	See Report
	Radiation	See Report
	Environmental	See Report
	Neutron	See Report
	Plant computer	See Report
	Safety parameter	See Report

**11.2 ROTATING EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to identify the vibration limits.

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	0
	* impulse	0
	* reaction	0
	Diesel	0
Electrical Generators	Main	ADDRESSED
	Auxiliary	0
	Emergency	0
Pumps	Centrifugal	ADDRESSED
	Positive displacement	ADDRESSED
	Jet	0
Compressors	Rotary vane	ADDRESSED
	Reciprocating	ADDRESSED
	Rotary screw	ADDRESSED
	Centrifugal	ADDRESSED

INPO 86-018 COMPARISON MILLWRIGHTS

Subject

Topic

Fans

Vaneaxial  
Propeller  
Squirrel cage  
Centrifugal

0
0
0
0



**11.3 HEAT TRANSFER EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Mechanical	Heat exchangers	See Report
	Feedwater heater	See Report
	Steam generator	See Report
	Moisture separator	See Report
	Condensers	See Report
	Cooling towers	See Report
	Reboilers	0
Electro-mechanical	Air handlers	0
	Refrigeration units	0
Electrical	Recombiners	0
	Heat tracing	0
	Heaters	0

**11.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	0
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	0
	Ejectors	0
	Eductors	0
Mechanical	Filters	0
	Strainers	0
	Screens	0
	Centrifuges	0
	Traps	0

**11.5 ELECTRICAL EQUIPMENT MATRIX (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols to interpret print information
- \*explain the purpose and use of applicable types of equipment

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify indications of normal and abnormal equipment operation during troubleshooting and testing
- \*identify the probable cause of abnormal indications
- identify abnormal conditions that preclude safe work in the vicinity of equipment

**Module C**

Instruction should enable the trainee to perform the following:

- \*locate equipment in panels and cabinets
- \*identify breaker, switch, and disconnect position indications

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	0
	* general	0
	* station	0
	* current	0
	* potential	0
	Batteries	0
	Inverters	0
	Battery chargers	0
Control	Switchgear	0
	Breakers	0
	Relays	0
	Switches	0
	Disconnects	0
	High voltage breakers	0

**11.6 CONTROL ELEMENTS MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to explain the proper use of applicable lubricants.

Topic	Subject	
Valves	Gate	0
	Globe	0
	Butterfly	0
	Diaphragm	0
	Ball	0
	Plug	0
	Check	0
	Stop-check	0
	Relief	0
Actuators	Electric	ADDRESSED
	Pneumatic	0
	Explosive	0
Dampers	Blade	0
	Vane	0
	Louver	0

**11.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols
- \*explain the purpose of equipment

**Module B**

Instruction should enable the trainee to identify the following:

- \*the instrument range
- \*the instrument units

**Module C**

Instruction should enable the trainee to identify the following:

- \*the input and output ranges
- \*the input and output medium

**Module D**

Instruction should enable the trainee to identify the following:

- \*the power source(s)
- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Subject****Topic**

Instruments

Sensors

0

Indicators

0

Recorders

0

Switches

0

Controllers

0

Positioners

0

Transmitters

0

Annunciators

0

Detectors

0

Electronic Equipment

Analyzers

0

Signal converters

0

Monitors

0

Computers

0

**11.8 PASSIVE COMPONENTS MATRIX (Knowledge)****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

**Module B**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the pressure and volume capacity limits

**Module C**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the flow capacity limits

Subject	Topic	
Pressure Vessels	Containment	See Report
	Reactor	See Report
	Pressurize	See Report
Volume	Tanks	0
	Reservoirs	0
	Pools	0
	Accumulator	0
	Piping	0
	Tubing	0
Flow	Orifice	0

**11.9 MISCELLANEOUS EQUIPMENT MATRIX (Knowledge)****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

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify the load limits
- \*identify the major parts

**Module C**

Instruction should enable the trainee to perform the following:

- \*explain the principles of operation
- \*identify the normal and abnormal indications of equipment performance
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Auxiliary Equipment	Hoists	ADDRESSED
	Elevator	0
	Cranes	ADDRESSED
	Boiler	0
Structural Equipment	Mounts	ADDRESSED
	Bases	ADDRESSED
	Supports	ADDRESSED
	Hangers	ADDRESSED
	Cable trays	0
	Conduit	0
	Fire barriers	0
	Snubbers	0
	Anchor bolts	ADDRESSED

**SECTION 12****PLANT SYSTEMS AND COMPONENTS SKILLS TRAINING**

This section provides the trainee with the skills necessary to perform maintenance on systems and components. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The module indicates the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

**12.1 Plant Systems (Skills)****Module A**

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

Subject	Topic	
Primary	NSSS	
	Containment	
	Fuel Handling/storage	
	Engineered safety features	
	Sampling	
	Reactor protection	
	Auto control	
	Steam (BWR)	
Secondary	Steam (PWR)	
	Feedwater	
	Condensate	
	Sampling	
	Auto control	
	Water treatment	
Auxiliary	Component cooling	
	Containment cooling	
	Air supply	
	Gas supply	
	Water supply	
	Oil	
	HVAC	
	Radwaste	0
	Bulk storage	
Electrical	Switchyard	
	Generator	
	AC distribution	
	DC distribution	
	Heat tracing	
	Grounding	



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Subject	Topic	
Monitoring	Seismic	
	Loose parts	
	Radiation	
	Environmental	
	Neutron	
	Plant computer	
	Safety parameter	

**12.2 ROTATING EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

**Module B**

Instruction should enable the trainee to demonstrate the ability to measure equipment vibration properly.

**Module C**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to install and remove couplings/belts
- \*the ability to align rotating equipment
- \*the ability to test rotating equipment for "soft feet"
- \*the ability to lubricate designated equipment

Subject	Topic	
Prime Movers	Electrical	ADDRESSED
	* AC	ADDRESSED
	* DC	ADDRESSED
	Turbine	ADDRESSED
	* impulse	ADDRESSED
	* reaction	ADDRESSED
	Diesel	ADDRESSED
Electrical Generators	Main	ADDRESSED
	Auxiliary	ADDRESSED
	Emergency	ADDRESSED
Pumps	Centrifugal	ADDRESSED
	Positive displacement	ADDRESSED
	Jet	ADDRESSED
Compressors	Rotary vane	ADDRESSED
	Reciprocating	ADDRESSED
	Rotary screw	ADDRESSED
	Centrifugal	ADDRESSED
Fans	Vaneaxial	ADDRESSED
	Propeller	ADDRESSED
	Squirrel cage	ADDRESSED
	Centrifugal	ADDRESSED

**12.3 HEAT TRANSFER EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*methods for breaching equipment or system integrity
- \*techniques for testing tubes for leaks
- \*techniques to repair or plug leaking tubes

**Module B**

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

Subject	Topic	
Mechanical	Heat exchangers	See Report
	Feedwater heater	See Report
	Steam generator	See Report
	Moisture separator	See Report
	Condensers	See Report
	Cooling towers	See Report
	Reboilers	See Report
Electro-mechanical	Air handlers	See Report
	Refrigeration units	See Report
Electrical	Recombiners	See Report
	Heat tracing	See Report
	Heaters	See Report

**12.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*methods of medium removal and replacement
- \*methods for handling and disposing of medium

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

Subject	Topic	
Chemical	Ion exchangers	See Report
	Demineralizers	See Report
	Purifiers	See Report
	Absorbers	See Report
	Catalytic recombiners	See Report
Gaseous	Mechanical recombiners	See Report
	Ejectors	See Report
	Eductors	See Report
Mechanical	Filters	See Report
	Strainers	See Report
	Screens	See Report
	Centrifuges	See Report
	Traps	See Report

**12.5 ELECTRICAL EQUIPMENT MATRIX (Skills)****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
- \*repair techniques

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*adjustment and calibration
- \*testing methods

Subject

Topic

Supply

Buses  
Cables  
Transformers  
\* general  
\* station  
\* current  
\* potential  
Batteries  
Inverters  
Battery chargers


Control

Switchgear  
Breakers  
Relays  
Switches  
Disconnects  
High voltage breakers


**12.6 CONTROL ELEMENTS MATRIX (Skills)****Module A**

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

**Module B**

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

Subject	Topic	
Valves	Ball	0
	Butterfly	0
	Check	0
	Diaphragm	0
	Gate	0
	Globe	0
	Plug	0
	Stop-check	0
	Relief	0
Actuators	Electric	ADDRESSED
	Explosive	0
	Pneumatic	0
Dampers	Blade	0
	Louver	0
	Vane	0

**12.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Skills)****Module A**

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

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to remove equipment from service properly
- \*assembly and disassembly methods
- \*inspection and cleaning techniques
- \*the ability to logically troubleshoot defective equipment
- \*repair techniques
- \*adjustment and calibration
- \*methods for returning equipment to service
- \*use of special purpose tools and equipment

**Subject****Topic**

Instruments

Annunciators

0

Controllers

Indicators

0

Positioners

0

Recorders

0

Sensors

Switches

Transmitters

Detectors

Electronic Equipment

Analyzers

0

Monitors

0

Computers

0

Signal converters

**12.8 PASSIVE COMPONENTS MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*the ability for breaching equipment or system integrity
- \*inspection and cleaning techniques
- \*use of special purpose tools and equipment

Subject	Topic	
Pressure Vessels	Containment	0
	Pressurizer	0
	Reactor	0
Volume	Accumulators	0
	Piping	0
	Pools	0
	Reservoirs	0
	Tanks	0
	Tubing	0
Flow	Orifice	0



**12.9 MISCELLANEOUS EQUIPMENT MATRIX (Skills)****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

**Module B**

Instruction should enable the trainee to demonstrate the ability to lubricate designated equipment.

Subject	Topic	
Auxiliary Equipment	Boilers	0
	Cranes	ADDRESSED
	Elevators	
	Hoists	ADDRESSED
Structural Equipment	Anchor bolts	ADDRESSED
	Bases	ADDRESSED
	Cable trays	
	Conduit	
	Fire barrier	
	Hangers	ADDRESSED
	Mounts	ADDRESSED
	Snubbers	ADDRESSED
	Supports	ADDRESSED

# TRADE SPECIFIC JOB/TASK LISTING KNOWLEDGE AND SKILL REQUIREMENTS FOR MILLWRIGHTS

## **GENERIC JOBS:**

## **TASK-KNOWLEDGE AND SKILL**

### Precision measuring

Precision Level(s)  
Dial Indicator  
Outside Micrometer, 0 to 1"  
Outside Micrometer, 1 to 2"  
Inside Micrometer, 0 to 4"  
Depth Gages  
Telescoping Gages  
Inside Caliper, Small  
Inside Caliper, Large  
Outside Caliper, small  
Outside Caliper, large  
Inside-Outside Calipers

### Bolting and Torquing

Identify U..N.C. threads  
Identify U..N.F. threads  
Identify pipe threads  
Identify Metric threads  
Determine class of thread fit  
Identify ASTM and SAE grade marking for standard bolts  
Select correct bolts/fasteners for a given job  
Identify bolting sequence for a 4, 6, and 8 pattern  
Demonstrate the use of assorted sizes of torque wrenches

### Setting Sole Plates

Demonstrate understanding of Millwright related math  
Demonstrate ability to interpret mechanical blueprints  
Demonstrate knowledge of Layout techniques  
Establish elevation  
Set sub-sole plate  
Set sole plate  
Grout sole plate  
Align anchor bolts  
Precision align sole plates

Precision level sole plates

Lubrication

Identify lubrication materials  
Ability to follow OSHA regulations  
Ability to interpret manufactures specifications  
Installation of lubrication systems

Rigging of material/equipment

Follow OSHA Regs 1910/1926  
Inspect and identify rigging hardware  
Select rigging hardware  
Attaching rigging hardware  
Tieing knots, splicing rope  
Cribbing machinery  
Determining Safe Working Load of rigging hardware  
Determine Safe Working Load of rigging hitches  
Calculating effective strain on slings  
Using chainfalls and come-alongs  
Using hand rigging signals  
Using voice rigging signals  
Interpreting crane capacity charts  
Splicing cable  
Weight calculations  
Interpreting sling capacity charts

Fabrication of special tools,  
Mock-ups, and parts for  
Support equipment

Material handling  
Off-set line development  
Operating power shears  
Operating sheetmetal break  
Preparing welds  
Layout chutes  
Layout spiral chutes  
Layout guards

Mechanical blueprint reading

Identifying types of lines  
Identifying types of views  
Identifying isometric drawings  
Determining dimensions of objects on drawings  
Determine scale of drawing

Interpreting bill of materials  
Interpreting title block  
Identifying types of sections  
Identifying special views  
Interpreting assembly drawings  
Interpreting tolerances  
Identifying exploded views  
Interpreting material designation  
Determining location and size of holes  
Determine basic welding symbols  
Determine location and size of radii  
Reference specification  
Sketching  
Measurement take-offs

## **FABRICATION /INSTALLATION**

### **Sole plates**

Use of plant drawings, procedures and administrative forms  
Blueprint reading  
Knowledge of layout techniques  
Precision measuring tools  
Establish elevation  
Set sub-sole plate  
Set sole plate  
Grouting sole plates  
Align anchor bolts  
Precision align sole plates  
Precision level sole plates

### **Basic machinery installation**

Use of plant drawings, procedures and administrative forms  
Layout techniques  
Laying out machinery location  
Establish machinery elevation  
Set anchor bolts  
Set machinery Bases  
Determine grout clearance  
Building grout forms  
Cleaning machinery  
Protecting machinery  
Isolate machinery vibration

Rigging, moving, jacking and cribbing machinery

Bearings

Use of plant drawings, procedures and administrative forms  
Knowledge of approved lubricants  
Identifying ball bearings  
Identifying roller bearings  
Identifying needle bearings  
Identifying babbitt bearings  
Inspecting bearings  
Inspecting journals  
Installing bearings  
Scraping babbitt bearings  
Lubricating bearings  
Inspecting thrust bearings  
Repairing thrust bearings  
Assembling thrust bearings  
Installing magnetic and linear bearings  
Installing bushings

Gaskets and seals (including mechanical seals)

Use of plant drawings, procedures and administrative forms  
Selecting gasket material from approved list  
Selecting gaskets  
Layout techniques  
  
Making gaskets  
Installing gaskets  
Selecting packing materials  
Installing packing  
Installing labyrinth seals  
Installing mechanical seals  
Installing O-rings  
Installing steam packing  
Installing Hydrogen seals

Hydraulic and pneumatic systems

Use of plant drawings, procedures and administrative forms  
Discuss lock/tagout procedures  
Inspect hydraulic pumps  
Test hydraulic pumps  
Repairing vane hydraulic pumps

Repairing piston hydraulic pumps  
Repair hand operated hydraulic pumps  
Inspecting hydraulic cylinders (actuators)  
Testing hydraulic cylinders  
Repairing hydraulic cylinders  
Inspecting accumulators  
Testing Accumulators  
Repairing Accumulators  
Charging Accumulators  
Install, inspect, and repair hydraulic motors  
Install hydraulic servo controlled relief valve and motors  
Installation and repair of compressor systems  
Installation and repair of pneumatic cylinders  
Use of cam operated relief valves  
Use of high-low pump  
Repair of valve sequence flow control valve  
Install air cylinders, tubing and hoses  
Install and maintain regulators, filters and oilers

#### Installing Belting

Use of plant drawings, procedures and administrative forms  
Inspecting plate-and-button metal fasteners  
Installing Two-plate metal fasteners  
Vulcanizing conveyor belts  
Repairing conveyor belts  
Training conveyor belts

#### Gear boxes

Use of plant drawings, procedures and administrative forms  
Identifying types of gears  
Measuring gear backlash  
Inspecting gears  
Hone gears  
Adjust gear mesh  
Adjust clutch mechanisms  
Inspect lubrication system  
Adjust internal brake mechanisms

#### Turbine-generator-exciter

Use of plant drawings, procedures and

administrative forms  
Use of precision measuring tools  
Turbine theory  
Identify turbine components  
Install stationary components  
Align stationary components  
Install rotating components  
Set blade clearances  
Assemble thrust bearing  
Install sealing glands  
Align turbines  
Remove coupling bolts  
Install coupling bolts  
Adjust turbine governor  
Adjust turbine trips  
Rigging generator and stator assembly  
Cooler installation  
Generator rotor installation  
Installing bearing brackets  
Installing gland seal  
Installing blower assembly  
Installing exciter  
Aligning generator assembly

### Air compressors

Use of plant drawings, procedures and administrative forms  
Removing reciprocating air compressor valves  
Disassembling reciprocating air compressor valves  
Inspect reciprocating air compressor valves  
Lapping reciprocating air compressor valves  
Assemble reciprocating air compressor valves  
Disassemble reciprocating air compressor  
Removing piston and piston rod  
Measuring piston, cylinder and rings  
Installing piston rings  
Installing piston and piston rod  
Adjusting piston to head clearance  
Disassembling rotary blower  
Removing timing gears from rotary blowers  
Removing head plat and shafts  
Replacing bearings  
Installing timing gears  
Adjusting timing  
Assembling rotor blower

Stress relieving the piping system

Pumps

Use of plant drawings, procedures and administrative forms  
Identifying impeller pumps  
Disassembling impeller pumps  
Repairing impeller pumps  
Assembling impeller pumps  
Identifying gear pumps  
Disassembling gear pumps  
Assembling gear pumps  
Identifying piston pumps  
Inspect piston pumps  
Disassembling piston pumps  
Repairing piston pumps  
Assembling piston pumps  
Identifying vane pumps  
Inspect vane pumps  
Disassembling vane pumps  
Repairing vane pumps  
Assembling vane pumps  
Identifying diaphragm pumps  
Inspect diaphragm pumps  
Disassembling diaphragm pumps  
Repairing diaphragm pumps  
Assembling diaphragm pumps

Monorail Systems

Use of plant drawings, procedures and administrative forms  
Layout technique  
Follow OSHA Machine Guarding Regulations  
Determining elevation  
Installing hangers  
Installing rails  
Installing switches  
Assembling trolleys  
Assembling monorail components  
Install monorail components  
Align monorail components  
Repair monorails Align monorail system

Conveyor systems

Use of plant drawings, procedures and administrative forms



Knowledge of industrial belting  
Follow OSHA Machine Guarding Regulation  
Follow OSHA regulations listed in  
29 CFR 1926.555  
Identify types of conveyors  
Identify conveyor components  
Assemble conveyor components  
Install conveyor components  
Align conveyor components  
Repair conveyors  
Alignment of conveyor systems

### Drive systems

Use of plant drawings, procedures and  
administrative forms  
Knowledge of precision measuring tools  
Knowledge of thermal expansion  
Know of lubricants and lubrication methods  
Installing slip fit coupling  
Install taper lock coupling  
Install interference fit coupling  
Installing friction clutches  
Install centrifugal clutches  
Installing speed reducers  
Installing gear couplings  
Install variable speed drives  
Installing brakes  
Identify advantages and disadvantages of  
belt drive  
Determine sheave ratio  
Selecting belts  
Selecting Sheaves  
Determining belt length  
Aligning single belt systems  
Aligning multiple belt systems  
Adjusting belt tension  
Identify advantages and disadvantages of  
chain drive  
Determine sprocket ratio  
Selecting chains  
Selecting sprockets  
Determining length of chain  
Aligning chain drive sprockets  
Adjusting chain tension  
Lubricating chain  
Adjusting of linear induction motors

## **MAINTENANCE:**

### **Motor operated valve (MOV) repair**

Identify type and sizes of MOV's  
Installation and removal of motorized valve actuators from valves  
Assemble and disassembling of motorized valve actuators  
Repairing motorized valve actuators  
  
Adjusting limit switches  
Adjusting torque switched  
Testing motorized valve actuators  
Trouble shooting motorized valve actuators

### **Valve repair**

Disassemble gate valves  
Inspect gate valve components  
Repair gate valves  
Assemble gate valve  
Disassemble globe valves  
Inspect globe valve components  
Repair globe valves  
Assemble globe valve  
Disassemble check valves  
Inspect check valve components  
Repair check valves  
Assemble check valve  
Disassemble diaphragm valves  
Inspect diaphragm valve components  
Repair diaphragm valves  
Assemble diaphragm valve  
Disassemble butterfly valves  
Inspect butterfly valve components  
Repair butterfly valves  
Assemble butterfly valve  
Blue checking of valve seats  
Lapping and grinding techniques

### **Safety and relief valve repair**

Knowledge of safety and relief valve operation  
Disassembling relief valve

Removing pilot valve  
Blue checking pilot valve seat  
Repairing pilot valve seats  
Assembling relief valve  
Installing relief valve  
Perform to ANSI/NBIC Requirements

Mechanical seal installation and  
Troubleshooting

Identify types of mechanical seals  
Select proper mechanical seal  
Check alignment of equipment  
Check axial shaft movement of equipment  
Check stuffing box runout of equipment  
Check stuffing box bore concentricity of  
equipment  
Check condition of equipment  
Install mechanical seal  
Start-up the equipment  
Troubleshoot mechanical seals  
Follow seal installation safety procedures

Laser shaft alignment

Verify Laser alignment equipment certification  
and calibration current  
Identify angular misalignment  
Identify parallel misalignment  
Measure soft foot  
Correcting soft foot  
Measuring pipe strain  
Correcting pipe strain  
Installing laser alignment system  
components  
Measuring misalignment using laser  
alignment  
Correct misalignment

Perform vibration analysis

Verify that vibration analysis equipment  
calibration is current  
Measure vibration  
Measure phase  
Detect resonance  
Determine vibration severity  
Analyze vibration signatures  
Select sensor

	Setup (recommend) predictive maintenance program Perform orbital analysis Perform spectral analysis Perform time waveform analysis Perform phase analysis Two-plane balancing
<u>Support NDE testing</u>	Magnetic particle testing Dye-penetrant testing X-ray testing Ultra-sonic testing Ultra-violet testing
<u>Bearings inspection, repair and installation</u>	Use of plant drawings, procedures and administrative forms Knowledge of approved lubricants Identifying ball bearings Identifying roller bearings Identifying needle bearings Identifying babbitt bearings Inspecting bearings Inspecting journals Installing bearings Scraping babbitt bearings Lubricating bearings Inspecting thrust bearings Repairing thrust bearings Assembling thrust bearings Installing magnetic and linear bearings Installing bushings
<u>Coupling alignment (Rim-Face Reverse Dial and Vertical Coupling)</u>	Knowledge of precision measuring tools Knowledge of drive systems Check machine runout Maintaining magnetic center Check end thrust Checking the lubrication and condition of bearings Identifying angular misalignment Identifying parallel misalignment Measuring soft foot Correcting soft foot

Measuring pipe strain  
Correct pipe strain  
Measure bracket sag  
Measuring misalignment using one of the following methods:  
Rim-Face alignment procedures  
Reverse Dial alignment procedure  
Vertical coupling alignment procedure  
Calculate heat rise  
Determine shim requirements with formula  
Correcting misalignment  
Evaluating magnetic center  
Checking end thrust  
Checking condition of bearings and hubs

#### Gear alignment

Knowledge of gearboxes  
Knowledge of precision measuring tools  
Identifying different types of gears  
Identify gear nomenclature  
Aligning gears with feeler gauges  
Aligning gears with plastic-gauges  
Setting gear backlash with feeler gauge  
Setting gear backlash with plastic-gauge  
Setting gear backlash with indicators  
Blue checking gear mesh and carbon paper inspection

#### Crane inspection

Use of plant drawings, procedures, administrative forms and checklist  
Knowledge of OSHA Regs 1910/1926  
Perform periodic crane inspections  
Perform annual crane inspections  
Check gearbox fluid levels  
Inspect brake shoes  
Inspect drums  
Inspect wire rope  
Inspect  
Sheaves  
Check rails  
Check travel limits  
Check warning devices  
Lubricate wheels  
Inspect guards

Gearbox Inspection and adjustment

Identify types of gears  
Measure gear backlash  
Adjust backlash  
Inspect gears  
Hone gears  
Adjust gear mesh  
Adjust clutch mechanisms  
Inspect lubrication system  
Adjust internal brake system

Fan inspection and repair

Inspect fan louvers  
Adjust fan louvers  
Check alignment of driver to fan shaft  
Check overspeed trip  
Set overspeed trip  
Check blade angles  
Set blade angles  
Check gearbox  
Set gear box

**Note:** This listing of tasks is intended to be used in determining the training requirements for contracted craft labor personnel at a Nuclear Power Plant. The list *is not* designed or intended for determining jurisdictional work assignments. The contractor is responsible for supplying the utility with qualified craft. He is also responsible for making appropriate work assignments based on the applicable work agreement.

NMAP

# Study Report

Detailed Review Documents  
Iron Workers

IRON WORKERS EVALUATION SUMMARY

Title	Section	Number of Subjects	Number of Subjects Addressed	Number of Topics	Number of Topics * Addressed	Number of topics w/ 'S' > 0	Ave 'S'> 0
Mathematics	9.1	7	6	13	12	0	0
Classical Physics	9.2	2	2	35	33	0	0
Electrical Science	9.3	7	3	27	5	0	0
Instrument and Control	9.4	2	0	9	0	0	0
Principles of Radiation Detection	9.5	0	0	0	0	0	0
Properties of Reactor Plant Materials	9.6	7	7	26	25	0	0
Basic Atomic and Nuclear Physics	9.7	5	2	20	8	0	0
Heat transfer and Fluid Flow	9.8	3	1	26	4	0	0
Reactor Plant Protection	9.9	3	1	18	2	0	0
Chemistry	9.1	4	1	26	9	0	0
Hand Tools	10.1	9	9	74	64	0	0
Power Driven Hand Tools	10.2	2	2	16	16	0	0
Measuring and Test Equipment	10.3	4	2	14	7	0	0
<b>Plant Systems and Components</b>							
<b>Knowledge Training</b>							
<b>knowledge</b>							
plant systems matrix	11	5	1	37	1	0	0
rotating equipment matrix	11	5	0	21	0	0	0
heat transfer equipment matrix	11	3	0	12	0	0	0
process conditioning equipment matrix	11	3	0	13	0	0	0
electrical equipment matrix	11	2	0	14	0	0	0
control elements matrix	11	3	0	15	0	0	0
instrument and control equipment matrix	11	2	0	13	0	0	0
passive components matrix	11	3	0	10	0	0	0
miscellaneous equipment matrix	11	2	0	13	0	0	0
<b>skills</b>							
plant systems matrix	12	1	0	1	0	0	0
rotating equipment matrix	12	5	0	21	0	0	0
heat transfer	12	3	0	12	0	0	0
process conditioning equipment	12	3	0	13	0	0	0
electrical equipment matrix	12	0	0	0	0	0	0
control elements matrix	12	3	0	15	0	0	0
instrument and control equipment matrix	12	2	0	7	0	0	0
passive components matrix	12	3	0	10	0	0	0
miscellaneous equipment matrix	12	2	0	9	0	0	0
totals		105	37	540	186		
<b>subject % addressed</b>		<b>35%</b>					
<b>topic % addressed</b>		<b>34%</b>					
* DOES NOT COUNT TOPICS NOT APPLICABLE TO THIS CRAFT AS DEFINED BY INPO 86-018							






**9.1 Mathematics****Module A**

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

**Module B**

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

 = Not Applicable  
To This Craft  
Mech.

Subject	Topic	
Basic Mathematical Concepts	Basic arithmetic functions	ADDRESSED
	Percentage	ADDRESSED
	Square root	ADDRESSED
	Averages	ADDRESSED
Scientific Notation	Conversion	
	Application of scientific notation	
Dimensional Analysis	Unit conversions	ADDRESSED
	Unit modifiers	ADDRESSED
	Metric measurements	ADDRESSED
Algebra	Basic equation solving	ADDRESSED
	Quadratic equations	
Trigonometry	Basic relationships	ADDRESSED
Geometry	Basic relationships	ADDRESSED
	Vectors	ADDRESSED
Calculus	Concept of rate of change	
	Concept of integration	
Analysis of Graphs and Control Charts	Obtaining information from graphs	ADDRESSED
	Rectangular coordinate system	ADDRESSED
	Polar coordinate system	
	Logarithmic coordinate system	

INPO 86-018 COMPARISON IRONWORKERS

Subject	Topic	
Nomograms	Obtaining information from nomograms	<div>0</div>
Exponents Base	"E" exponents (Natural/Napierian)	<div></div>
Numbering Systems	Binary numbering system	<div></div>
	Octal numbering system	<div></div>
	Hexidecimal numbering system	<div></div>
	Conversion of numbering systems	<div></div>

## 9.2 Classical Physics

### Module A

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

### Module B

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

Subject	Topic	
Units	Systems of units	ADDRESSED
	Units of pressure (vacuum/pressure, differential pressure) measurement	ADDRESSED
	Units of temperature measurement	ADDRESSED
	Units of periodic motion measurement	0
	Units of flow	ADDRESSED
	Units of volume	ADDRESSED
	Units of mass	ADDRESSED
	Units of weight	ADDRESSED
	Units of distance measurement	ADDRESSED
	Units of time measurement	ADDRESSED
Mechanical Principles Acceleration	Cams	ADDRESSED
	Conditions of equilibrium	0
	Conservation of energy	ADDRESSED
	Density, height, and temperature effects on process fluids	ADDRESSED
	Energy	ADDRESSED
	Fluid mechanics	ADDRESSED
	Force	ADDRESSED
	Friction	ADDRESSED
	Gear ratios	ADDRESSED
	Gravitation	ADDRESSED
	Heat	ADDRESSED
	Hydraulics	ADDRESSED
	Inclined planes	ADDRESSED

# INPO 86-018 COMPARISON IRONWORKERS

Subject

Topic

Mechanical Principles

Acceleration

Laws of motion

ADDRESSED

Mass

ADDRESSED

Momentum

ADDRESSED

Power

ADDRESSED

Pulleys

ADDRESSED

Simple machines

ADDRESSED

Temperature systems

ADDRESSED

Temperature system

conversions

ADDRESSED

Translational and  
rotational motion

ADDRESSED

Velocity

ADDRESSED

Weight

ADDRESSED

Work

ADDRESSED

### 9.3 Electrical Science

#### Module A

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

#### Module B

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

Subject	Topic	
Basic Electrical	Electron theory	
	Insulators	
	Conductors	
	Static electricity	
	Magnetism	
	Direct current (DC)	
	DC sources	
	Units of electrical measurement	
	Fundamental electrical laws	
	Electrical hazards and safety	ADDRESSED
	Electrical grounds	ADDRESSED
	Basic electrical circuits	0
	Bistables	
	Relays	
Alternating Current	Basic alternating current theory	
	Sources	ADDRESSED
	Simple circuits	ADDRESSED
	AC waveforms	
	Inductance and inductive reactance	
	Mutual inductance and transformers	
	Capacitance and capacitive reactance	
	Impedance	
	Series, parallel and combination circuits	
	Resonance	0

# INPO 86-018 COMPARISON IRONWORKERS

Subject	Topic	
Alternating Current	Power factor	
	Single-phase circuits	
	Multi-phase circuits	
Plant Electrical	Sources of electrical power	0
	Switchgear components	0
	Power distribution (AC and DC)	ADDRESSED
Power Transformers	Theory	
	Internal construction	
	Tap changers and hazards	
	Effects of exceeding ratings	
	Cooling systems	0
	Oil system air entrainment	0
	Safety precautions associated with cooling mediums	0
	Construction of terminal connections	
	Fault symptoms	0
	Fire protection systems	0
Current Transformers	Theory	0
	Use	
	Hazards	
Potential Transformers	Theory	0
	Use	
	Hazards	
Advanced Electrical	AC motors	0
	AC generators	0
	DC motors	0
	DC generators	0
	Control circuits	
	utility grid switchgear	0
	Synchrosopes	
	Voltage regulator	0
	Ground detection	0

## INPO 86-018 COMPARISON IRONWORKERS

Subject

Topic

Advanced Electrical

Control circuits for  
in-plant electrical  
switchgear  
Protective relaying  
Lightning arrestors  
Batteries

0
0
0
0

## 9.4 Instrumentation and Control

### Module A

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

### Module B

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

Subject	Topic	
Basic Electronics	Semiconductors	
	Diodes	
	Transistors	
	Amplifier basics	
	Operational amplifiers	
	Integrated circuits	
	Solid state circuitry	
	Wave-shaping circuits	
	Noise suppression techniques	
Digital Electronics	Boolean algebra	
	Combinational logic	
	Sequential logic	
	Logic circuit timing	
	Input/output methods	
	Programming	
Process Measurement	Pressure measurement	0
	Temperature measurement	0
	Fluid flow measurement	0
	Level measurement	0
	Analytical measurements	0
Process Control	Automatic control fundamentals	0
	Basic control circuits	
	Open-loop control	0
	Closed-loop control	0
	Two-position control	0
	Proportional control	
	Reset action	
	Rate action	
	Control loop tuning	



## 9.5 Principles of Radiation Detection

### Module A

Instruction should enable the trainee to identify the location of and applications for each applicable instrument and detector.

### Module B

Instruction should enable the trainee to explain the principles of operation for each instrument and detector.

Subject	Topic	
Detectors	Geiger-Mueller (G.M.)	
	Scintillation	
	Proportional counter	
	Ion chamber	
	Fission chamber	
	Self-powered neutron	

## 9.6 Properties of Reactor Plant Materials

### Module A

Instruction should enable the trainee to explain the terms, definitions, and basic concepts and to recognize conditions that are detrimental to reactor plant materials.

Subject	Topic	
Properties of Metals	Structure basics	ADDRESSED
	Changes in structure	ADDRESSED
	Expansion	ADDRESSED
	Embrittlement	ADDRESSED
Alloy	Definition	ADDRESSED
	Applications	ADDRESSED
Brittle Fracture	Characteristics	ADDRESSED
	Mechanisms	ADDRESSED
	Heatup/cooldown effects	ADDRESSED
	Heat treating	ADDRESSED
	Annealing	ADDRESSED
Plant Material Problems	Fatiguefailure/work hardening	ADDRESSED
	Corrosion	ADDRESSED
	Contamination	ADDRESSED
	Radiation-induced embrittlement	
Thermal Shock/Stress	Definition	ADDRESSED
	Causes and effects	ADDRESSED
Strength of Materials	Compressive strength	ADDRESSED
	Tensile strength	ADDRESSED
	Torque limits	ADDRESSED
Corrosion and Corrosion and Control	General	ADDRESSED
	Pit and crevice	ADDRESSED
	Galvanic	0
	Chloride stress	ADDRESSED
	Caustic stress	ADDRESSED
	Stress corrosion cracking	ADDRESSED

## 9.7 Basic Atomic and Nuclear Physics

### Module A

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

Subject	Topic	
Atomic Structure	Atomic mass unit	ADDRESSED
	Protons	ADDRESSED
	Neutrons	ADDRESSED
	Electrons	ADDRESSED
Nuclear Interactions	Ionization	ADDRESSED
	Radiation interactions	ADDRESSED
	Neutron interactions	ADDRESSED
	Radioactive decay process	ADDRESSED
Fission Process	Definition	0
	Theory of fission process	0
	Control of fission process	0
	Neutrons associated with fission	0
	Neutron flux effects on reactor power	0
	Neutron Leakage	
Residual Heat/Decay Heat	Sources of decay heat	0
Reactor Operation	Basic reactor types	0
	Reactor parameters	0
	Power-to-flow relationships	0
	Axial flux	
	Core imbalance	
	Core quadrant power tilt	
	Reactivity	
	Reactor response to control rods	0
	Reactor start-up and shutdown	0
	Reactivity accidents	0

## 9.8 Heat Transfer and Fluid Flow

### Module A

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

### Module B

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

Subject	Topic	
Basic Thermodynamics	Temperature	0
	Sensible heat	0
	Latent heat--vaporization, condensation	
	Properties of water and steam	0
	Pressure/temperature relationship	0
	Specific volume	0
	Basic steam-water cycle	0
	Steam tables	0
	Specific heat	0
	Boiling	0
	Saturation	0
	Properties of gases, gas-liquid interfaces	0
	Heat transfer mechanisms	0
	Heat cycles (basic)	0
	Heat exchangers	0
Properties of Fluids	Flow rate	ADDRESSED
	Fluid statics	ADDRESSED
	Density	ADDRESSED
	Buoyancy	ADDRESSED
Principles of Fluid Flow	Pump theory	0
	Cavitation	0
	Fluid flow in a closed system	0
	Water hammer	0
	Heating a closed system	0
	Filling and Venting	0
	Draining a closed system	0

## 9.9 Reactor Plant Protection

### Module A

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

### Module B

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

Subject	Topic	
Reactor Plant Protection Concepts	Thermal-hydraulic operating	0
	Safety limits	0
	Limiting conditions for operation	0
	Administrative controls and procedural concepts	0
	Automatic reactor plant protection concepts	0
Design Basis Accident	Discussion	0
	Symptoms and indications	0
	Anticipated radiation levels	0
	Effect on work place	0
	Evacuation criteria	0
	Recovery process	0
Transient Prevention and Mitigation of Core Damage	Integrated plant transient response	0
	Core cooling mechanisms	0
	Potentially damaging operating conditions	0
	Core damage	0
	Hydrogen hazards during accidents	0
	Monitoring critical parameters during accident conditions	ADDRESSED
	Radiation hazards and radiation monitor response	ADDRESSED

## 9.10 Chemistry

### Module A

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

### Module B

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

Subject	Topic	
Fundamentals of Chemistry	Mixtures, solutions, compounds	ADDRESSED
	Properties and uses of gases	ADDRESSED
	oxygen	ADDRESSED
	nitrogen	ADDRESSED
	hydrogen	ADDRESSED
	noble gases	0
	Ideal gas law	0
	Conductivity	ADDRESSED
	Acids and bases	ADDRESSED
	Corrosion chemistry	ADDRESSED
	pH	ADDRESSED
	Ion exchangers	0
Water Chemistry Control	S/G chemistry	0
	Secondary chemistry control	0
	Water chemistry control methods	0
Reactor Water Chemistry	Types of impurities	0
	Sources of impurities	0
	Effects of impurities	0
	Control/removal of impurities	0
	Radiochemistry	0
	Analytical results and core conditions	
	Sampling methods	
	Radiolysis and recombination	0
	Hydrogen gas in reactor water	0

Subject	Topic	
Principles of Water Treatment	Purpose	0
	Methods	0
	Water quality/purity	0
	Grades of water	0

## SECTION 10

### TOOLS AND EQUIPMENT SKILLS TRAINING

This section 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. Subject matrices show the applicability of types of tools and equipment to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

#### 10.1 Hand Tools

##### 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

##### Module B

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
- \* explain the limitations of each tool
- \* explain the importance of maintaining tools in excellent condition
- \* describe the common failure mechanism(s) of each type of tool
- \* identify precursors 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., redressing 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 area 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.



INPO 86-018 COMPARISON IRONWORKERS

Subject	Topic	
Hammers	Machinist (ballpeen)	ADDRESSED
	Carpenter (claw)	ADDRESSED
	Sledge	ADDRESSED
	Chipping	ADDRESSED
	Slide	0
Mallets	Plastic	ADDRESSED
	Rubber	ADDRESSED
	Rawhide	ADDRESSED
	Brass	ADDRESSED
	Lead	0
Punches	Drift	ADDRESSED
	Center	ADDRESSED
	Pin	ADDRESSED
	Hole	ADDRESSED
	Alignment	ADDRESSED
Wrenches	Open-end	ADDRESSED
	Box-end	ADDRESSED
	Combination	ADDRESSED
	Socket	ADDRESSED
	Socket set attachments	ADDRESSED
	* handles	ADDRESSED
	* extensions	ADDRESSED
	* adapters	ADDRESSED
	Tubing	
	Adjustable open-end	ADDRESSED
	Adjustable pipe	ADDRESSED
	* open Jaw	ADDRESSED
	* strap	ADDRESSED
	* chain	0
	Slugging	ADDRESSED
	Spanner	ADDRESSED
	* pin	ADDRESSED
	* hook	ADDRESSED
	* face	ADDRESSED
	Hexagonal (Allen)	ADDRESSED
	Splined (Bristol)	0
	Torque	ADDRESSED
Screwdrivers	Flat	ADDRESSED
	Phillips	ADDRESSED
	Reed-Prince	0
	Off set	ADDRESSED
	Holding/starting	ADDRESSED

# INPO 86-018 COMPARISON IRONWORKERS

Subject	Topic	
Pliers	Slipjoint	ADDRESSED
	Lineman	ADDRESSED
	Needle-nose	ADDRESSED
	Diagonal	ADDRESSED
	Round nose	ADDRESSED
	Duckbill	0
	Snap ring	ADDRESSED
	Parallel jaw	ADDRESSED
	(channel/pump)	ADDRESSED
	Locking	ADDRESSED
	Lockwire	ADDRESSED
Vises and Clamps	Mechanics bench vise	ADDRESSED
	Pipe vise	ADDRESSED
	* yoke	ADDRESSED
	* bench	ADDRESSED
	Vise grips	ADDRESSED
	C-clamps	ADDRESSED
	V-clamps	ADDRESSED
	Spring clamps	ADDRESSED
	Table clamps	ADDRESSED
Cutting	Saws	ADDRESSED
	* wood cutting	ADDRESSED
	* metal cutting	ADDRESSED
	Knives	ADDRESSED
	Scissors/shears	ADDRESSED
	Bolt cutter	ADDRESSED
	Cable cutter	ADDRESSED
	Chisels	ADDRESSED
	Files	ADDRESSED
Other	Crimpers	
	Nutdrivers	0
	Cable strippers	
	Wire strippers	
	Threaders	0
	Benders	ADDRESSED

## 10.2 Power-driven Hand Tools

### Module A

Instruction should enable the trainee to perform the following:

- \* describe administrative controls on power-driven 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 radiologically 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 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 attachments for each tool
- \* describe the function of each attachment
- \* identify power sources that may be connected to power-driven hand tools
- \* identify areas of the plant where power sources are not available
- \* identify power source connection equipment- air hoses, extension cords, connectors, adaptors
- \* explain the limitations of each tool

### Module B

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 precursors of 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 adaptors

### Module C

Instruction should enable the trainee to perform the following:

- \* demonstrate the proper procedure to assemble and disassemble each tool
- \* demonstrate the proper procedure to inspect and clean each tool
- \* demonstrate the proper procedure to adjust and repair each tool

# INPO 86-018 COMPARISON IRONWORKERS

Subject

Topic

Pneumatic

Hammer  
Drill  
Chisel  
Grinder  
Punch  
Wrench  
Screwdriver  
Saw

ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED

Electrical

Drill  
Grinder  
Wrench  
Screwdriver  
Saw  
Spot welder  
Heat gun  
Vacuum cleaner

ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED

### 10.3 Measuring and Test Equipment (M&TE)

#### Module A

Instruction should enable the trainee to perform the following:

- \* define calibration
- \* explain requirements for maintaining an audiable calibration program
- \* explain calibration cycle
- \* explain requirements for instruments and test equipment found out of calibration
- \* identify information displayed on calibration sticker
- \* explain use of information on 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
- \* demonstrate procedures for obtaini ng M&TE
- \* identify the types of M&TE
- \* explain the use of inventory lists or printouts in selection of M&TE
- \* define "or equivalent" as applied to M&TE
- \* describe procedures to determine equivalency

#### Module B

Instruction should enable the trainee to perform the following:

- \* explain the special handling procedures for each type of test equipment
  - \* demonstrate proper method of protecting M&TE
    - in a radiologically controlled area
    - in a confined space
    - when working from hights
    - 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
  - \* the proper procedure to connect and disconnect each type of equipment
  - \* the proper procedure to operate each type of equipment
  - \* the proper use of connectors, adaptors, and leads
- Module C Instruction should enable the trainee to demonstrate the following:
- \* the proper procedure to inspect and clean each type of equipment
  - \* the proper procedure to adjust and calibrate each type of equipment
  - \* the proper procedure to repair each type of equipment

Subject	Topic	
General M&TE	All	ADDRESSED
Sources	Current	
	Frequency	
	Heat	
	Pressure	

# INPO 86-018 COMPARISON IRONWORKERS

Subject	Topic	
Sources	Radiation	
	Resistance	
	Vibration	
	Voltage	
Measuring Devices	Capacitance	
	Current	
	Distance	ADDRESSED
	Frequency	
	Mass	ADDRESSED
	Pressure	ADDRESSED
	Differential pressure	ADDRESSED
	Resistance	
	Speed	0
	Temperature	
	Time	0
	Torque	ADDRESSED
	Vibration	0
	Voltage	
	Scales	0
	Radiation	ADDRESSED
	Flow	0
Analytical Devices	Oscilloscope	
	Vibration analyzer	0
	Gas analyzer	
Special Purpose Devices	Plant protection system test set	
	Hydrostatic test set	
	Inverter test set	
	Leak-rate test set	0

**SECTION 11****PLANT SYSTEMS AND COMPONENTS KNOWLEDGE TRAINING**

This section provides the trainee with the knowledge necessary to understand systems and components and apply that information to the job. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments. It is expected that a one to two week basic systems and components course would cover the recommendations for electricians and maintenance mechanics. A four week course would probably be necessary for instrumentation and control technicians.

**11.1 Plant Systems (Knowledge)****Module A**

Instruction should enable the trainee to perform the following:

- \* explain the purpose
- \* identify the components
- \* identify the alarms and indications affected by maintenance
- \* describe each system at the block diagram level \* explain the importance to plant operations"
- \* identify conditions that preclude safe work in the vicinity of system components
- \* describe the effect of isolating system components on plant operation
- \* identify the basic the interrelationships with other plant systems

**Module B**

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

Subject	Topic	
Primary	NSSS	0
	Containment	0
	Fuel handling/storage	0
	Engineered safety features	0
	Sampling	0
	Reactor protection	0
	Auto control	0
	Steam (BWR)	0
Secondary	Steam (PWR)	0
	Feedwater	0
	Condensate	0
	Sampling	0
	Auto control	0
	Water treatment	0

# INPO 86-018 COMPARISON IRONWORKERS

Subject	Topic	
Auxiliary	Component cooling	0
	Containment cooling	0
	Air supply	0
	Gas supply	0
	Water supply	0
	Oil	0
	HVAC	0
	Radwaste	0
	Bulk storage	0
	Waste treatment	0
Electrical	Switchyard	0
	Generator	0
	AC distribution	0
	DC distribution	0
	Heat tracing	0
	Grounding	0
Monitoring	Seismic	0
	Loose parts	0
	Radiation	ADDRESSED
	Environmental	0
	Neutron	0
	Plant computer	0
	Safety parameter	0



## 11.2 ROTATING EQUIPMENT MATRIX (Knowledge)

### 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

### Module B

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

### Module C

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

### Module D

Instruction should enable the trainee to identify the vibration limits.

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	0
	* impulse	0
	* reaction	0
	Diesel	0
Electrical Generators	Main	0
	Auxiliary	0
	Emergency	0
Pumps	Centrifugal	0
	Positive displacement	0
	Jet	0
Compressors	Rotary vane	0
	Reciprocating	0
	Rotary screw	0
	Centrifugal	0

INPO 86-018 COMPARISON IRONWORKERS

Subject	Topic	
Fans	Vaneaxial	0
	Propeller	0
	Squirrel cage	0
	Centrifugal	0

### 11.3 HEAT TRANSFER EQUIPMENT MATRIX (Knowledge)

#### 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

#### Module B

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

#### Module C

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Mechanical	Heat exchangers	0
	Feedwater heater	0
	Steam generator	0
	Moisture separator	0
	Condensers	0
	Cooling towers	0
	Reboilers	0
Electro-mechanical	Air handlers	0
	Refrigeration units	0
Electrical	Recombiners	0
	Heat tracing	0
	Heaters	0

**11.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Knowledge)****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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	0
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	0
	Ejectors	0
	Eductors	0
Mechanical	Filters	0
	Strainers	0
	Screens	0
	Centrifuges	0
	Traps	0

## 11.5 ELECTRICAL EQUIPMENT MATRIX (Knowledge)

### Module A

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols to interpret print information
- \*explain the purpose and use of applicable types of equipment

### Module B

Instruction should enable the trainee to perform the following:

- \*identify indications of normal and abnormal equipment operation during troubleshooting and testing
- \*identify the probable cause of abnormal indications
- identify abnormal conditions that preclude safe work in the vicinity of equipment

### Module C

Instruction should enable the trainee to perform the following:

- \*locate equipment in panels and cabinets
- \*identify breaker, switch, and disconnect position indications

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	0
	* general	0
	* station	0
	* current	0
	* potential	0
	Batteries	0
	Inverters	0
	Battery chargers	0
Control	Switchgear	0
	Breakers	0
	Relays	0
	Switches	0
	Disconnects	0
	High voltage breakers	0

## 11.6 CONTROL ELEMENTS MATRIX (Knowledge)

### 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

### Module B

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

### Module C

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

### Module D

Instruction should enable the trainee to explain the proper use of applicable lubricants.

Topic	Subject	
Valves	Gate	0
	Globe	0
	Butterfly	0
	Diaphragm	0
	Ball	0
	Plug	0
	Check	0
	Stop-check	0
	Relief	0
Actuators	Electric	0
	Pneumatic	0
	Explosive	0
Dampers	Blade	0
	Vane	0
	Louver	0

## 11.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Knowledge)

### Module A

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols
- \*explain the purpose of equipment

### Module B

Instruction should enable the trainee to identify the following:

- \*the instrument range
- \*the instrument units

### Module C

Instruction should enable the trainee to identify the following:

- \*the input and output ranges
- \*the input and output medium

### Module D

Instruction should enable the trainee to identify the following:

- \*the power source(s)
- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Instruments	Sensors	0
	Indicators	0
	Recorders	0
	Switches	0
	Controllers	0
	Positioners	0
	Transmitters	0
	Annunciators	0
	Detectors	0
Electronic Equipment	Analyzers	0
	Signal converters	0
	Monitors	0
	Computers	0

**11.8 PASSIVE COMPONENTS MATRIX (Knowledge)****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

**Module B**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the pressure and volume capacity limits

**Module C**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the flow capacity limits

Subject	Topic	
Pressure Vessels	Containment	0
	Reactor	0
	Pressurize	0
Volume	Tanks	0
	Reservoirs	0
	Pools	0
	Accumulator	0
	Piping	0
	Tubing	0
Flow	Orifice	0



## 11.9 MISCELLANEOUS EQUIPMENT MATRIX (Knowledge)

### 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

### Module B

Instruction should enable the trainee to perform the following:

- \*identify the load limits
- \*identify the major parts

### Module C

Instruction should enable the trainee to perform the following:

- \*explain the principles of operation
- \*identify the normal and abnormal indications of equipment performance
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Auxiliary Equipment	Hoists	0
	Elevator	0
	Cranes	0
	Boiler	0
Structural Equipment	Mounts	0
	Bases	0
	Supports	0
	Hangers	0
	Cable trays	0
	Conduit	0
	Fire barriers	0
	Snubbers	0
	Anchor bolts	0

## SECTION 12

**PLANT SYSTEMS AND COMPONENTS SKILLS TRAINING**

This section provides the trainee with the skills necessary to perform maintenance on systems and components. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The module indicates the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

**12.1 Plant Systems (Skills)****Module A**

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

Subject	Topic	
Primary	NSSS	
	Containment	
	Fuel Handling/storage	
	Engineered safety features	
	Sampling	
	Reactor protection	
	Auto control	
	Steam (BWR)	
Secondary	Steam (PWR)	
	Feedwater	
	Condensate	
	Sampling	
	Auto control	
	Water treatment	
Auxiliary	Component cooling	
	Containment cooling	
	Air supply	
	Gas supply	
	Water supply	
	Oil	
	HVAC	
	Radwaste	
	Bulk storage	
Electrical	Switchyard	
	Generator	
	AC distribution	
	DC distribution	
	Heat tracing	
	Grounding	

Subject	Topic	
Monitoring	Seismic	
	Loose parts	
	Radiation	
	Environmental	
	Neutron	
	Plant computer	
	Safety parameter	

## 12.2 ROTATING EQUIPMENT MATRIX (Skills)

### Module A

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

### Module B

Instruction should enable the trainee to demonstrate the ability to measure equipment vibration properly.

### Module C

Instruction should enable the trainee to demonstrate the following:

- \*the ability to install and remove couplings/belts
- \*the ability to align rotating equipment
- \*the ability to test rotating equipment for "soft feet"
- \*the ability to lubricate designated equipment

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	0
	* impulse	0
	* reaction	0
	Diesel	0
Electrical Generators	Main	0
	Auxiliary	0
	Emergency	0
Pumps	Centrifugal	0
	Positive displacement	0
	Jet	0
Compressors	Rotary vane	0
	Reciprocating	0
	Rotary screw	0
	Centrifugal	0
Fans	Vaneaxial	0
	Propeller	0
	Squirrel cage	0
	Centrifugal	0

**12.3 HEAT TRANSFER EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

- \*methods for breaching equipment or system integrity
- \*techniques for testing tubes for leaks
- \*techniques to repair or plug leaking tubes

**Module B**

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

Subject	Topic	
Mechanical	Heat exchangers	0
	Feedwater heater	0
	Steam generator	0
	Moisture separator	0
	Condensers	0
	Cooling towers	0
	Reboilers	0
Electro-mechanical	Air handlers	0
	Refrigeration units	0
Electrical	Recombiners	0
	Heat tracing	0
	Heaters	0

**12.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

\*methods of medium removal and replacement

\*methods for handling and disposing of medium

**Module B**

Instruction should enable the trainee to demonstrate the following:

\*assembly and disassembly methods

\*repair techniques

\*use of special purpose tools and equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	0
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	0
	Ejectors	0
	Eductors	0
Mechanical	Filters	0
	Strainers	0
	Screens	0
	Centrifuges	0
	Traps	0

## 12.5 ELECTRICAL EQUIPMENT MATRIX (Skills)

### 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
- \*repair techniques

### Module B

Instruction should enable the trainee to demonstrate the following:

- \*adjustment and calibration
- \*testing methods

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	
	* general	
	* station	
	* current	
	* potential	
	Batteries	
	Inverters	
	Battery chargers	
Control	Switchgear	
	Breakers	
	Relays	
	Switches	
	Disconnects	
	High voltage breakers	

**12.6 CONTROL ELEMENTS MATRIX (Skills)****Module A**

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

**Module B**

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

Subject	Topic	
Valves	Ball	0
	Butterfly	0
	Check	0
	Diaphragm	0
	Gate	0
	Globe	0
	Plug	0
	Stop-check	0
	Relief	0
Actuators	Electric	0
	Explosive	0
	Pneumatic	0
Dampers	Blade	0
	Louver	0
	Vane	0



## 12.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Skills)

### Module A

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

### Module B

Instruction should enable the trainee to demonstrate the following:

- \*the ability to remove equipment from service properly
- \*assembly and disassembly methods
- \*inspection and cleaning techniques
- \*the ability to logically troubleshoot defective equipment
- \*repair techniques
- \*adjustment and calibration
- \*methods for returning equipment to service
- \*use of special purpose tools and equipment

Subject	Topic	
Instruments	Annunciators	0
	Controllers	
	Indicators	0
	Positioners	0
	Recorders	0
	Sensors	
	Switches	
	Transmitters	
	Detectors	
Electronic Equipment	Analyzers	0
	Monitors	0
	Computers	0
	Signal converters	

**12.8 PASSIVE COMPONENTS MATRIX (Skills)****Module A**

Instruction should enable the trainee to demonstrate the following:

\*the ability for breaching equipment or system integrity

\*inspection and cleaning techniques

\*use of special purpose tools and equipment

Subject	Topic	
Pressure Vessels	Containment	0
	Pressurizer	0
	Reactor	0
Volume	Accumulators	0
	Piping	0
	Pools	0
	Reservoirs	0
	Tanks	0
	Tubing	0
Flow	Orifice	0

**12.9 MISCELLANEOUS EQUIPMENT MATRIX (Skills)****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

**Module B**

Instruction should enable the trainee to demonstrate the ability to lubricate designated equipment.

Subject	Topic	
Auxiliary Equipment	Boilers	0
	Cranes	0
	Elevators	
	Hoists	0
Structural Equipment	Anchor bolts	0
	Bases	0
	Cable trays	
	Conduit	
	Fire barrier	
	Hangers	0
	Mounts	0
	Snubbers	0
	Supports	0

**TRADE SPECIFIC JOB/TASK LISTING  
KNOWLEDGE AND SKILL REQUIREMENTS  
FOR  
IRON WORKERS**

**GENERIC JOBS:**

**TASK-KNOWLEDGE AND SKILL**

Precision measuring

Precision Level(s)  
Laser Alignment Instrument  
Theodolite  
Transit

Bolting and Torquing

Identify U..N.C. threads  
Identify U..N.F. threads  
Identify pipe threads  
Identify Metric threads  
Determine class of thread fit  
Identify ASTM and SAE grade marking for standard bolts  
Select correct bolts/fasteners for a given job  
Demonstrate the use of assorted sizes of torque wrenches

Skids, Rollers & Jacks

Timber skids  
Timber skid material selection  
Greased skid dangers  
Hardwood rollers  
Pipe rollers  
Ratchet Lever Jacks  
Steamboat Ratchets  
Screw Jacks  
Hydraulic Jacks

Lubrication

Identify lubrication materials  
Ability to follow OSHA regulations  
Ability to interpret manufactures specifications  
Installation of lubrication systems

### Rigging of material/equipment

Discuss rigging Safety

- Planning
- Supply and Care of Rigging Equipment
- Rigging Operation and Responsibility

Follow OSHA Regs 1910/1926

Inspect and identify rigging hardware

Select rigging hardware

Attaching rigging hardware

Tieing knots, splicing rope

Cribbing machinery

Determining Safe Working Load of rigging hardware

Determine Safe Working Load of rigging hitches

Calculating effective strain on slings

Using chainfalls and come-alongs

Using hand rigging signals

Using voice rigging signals

Interpreting crane capacity charts

Splicing cable

Weight calculations

Interpreting sling capacity charts

### Mechanical blueprint reading

Identifying types of lines

Identifying types of views

Identifying isometric drawings

Determining dimensions of objects on drawings

Determine scale of drawing

Interpreting bill of materials

Interpreting title block

Identifying types of sections

Identifying special views

Interpreting assembly drawings

Interpreting tolerances

Identifying exploded views

Interpreting material designation

Determining location and size of holes

Determine basic welding symbols

Determine location and size of radii

Reference specification

Sketching

Measurement take-offs

## **FABRICATION /INSTALLATION**

### **Structural Steel Planning and Scheduling**

Plan Structural Erection  
Schedule the job  
Knowledge and use of trade terminology

### **Structural Steel Erection**

Principles of structural steel erection  
Job safety  
Rigging  
Tool and equipment requirements  
Duties and responsibilities of personnel  
Erection procedures  
Techniques and acceptable 'tricks of the trade'

### **Metal Decking, Grating, Siding and Metal Buildings**

Methods of handling Decking and Grating  
Methods for handling Siding materials  
Rigging of decking, grating, and siding materials  
Installation techniques  
Installation of concrete stops and flashing  
Burning and clean-up of metal decking and siding  
Metal building fundamentals

### **Reinforcing materials**

Rebar fastening  
Plumbing reinforcing materials  
Bolt, clips and pin installation  
Footings  
Columns  
Beams  
Joists  
Slabs and walls

### **Containment/Reactor Building tendons (post tensioning)**

Read post tensioning blueprints  
Use of hydraulic pumps  
Use of hydraulic jacks  
Post tensioning safety guidelines  
Importance of post tensioning specifications

Assemble cranes (overhead)

Match-marking  
Erection drawings  
Bridge erection  
Trolley erection  
Coupling connections  
Operators cab installation

Cable reeving

Attaching wire rope to drum  
Direct lifting reeving  
4 part conventional reeving with equalizer  
6-16 part reeving (with upper and bottom blocks with equalizer)

Special Doors (steel; such as radiation, tornado, watertight)

Nuclear plant application  
Special installation requirements  
Special testing requirements  
Special locking devices

Fences, gates, barriers

Special security fence specifications  
Security fence information access  
Special installation procedures  
Security gate special installation procedures  
Special gate hinges  
Rolling gates  
Turn-style gates  
Space barriers, steel  
Security barrier metal selection  
Steel security barrier installation

Galleries

Special specifications  
Special installation procedures

**MAINTENANCE:**

Repair/replacement of structural steel

Material selection and staging  
Safety and Security  
Access to work area  
Rigging requirements  
Cutting/burn permit  
Welding requirements

	<p>Scaffold requirement</p> <p>Special tooling and equipment</p>
<p><u>Removal/replacement/ repair of grating and steel flooring</u></p>	<p>Scaffold requirements</p> <p>Rigging requirements</p> <p>Cutting/burning permit</p> <p>Material selection and staging</p> <p>Alternate route(s) designated</p> <p>Interference removal</p> <p>Post maintenance testing</p>
<p><u>Labor support for Containment/Reactor building tendon surveillances (post tensioning)</u></p>	<p>Principles of post tensioning</p> <p>Post tensioning stressing</p> <p>Post tension grouting</p>
<p><u>Install/remove metal sheeting</u></p>	<p>Material selection and staging</p> <p>Safety and Security</p> <p>Access to work area with environmental considerations</p> <p>Rigging requirements</p> <p>Cutting/burn permit</p> <p>Welding requirements</p> <p>Scaffold requirement</p> <p>Special tooling and equipment</p>
<p><u>Crane inspection and surveillance support</u></p>	<p>Cable and block removal support</p> <p>Cable to drum connection</p> <p>Cable inspection and measurement</p> <p>Block and drum inspection (NDE)</p> <p>Cable lubrication</p> <p>Cable reeving</p> <p>Staging load weights</p> <p>Load test support</p>
<p><u>Removal/replacement/and repair of galleries</u></p>	<p>Scaffold requirements</p> <p>Rigging requirements</p> <p>Cutting/burning permit</p> <p>Material selection and staging</p> <p>Interference removal</p>



**Note:** This listing of tasks is intended to be used in determining the training requirements for contracted craft labor personnel at a Nuclear Power Plant. The list is not designed or intended for determining jurisdictional work assignments. The contractor is responsible for supplying the utility with qualified craft. He is also responsible for making appropriate work assignments based on the applicable work agreement.

NMAP

# Study Report

Detailed Review Documents  
Sheet Metal Workers

SHEET METAL WORKERS EVALUATION SUMMARY

Title	Section	Number of Subjects	Number of Subjects Addressed	Number of Topics	Number of Topics * Addressed	Number of topics w/ 'S' > 0	Ave 'S'> 0
Mathematics	9.1	7	7	13	12	0	0
Classical Physics	9.2	2	2	35	14	0	0
Electrical Science	9.3	7	4	27	13	0	0
Instrument and Control	9.4	2	2	9	9	0	0
Principles of Radiation Detection	9.5	0	0	0	0	0	0
Properties of Reactor Plant Materials	9.6	7	5	26	14	1	1
Basic Atomic and Nuclear Physics	9.7	5	0	20	0	0	0
Heat transfer and Fluid Flow	9.8	3	1	26	7	0	0
Reactor Plant Protection	9.9	3	0	18	0	0	0
Chemistry	9.1	4	0	26	0	0	0
Hand Tools	10.1	9	8	74	38	1	1
Power Driven Hand Tools	10.2	2	2	16	10	0	0
Measuring and Test Equipment	10.3	4	2	14	5	1	1
<b>Plant Systems and Components</b>							
<b>Knowledge Training</b>							
<b>knowledge</b>							
plant systems matrix	11	5	0	37	0	0	0
rotating equipment matrix	11	5	1	21	4	0	0
heat transfer equipment matrix	11	3	2	12	3	0	0
process conditioning equipment matrix	11	3	0	13	0	0	0
electrical equipment matrix	11	2	0	14	0	0	0
control elements matrix	11	3	1	15	3	0	0
instrument and control equipment matrix	11	2	0	13	0	0	0
passive components matrix	11	3	0	10	0	0	0
miscellaneous equipment matrix	11	2	1	13	2	0	0
<b>skills</b>							
plant systems matrix	12	1	0	1	0	0	0
rotating equipment matrix	12	5	1	21	4	0	0
heat transfer	12	3	1	12	3	0	0
process conditioning equipment	12	3	0	13	0	0	0
electrical equipment matrix	12	0	0	0	0	0	0
control elements matrix	12	3	1	15	3	0	0
instrument and control equipment matrix	12	2	0	7	0	0	0
passive components matrix	12	3	0	10	0	0	0
miscellaneous equipment matrix	12	2	1	9	3	0	0
totals		105	42	540	147		
subject % addressed		40%					
topic % addressed		27%					
* DOES NOT COUNT TOPICS NOT APPLICABLE TO THIS CRAFT AS DEFINED BY INPO 86-018							

INPO 86-018 COMPARISON  
SHEET METAL WORKERS


**9.1 Mathematics**









**Module A**

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

**Module B**

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

 = Not Applicable  
To This Craft  
Mech.

Subject	Topic	
Basic Mathematical Concepts	Basic arithmetic functions	ADDRESSED
	Percentage	ADDRESSED
	Square root	ADDRESSED
	Averages	0
Scientific Notation	Conversion	
	Application of scientific notation	
Dimensional Analysis	Unit conversions	ADDRESSED
	Unit modifiers	
	Metric measurements	ADDRESSED
Algebra	Basic equation solving	ADDRESSED
	Quadratic equations	
Trigonometry	Basic relationships	ADDRESSED
Geometry	Basic relationships	ADDRESSED
	Vectors	ADDRESSED
Calculus	Concept of rate of change	
	Concept of integration	
Analysis of Graphs and Control Charts	Obtaining information from graphs	ADDRESSED
	Rectangular coordinate system	ADDRESSED
	Polar coordinate system	
	Logarithmic coordinate system	

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject	Topic	
Nomograms	Obtaining information from nomograms	ADDRESSED
Exponents Base	"E" exponents (Natural/Napierian)	
Numbering Systems	Binary numbering system	
	Octal numbering system	
	Hexidecimal numbering system	
	Conversion of numbering systems	

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 9.2 Classical Physics

### Module A

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

### Module B

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

Subject	Topic	
Units	Systems of units	ADDRESSED
	Units of pressure (vacuum/ pressure, differential pressure) measurement	ADDRESSED
	Units of temperature measurement	ADDRESSED
	Units of periodic motion measurement	0
	Units of flow	ADDRESSED
	Units of volume	ADDRESSED
	Units of mass	0
	Units of weight	0
	Units of distance measurement	ADDRESSED
	Units of time measurement	ADDRESSED
Mechanical Principles Acceleration	Cams	0
	Conditions of equilibrium	ADDRESSED
	Conservation of energy	ADDRESSED
	Density, height, and temperature effects on process fluids	0
	Energy	ADDRESSED
	Fluid mechanics	0
	Force	0
	Friction	0
	Gear ratios	0
	Gravitation	0
	Heat	ADDRESSED
	Hydraulics	0
	Inclined planes	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject

Topic

Mechanical Principles  
Acceleration

Laws of motion  
Mass  
Momentum  
Power  
Pulleys  
Simple machines  
Temperature systems  
Temperature system  
conversions  
Translational and  
rotational motion  
Velocity  
Weight  
Work

0
0
0
ADDRESSED
0
0
ADDRESSED
ADDRESSED
0
0
0
0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

### 9.3 Electrical Science

#### Module A

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

#### Module B

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

Subject	Topic	
Basic Electrical	Electron theory	
	Insulators	ADDRESSED
	Conductors	ADDRESSED
	Static electricity	ADDRESSED
	Magnetism	ADDRESSED
	Direct current (DC)	ADDRESSED
	DC sources	ADDRESSED
	Units of electrical measurement	ADDRESSED
	Fundamental electrical laws	ADDRESSED
	Electrical hazards and safety	ADDRESSED
	Electrical grounds	ADDRESSED
	Basic electrical circuits	ADDRESSED
	Bistables	ADDRESSED
	Relays	ADDRESSED
Alternating Current	Basic alternating current theory	ADDRESSED
	Sources	ADDRESSED
	Simple circuits	ADDRESSED
	AC waveforms	ADDRESSED
	Inductance and inductive reactance	
	Mutual inductance and transformers	
	Capacitance and capacitive reactance	ADDRESSED
	Impedance	ADDRESSED
	Series, parallel and combination circuits	ADDRESSED
	Resonance	ADDRESSED



INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject	Topic	
Alternating Current	Power factor	
	Single-phase circuits	ADDRESSED
	Multi-phase circuits	ADDRESSED
Plant Electrical	Sources of electrical power	0
	Switchgear components	0
	Power distribution (AC and DC)	0
Power Transformers	Theory	
	Internal construction	0
	Tap changers and hazards	
	Effects of exceeding ratings	
	Cooling systems	0
	Oil system air entrainment	0
	Safety precautions associated with cooling mediums	0
	Construction of terminal connections	
	Fault symptoms	0
	Fire protection systems	0
Current Transformers	Theory	ADDRESSED
	Use	
	Hazards	
Potential Transformers	Theory	0
	Use	
	Hazards	
Advanced Electrical	AC motors	ADDRESSED
	AC generators	ADDRESSED
	DC motors	ADDRESSED
	DC generators	ADDRESSED
	Control circuits	
	utility grid switchgear	0
	Synchrosopes	
	Voltage regulator	ADDRESSED
	Ground detection	ADDRESSED

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject

Topic

Advanced Electrical

Control circuits for  
in-plant electrical  
switchgear  
Protective relaying  
Lightning arrestors  
Batteries

0
0
0
0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**9.4 Instrumentation and Control**

**Module A**

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

**Module B**

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

Subject	Topic	
Basic Electronics	Semiconductors	
	Diodes	
	Transistors	
	Amplifier basics	
	Operational amplifiers	
	Integrated circuits	
	Solid state circuitry	
	Wave-shaping circuits	
	Noise suppression techniques	
Digital Electronics	Boolean algebra	
	Combinational logic	
	Sequential logic	
	Logic circuit timing	
	Input/output methods	
	Programming	
Process Measurement	Pressure measurement	ADDRESSED
	Temperature measurement	ADDRESSED
	Fluid flow measurement	ADDRESSED
	Level measurement	ADDRESSED
	Analytical measurements	ADDRESSED
Process Control	Automatic control fundamentals	ADDRESSED
	Basic control circuits	
	Open-loop control	ADDRESSED
	Closed-loop control	ADDRESSED
	Two-position control	ADDRESSED
	Proportional control	
	Reset action	
	Rate action	
	Control loop tuning	

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**9.5 Principles of Radiation Detection**

**Module A**

Instruction should enable the trainee to identify the location of and applications for each applicable instrument and detector.

**Module B**

Instruction should enable the trainee to explain the principles of operation for each instrument and detector.

Subject

Topic

Detectors

Geiger-Mueller (G.M.)  
Scintillation  
Proportional counter  
Ion chamber  
Fission chamber  
Self-powered neutron


INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 9.6 Properties of Reactor Plant Materials

### Module A

Instruction should enable the trainee to explain the terms, definitions, and basic concepts and to recognize conditions that are detrimental to reactor plant materials.

Subject	Topic	
Properties of Metals	Structure basics	ADDRESSED
	Changes in structure	ADDRESSED
	Expansion	ADDRESSED
	Embrittlement	ADDRESSED
Alloy	Definition	ADDRESSED
	Applications	ADDRESSED
Brittle Fracture	Characteristics	ADDRESSED
	Mechanisms	ADDRESSED
	Heatup/cooldown effects	ADDRESSED
	Heat treating	ADDRESSED
	Annealing	ADDRESSED
Plant Material Problems	Fatiguefailure/work hardening	0
	Corrosion	0
	Contamination	0
	Radiation-induced embrittlement	
Thermal Shock/Stress	Definition	0
	Causes and effects	0
Strength of Materials	Compressive strength	ADDRESSED
	Tensile strength	ADDRESSED
	Torque limits	1
Corrosion and Corrosion and Control	General	ADDRESSED
	Pit and crevice	0
	Galvanic	0
	Chloride stress	0
	Caustic stress	0
	Stress corrosion cracking	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 9.7 Basic Atomic and Nuclear Physics

### Module A

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

Subject	Topic	
Atomic Structure	Atomic mass unit	0
	Protons	0
	Neutrons	0
	Electrons	0
Nuclear Interactions	Ionization	0
	Radiation interactions	0
	Neutron interactions	0
	Radioactive decay process	0
Fission Process	Definition	0
	Theory of fission process	0
	Control of fission process	0
	Neutrons associated with fission	0
	Neutron flux effects on reactor power	0
	Neutron Leakage	
Residual Heat/Decay Heat	Sources of decay heat	0
Reactor Operation	Basic reactor types	0
	Reactor parameters	0
	Power-to-flow relationships	0
	Axial flux	
	Core imbalance	
	Core quadrant power tilt	
	Reactivity	
	Reactor response to control rods	0
	Reactor start-up and shutdown	0
	Reactivity accidents	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 9.8 Heat Transfer and Fluid Flow

### Module A

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

### Module B

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

Subject	Topic	
Basic Thermodynamics	Temperature	ADDRESSED
	Sensible heat	ADDRESSED
	Latent heat--vaporization, condensation	
	Properties of water and steam	0
	Pressure/temperature relationship	ADDRESSED
	Specific volume	ADDRESSED
	Basic steam-water cycle	0
	Steam tables	0
	Specific heat	0
	Boiling	0
	Saturation	0
	Properties of gases, gas-liquid interfaces	0
	Heat transfer mechanisms	ADDRESSED
	Heat cycles (basic)	ADDRESSED
	Heat exchangers	ADDRESSED
Properties of Fluids	Flow rate	0
	Fluid statics	0
	Density	0
	Buoyancy	0
Principles of Fluid Flow	Pump theory	0
	Cavitation	0
	Fluid flow in a closed system	0
	Water hammer	0
	Heating a closed system	0
	Filling and Venting	0
	Draining a closed system	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 9.9 Reactor Plant Protection

### Module A

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

### Module B

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

Subject	Topic	
Reactor Plant Protection Concepts	Thermal-hydraulic operating	0
	Safety limits	0
	Limiting conditions for operation	0
	Administrative controls and procedural concepts	0
	Automatic reactor plant protection concepts	0
Design Basis Accident	Discussion	0
	Symptoms and indications	0
	Anticipated radiation levels	0
	Effect on work place	0
	Evacuation criteria	0
	Recovery process	0
Transient Prevention and Mitigation of Core Damage	Integrated plant transient response	0
	Core cooling mechanisms	0
	Potentially damaging operating conditions	0
	Core damage	0
	Hydrogen hazards during accidents	0
	Monitoring critical parameters during accident conditions	0
	Radiation hazards and radiation monitor response	0



INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 9.10 Chemistry

### Module A

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

### Module B

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

Subject	Topic	
Fundamentals of Chemistry	Mixtures, solutions, compounds	0
	Properties and uses of gases	0
	oxygen	0
	nitrogen	0
	hydrogen	0
	noble gases	0
	Ideal gas law	0
	Conductivity	0
	Acids and bases	0
	Corrosion chemistry	0
	pH	0
	Ion exchangers	0
Water Chemistry Control	S/G chemistry	0
	Secondary chemistry control	0
	Water chemistry control methods	0
Reactor Water Chemistry	Types of impurities	0
	Sources of impurities	0
	Effects of impurities	0
	Control/removal of impurities	0
	Radiochemistry	0
	Analytical results and core conditions	
	Sampling methods	
	Radiolysis and recombination	0
	Hydrogen gas in reactor water	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject

Topic

Principles of Water  
Treatment

Purpose  
Methods  
Water quality/purity  
Grades of water

0
0
0
0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## SECTION 10

### TOOLS AND EQUIPMENT SKILLS TRAINING

This section 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. Subject matrices show the applicability of types of tools and equipment to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

#### 10.1 Hand Tools

##### 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

##### Module B

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
- \* explain the limitations of each tool
- \* explain the importance of maintaining tools in excellent condition
- \* describe the common failure mechanism(s) of each type of tool
- \* identify precursors 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., redressing 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 area 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.

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject	Topic	
Hammers	Machinist (ballpeen)	ADDRESSED
	Carpenter (claw)	ADDRESSED
	Sledge	ADDRESSED
	Chipping	ADDRESSED
	Slide	0
Mallets	Plastic	ADDRESSED
	Rubber	ADDRESSED
	Rawhide	0
	Brass	0
	Lead	0
Punches	Drift	ADDRESSED
	Center	ADDRESSED
	Pin	ADDRESSED
	Hole	ADDRESSED
	Alignment	ADDRESSED
Wrenches	Open-end	0
	Box-end	0
	Combination	0
	Socket	0
	Socket set attachments	0
	* handles	0
	* extensions	0
	* adapters	0
	Tubing	0
	Adjustable open-end	0
	Adjustable pipe	0
	* open Jaw	0
	* strap	0
	* chain	0
	Slugging	0
	Spanner	0
	* pin	0
	* hook	0
	* face	0
	Hexagonal (Allen)	0
	Splined (Bristol)	0
	Torque	1
Screwdrivers	Flat	ADDRESSED
	Phillips	ADDRESSED
	Reed-Prince	0
	Off set	0
	Holding/starting	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject	Topic	
Pliers	Slipjoint	ADDRESSED
	Lineman	ADDRESSED
	Needle-nose	ADDRESSED
	Diagonal	ADDRESSED
	Round nose	ADDRESSED
	Duckbill	ADDRESSED
	Snap ring	ADDRESSED
	Parallel jaw	ADDRESSED
	(channel/pump)	ADDRESSED
	Locking	0
	Lockwire	0
Vises and Clamps	Mechanics bench vise	ADDRESSED
	Pipe vise	0
	* yoke	0
	* bench	ADDRESSED
	Vise grips	ADDRESSED
	C-clamps	ADDRESSED
	V-clamps	ADDRESSED
	Spring clamps	ADDRESSED
	Table clamps	ADDRESSED
Cutting	Saws	ADDRESSED
	* wood cutting	0
	* metal cutting	ADDRESSED
	Knives	ADDRESSED
	Scissors/shears	ADDRESSED
	Bolt cutter	ADDRESSED
	Cable cutter	ADDRESSED
	Chisels	ADDRESSED
	Files	ADDRESSED
Other	Crimpers	ADDRESSED
	Nutdrivers	ADDRESSED
	Cable strippers	ADDRESSED
	Wire strippers	ADDRESSED
	Threaders	0
	Benders	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 10.2 Power-driven Hand Tools

### Module A

Instruction should enable the trainee to perform the following:

- \* describe administrative controls on power-driven 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 radiologically 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 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 attachments for each tool
- \* describe the function of each attachment
- \* identify power sources that may be connected to power-driven hand tools
- \* identify areas of the plant where power sources are not available
- \* identify power source connection equipment- air hoses, extension cords, connectors, adaptors
- \* explain the limitations of each tool

### Module B

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 precursors of 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 adaptors

### Module C

Instruction should enable the trainee to perform the following:

- \* demonstrate the proper procedure to assemble and disassemble each tool
- \* demonstrate the proper procedure to inspect and clean each tool
- \* demonstrate the proper procedure to adjust and repair each tool

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

Subject

Topic

Pneumatic

Hammer  
Drill  
Chisel  
Grinder  
Punch  
Wrench  
Screwdriver  
Saw

0
0
0
ADDRESSED
ADDRESSED
0
ADDRESSED
ADDRESSED

Electrical

Drill  
Grinder  
Wrench  
Screwdriver  
Saw  
Spot welder  
Heat gun  
Vacuum cleaner

ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED
0
0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

### 10.3 Measuring and Test Equipment (M&TE)

#### Module A

Instruction should enable the trainee to perform the following:

- \* define calibration
- \* explain requirements for maintaining an audiable calibration program
- \* explain calibration cycle
- \* explain requirements for instruments and test equipment found out of calibration
- \* identify information displayed on calibration sticker
- \* explain use of information on 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
- \* demonstrate procedures for obtaini ng M&TE
- \* identify the types of M&TE
- \* explain the use of inventory lists or printouts in selection of M&TE
- \* define "or equivalent" as applied to M&TE
- \* describe procedures to determine equivalency

#### Module B

Instruction should enable the trainee to perform the following:

- \* explain the special handling procedures for each type of test equipment
- \* demonstrate proper method of protecting M&TE
  - in a radiologically controlled area
  - in a confined space
  - when working from hights
  - 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
- \* the proper procedure to connect and disconnect each type of equipment
- \* the proper procedure to operate each type of equipment
- \* the proper use of connectors, adaptors, and leads Module C Instruction should enable the trainee to demonstrate the following:
  - \* the proper procedure to inspect and clean each type of equipment
  - \* the proper procedure to adjust and calibrate each type of equipment
  - \* the proper procedure to repair each type of equipment

Subject	Topic	
General M&TE	All	ADDRESSED
Sources	Current	ADDRESSED
	Frequency	
	Heat	
	Pressure	



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SHEET METAL WORKERS

Subject	Topic	
Sources	Radiation	
	Resistance	
	Vibration	
	Voltage	ADDRESSED
Measuring Devices	Capacitance	ADDRESSED
	Current	ADDRESSED
	Distance	ADDRESSED
	Frequency	
	Mass	0
	Pressure	0
	Differential pressure	ADDRESSED
	Resistance	ADDRESSED
	Speed	0
	Temperature	ADDRESSED
	Time	0
	Torque	1
	Vibration	0
	Voltage	ADDRESSED
	Scales	
	Radiation	ADDRESSED
	Flow	ADDRESSED
Analytical Devices	Oscilloscope	
	Vibration analyzer	0
	Gas analyzer	
Special Purpose Devices	Plant protection system test set	
	Hydrostatic test set	
	Inverter test set	
	Leak-rate test set	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

SECTION 11

**PLANT SYSTEMS AND COMPONENTS KNOWLEDGE TRAINING**

This section provides the trainee with the knowledge necessary to understand systems and components and apply that information to the job. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The modules indicate the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments. It is expected that a one to two week basic systems and components course would cover the recommendations for electricians and maintenance mechanics. A four week course would probably be necessary for instrumentation and control technicians.

**11.1 Plant Systems (Knowledge)**

**Module A**

Instruction should enable the trainee to perform the following:

- \* explain the purpose
- \* identify the components
- \* identify the alarms and indications affected by maintenance
- \* describe each system at the block diagram level \* explain the importance to plant operations"
- \* identify conditions that preclude safe work in the vicinity of system components
- \* describe the effect of isolating system components on plant operation
- \* identify the basic the interrelationships with other plant systems

**Module B**

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

Subject	Topic	
Primary	NSSS	0
	Containment	0
	Fuel handling/storage	0
	Engineered safety features	0
	Sampling	0
	Reactor protection	0
	Auto control	0
	Steam (BWR)	0
Secondary	Steam (PWR)	0
	Feedwater	0
	Condensate	0
	Sampling	0
	Auto control	0
	Water treatment	0

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Subject	Topic	
Auxiliary	Component cooling	0
	Containment cooling	0
	Air supply	0
	Gas supply	0
	Water supply	0
	Oil	0
	HVAC	0
	Radwaste	0
	Bulk storage	0
	Waste treatment	0
Electrical	Switchyard	0
	Generator	0
	AC distribution	0
	DC distribution	0
	Heat tracing	0
	Grounding	0
Monitoring	Seismic	0
	Loose parts	0
	Radiation	0
	Environmental	0
	Neutron	0
	Plant computer	0
	Safety parameter	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**11.2 ROTATING EQUIPMENT MATRIX (Knowledge)**

**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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

**Module D**

Instruction should enable the trainee to identify the vibration limits.

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	0
	* impulse	0
	* reaction	0
	Diesel	0
Electrical Generators	Main	0
	Auxiliary	0
	Emergency	0
Pumps	Centrifugal	0
	Positive displacement	0
	Jet	0
Compressors	Rotary vane	0
	Reciprocating	0
	Rotary screw	0
	Centrifugal	0

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SHEET METAL WORKERS

Subject

Topic

Fans

Vaneaxial  
Propeller  
Squirrel cage  
Centrifugal

ADDRESSED
ADDRESSED
ADDRESSED
ADDRESSED

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**11.3 HEAT TRANSFER EQUIPMENT MATRIX (Knowledge)**

**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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Mechanical	Heat exchangers	ADDRESSED
	Feedwater heaters	0
	Steam generator	0
	Moisture separator	0
	Condensers	0
	Cooling towers	0
	Reboilers	0
Electro-mechanical	Air handlers	ADDRESSED
	Refrigeration units	ADDRESSED
Electrical	Recombiners	0
	Heat tracing	0
	Heaters	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

11.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Knowledge)

**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

**Module B**

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

**Module C**

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	0
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	0
	Ejectors	0
	Eductors	0
Mechanical	Filters	0
	Strainers	0
	Screens	0
	Centrifuges	0
	Traps	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

### 11.5 ELECTRICAL EQUIPMENT MATRIX (Knowledge)

#### Module A

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols to interpret print information
- \*explain the purpose and use of applicable types of equipment

#### Module B

Instruction should enable the trainee to perform the following:

- \*identify indications of normal and abnormal equipment operation during troubleshooting and testing
- \*identify the probable cause of abnormal indications
- identify abnormal conditions that preclude safe work in the vicinity of equipment

#### Module C

Instruction should enable the trainee to perform the following:

- \*locate equipment in panels and cabinets
- \*identify breaker, switch, and disconnect position indications

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	0
	* general	0
	* station	0
	* current	0
	* potential	0
	Batteries	0
	Inverters	0
	Battery chargers	0
Control	Switchgear	0
	Breakers	0
	Relays	0
	Switches	0
	Disconnects	0
	High voltage breakers	0



INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 11.6 CONTROL ELEMENTS MATRIX (Knowledge)

### 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

### Module B

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

### Module C

Instruction should enable the trainee to perform the following:

- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

### Module D

Instruction should enable the trainee to explain the proper use of applicable lubricants.

Topic	Subject	
Valves	Gate	0
	Globe	0
	Butterfly	0
	Diaphragm	0
	Ball	0
	Plug	0
	Check	0
	Stop-check	0
	Relief	0
Actuators	Electric	0
	Pneumatic	0
	Explosive	0
Dampers	Blade	ADDRESSED
	Vane	ADDRESSED
	Louver	ADDRESSED

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

11.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Knowledge)

**Module A**

Instruction should enable the trainee to perform the following:

- \*identify types of equipment
- \*identify appropriate engineering drawing symbols
- \*explain the purpose of equipment

**Module B**

Instruction should enable the trainee to identify the following:

- \*the instrument range
- \*the instrument units

**Module C**

Instruction should enable the trainee to identify the following:

- \*the input and output ranges
- \*the input and output medium

**Module D**

Instruction should enable the trainee to identify the following:

- \*the power source(s)
- \*identify the normal and abnormal indications of equipment performance during troubleshooting and testing
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Instruments	Sensors	0
	Indicators	0
	Recorders	0
	Switches	0
	Controllers	0
	Positioners	0
	Transmitters	0
	Annunciators	0
	Detectors	0
Electronic Equipment	Analyzers	0
	Signal converters	0
	Monitors	0
	Computers	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**11.8 PASSIVE COMPONENTS MATRIX (Knowledge)**

**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

**Module B**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the pressure and volume capacity limits

**Module C**

Instruction should enable the trainee to perform the following:

- \*describe the physical characteristics
- \*identify the flow capacity limits

Subject	Topic	
Pressure Vessels	Containment	0
	Reactor	0
	Pressurize	0
Volume	Tanks	0
	Reservoirs	0
	Pools	0
	Accumulator	0
	Piping	0
	Tubing	0
Flow	Orifice	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**11.9 MISCELLANEOUS EQUIPMENT MATRIX (Knowledge)**

**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

**Module B**

Instruction should enable the trainee to perform the following:

- \*identify the load limits
- \*identify the major parts

**Module C**

Instruction should enable the trainee to perform the following:

- \*explain the principles of operation
- \*identify the normal and abnormal indications of equipment performance
- \*identify the probable cause of abnormal indication
- \*identify abnormal conditions that preclude safe work in the vicinity of the equipment

Subject	Topic	
Auxiliary Equipment	Hoists	0
	Elevator	0
	Cranes	0
	Boiler	0
Structural Equipment	Mounts	0
	Bases	0
	Supports	ADDRESSED
	Hangers	ADDRESSED
	Cable trays	0
	Conduit	0
	Fire barriers	0
	Snubbers	0
	Anchor bolts	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

SECTION 12

PLANT SYSTEMS AND COMPONENTS SKILLS TRAINING

This section provides the trainee with the skills necessary to perform maintenance on systems and components. Subject matrices show the applicability of types of systems and components to the various maintenance disciplines. The module indicates the necessary level of knowledge and performance. The matrices can be changed to reflect utility structure and responsibility assignments.

12.1 Plant Systems (Skills)

Module A

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

Subject	Topic	
Primary	NSSS	
	Containment	
	Fuel Handling/storage	
	Engineered safety features	
	Sampling	
	Reactor protection	
	Auto control	
	Steam (BWR)	
Secondary	Steam (PWR)	
	Feedwater	
	Condensate	
	Sampling	
	Auto control	
	Water treatment	
Auxiliary	Component cooling	
	Containment cooling	
	Air supply	
	Gas supply	
	Water supply	
	Oil	
	HVAC	
	Radwaste	0
	Bulk storage	
Electrical	Switchyard	
	Generator	
	AC distribution	
	DC distribution	
	Heat tracing	
	Grounding	

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SHEET METAL WORKERS

Subject

Topic

Monitoring

Seismic  
Loose parts  
Radiation  
Environmental  
Neutron  
Plant computer  
Safety parameter


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SHEET METAL WORKERS

## 12.2 ROTATING EQUIPMENT MATRIX (Skills)

### Module A

Instruction should enable the trainee to demonstrate the following:

- \*assembly and disassembly methods
- \*repair techniques
- \*use of special purpose tools and equipment

### Module B

Instruction should enable the trainee to demonstrate the ability to measure equipment vibration properly.

### Module C

Instruction should enable the trainee to demonstrate the following:

- \*the ability to install and remove couplings/belts
- \*the ability to align rotating equipment
- \*the ability to test rotating equipment for "soft feet"
- \*the ability to lubricate designated equipment

Subject	Topic	
Prime Movers	Electrical	0
	* AC	0
	* DC	0
	Turbine	0
	* impulse	0
	* reaction	0
	Diesel	0
Electrical Generators	Main	0
	Auxiliary	0
	Emergency	0
Pumps	Centrifugal	0
	Positive displacement	0
	Jet	0
Compressors	Rotary vane	0
	Reciprocating	0
	Rotary screw	0
	Centrifugal	0
Fans	Vaneaxial	ADDRESSED
	Propeller	ADDRESSED
	Squirrel cage	ADDRESSED
	Centrifugal	ADDRESSED

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

### 12.3 HEAT TRANSFER EQUIPMENT MATRIX (Skills)

#### Module A

Instruction should enable the trainee to demonstrate the following:

- \*methods for breaching equipment or system integrity
- \*techniques for testing tubes for leaks
- \*techniques to repair or plug leaking tubes

#### Module B

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

Subject	Topic	
Mechanical	Heat exchangers	0
	Feedwater heater	0
	Steam generator	0
	Moisture separator	0
	Condensers	0
	Cooling towers	0
	Reboilers	0
Electro-mechanical	Air handlers	0
	Refrigeration units	0
Electrical	Recombiners	0
	Heat tracing	0
	Heaters	0



INPO 86-018 COMPARISON  
SHEET METAL WORKERS

## 12.4 PROCESS CONDITIONING EQUIPMENT MATRIX (Skills)

### Module A

Instruction should enable the trainee to demonstrate the following:

\*methods of medium removal and replacement

\*methods for handling and disposing of medium

### Module B

Instruction should enable the trainee to demonstrate the following:

\*assembly and disassembly methods

\*repair techniques

\*use of special purpose tools and equipment

Subject	Topic	
Chemical	Ion exchangers	0
	Demineralizers	0
	Purifiers	0
	Absorbers	0
	Catalytic recombiners	0
Gaseous	Mechanical recombiners	0
	Ejectors	0
	Eductors	0
Mechanical	Filters	0
	Strainers	0
	Screens	0
	Centrifuges	0
	Traps	0

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**12.5 ELECTRICAL EQUIPMENT MATRIX (Skills)**

**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
- \*repair techniques

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*adjustment and calibration
- \*testing methods

Subject	Topic	
Supply	Buses	
	Cables	
	Transformers	
	* general	
	* station	
	* current	
	* potential	
	Batteries	
	Inverters	
	Battery chargers	
Control	Switchgear	
	Breakers	
	Relays	
	Switches	
	Disconnects	
	High voltage breakers	

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

**12.6 CONTROL ELEMENTS MATRIX (Skills)**

**Module A**

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

**Module B**

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

Subject	Topic	
Valves	Ball	0
	Butterfly	0
	Check	0
	Diaphragm	0
	Gate	0
	Globe	0
	Plug	0
	Stop-check	0
	Relief	0
Actuators	Electric	0
	Explosive	0
	Pneumatic	0
Dampers	Blade	ADDRESSED
	Louver	ADDRESSED
	Vane	ADDRESSED

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

12.7 INSTRUMENT AND CONTROL EQUIPMENT MATRIX (Skills)

**Module A**

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

**Module B**

Instruction should enable the trainee to demonstrate the following:

- \*the ability to remove equipment from service properly
- \*assembly and disassembly methods
- \*inspection and cleaning techniques
- \*the ability to logically troubleshoot defective equipment
- \*repair techniques
- \*adjustment and calibration
- \*methods for returning equipment to service
- \*use of special purpose tools and equipment

Subject	Topic	
Instruments	Annunciators	0
	Controllers	
	Indicators	0
	Positioners	0
	Recorders	0
	Sensors	
	Switches	
	Transmitters	
	Detectors	
Electronic Equipment	Analyzers	0
	Monitors	0
	Computers	0
	Signal converters	

INPO 86-018 COMPARISON  
SHEET METAL WORKERS

12.8 PASSIVE COMPONENTS MATRIX (Skills)

Module A

Instruction should enable the trainee to demonstrate the following:

\*the ability for breaching equipment or system integrity

\*inspection and cleaning techniques

\*use of special purpose tools and equipment

Subject	Topic	
Pressure Vessels	Containment	0
	Pressurizer	0
	Reactor	0
Volume	Accumulators	0
	Piping	0
	Pools	0
	Reservoirs	0
	Tanks	0
	Tubing	0
Flow	Orifice	0

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SHEET METAL WORKERS

**12.9 MISCELLANEOUS EQUIPMENT MATRIX (Skills)**

**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

**Module B**

Instruction should enable the trainee to demonstrate the ability to lubricate designated equipment.

Subject	Topic	
Auxiliary Equipment	Boilers	0
	Cranes	0
	Elevators	
	Hoists	0
Structural Equipment	Anchor bolts	0
	Bases	0
	Cable trays	
	Conduit	
	Fire barrier	
	Hangers	ADDRESSED
	Mounts	ADDRESSED
	Snubbers	0
	Supports	ADDRESSED

**TRADE SPECIFIC JOB/TASK LISTING  
KNOWLEDGE AND SKILL REQUIREMENTS  
FOR  
SHEET METAL WORKER**

**GENERIC JOBS:**

**TASK-KNOWLEDGE AND SKILL**

Bolting and Torquing

Identify U..N.C. threads  
Identify U..N.F. threads  
Identify pipe threads  
Identify Metric threads  
Determine class of thread fit  
Identify ASTM and SAE grade marking for standard bolts  
Select correct bolts/fasteners for a given job  
Demonstrate the use of assorted sizes of torque wrenches

Rigging of material/equipment

Discuss rigging Safety

- Planning
- Supply and Care of Rigging Equipment
- Rigging Operation and Responsibility
- OSHA Regs 1910/1926

Inspect and identify rigging hardware  
Select rigging hardware  
Attaching rigging hardware  
Tieing knots, splicing rope  
Cribbing machinery  
Determining Safe Working Load of rigging hardware  
Determine Safe Working Load of rigging hitches  
Calculating effective strain on slings  
Using chainfalls and come-alongs  
Using hand rigging signals  
Using voice rigging signals  
Interpreting crane capacity charts  
Splicing cable  
Weight calculations  
Interpreting sling capacity charts  
Identifying types of lines  
Identifying types of views  
Identifying isometric drawings

Mechanical blueprint reading

Determining dimensions of objects on drawings  
Determine scale of drawing  
Interpreting bill of materials  
Interpreting title block  
Identifying types of sections  
Identifying special views  
Interpreting assembly drawings  
Interpreting tolerances  
Identifying exploded views  
Interpreting material designation  
Determining location and size of holes  
Determine basic welding symbols  
Determine location and size of radii  
Reference specification  
Sketching  
Measurement take-offs

#### Architectural

Fabrication and Installation of:  
Coping , fascia, gutter, scuppers,  
downspouts, conductor heads,  
roofing , ceilings, and capping.

#### Blast-gate, Volume, Relief or Backdraft, Fire and smoke Dampers

Fabrication and Installation of:

- Custom made blast-gate dampers
- Manufactured blast-gate dampers
- Cast metal blast-gate dampers
- Types “A”, “B”, and “C” fire dampers
- Smoke dampers – pneumatic and motorized

Damper hardware setting  
Regulate setting position of blade  
Service and maintenance of dampers

#### HVAC Ducts

Installation of duct components  
Shape duct/components to job specifications  
On-site preparation work (beveling, welding, etc.)

#### Coils

Installation of cooling and heating coils  
Servicing and Maintenance



### Fans

Ventilation fan installation  
Exhausting fan installation  
Supply fan installation  
Returning fan installation  
Relieving fan installation  
Proper fan settings  
Proper sheaf adjustments  
Servicing and maintenance

### Filters

Custom filter fabrication  
Install filters in racks, frames or special holding devices  
Servicing and maintenance

### Lagging

Fabricate from various metals and gages  
Install on pipes, ducts, vessels, and heating/cooling purveyors

### Outlets

Fabricate various types of outlets  
Install grilles, registers, diffusers and louvers

### Roofing

Install manufactured roofing  
Fabricate roofing components

### Siding and decking

Install manufactured siding and decking  
Custom make metal siding  
Custom make metal decking

### HVAC Units (Built-up)

Installation planning  
Installation staging  
Distribution  
Sectioning and erecting components  
Servicing and maintenance

### HVAC Units (Packaged)

Job site delivery inspection  
Check filters, coils, fans, controls and dampers  
Set package unit  
Install unit according to plant work package

## Servicing and maintenance

### Welding and Cutting (gas)

Oxy-Acetylene cutting most metals  
Braze-welding on appropriate metals  
Fuse welding of appropriate metals

## **FABRICATION /INSTALLATION**

### HVAC duct work; round rectangle, square and flexible

Verify ducts fabricated to work package specifications  
Install any internal components  
Layout any required holes  
Cut required holes  
Install any required tap-ins  
Install clips, end caps, access doors, grilles, and other required items as listed  
Connect duct

### HVAC support and suspension systems

Install duct supports  
Raise ducts  
Make tie-ins

### Dampers (e.g. control, fire, balancing)

Install damper(s) per work package  
Set dampers according to specifications

### Air filters

Install air filters  
Test air filters  
Verify access for filter inspection  
Verify adequate space for filter changeout

### Temporary ventilation systems

Install temporary ventilation as required by work package (work plan)  
Inspect temporary system for safety concerns

Accessories (e.g. access doors turning vanes, grills, registers, diffusers and screens)

Remove accessories  
Inspect accessories  
Repair/rework accessories

Flanged connections

Make up flange connections  
Install flanged connections  
Test flanged connections

Duct repair

Temporary repairs (support operations)  
Field sketch effected repair area  
Fabricate repair part from field sketch  
Install permanent duct component

Filter inspection and change outs

State safety precaution applicable to filter inspections and change-outs  
Remove filter (if required)  
Inspect filter IAW work package and manufacture's specifications

Lagging removal, inspection, repair or replacement

Observe safety precautions when removing lagging  
Inspect lagging IAW work package criteria  
Make lagging repairs per work package  
Replace lagging IAW work package requirement

Install Metal roofing, siding and decking

Match material to be installed  
Install roofing IAW work package  
Install siding IAW work package  
Install decking IAW work package

Test, adjust and balance a HVAC system

Review installation specifications  
Inspect system for obstructions or interference's  
Commence test in accordance with system design specification  
Make required adjustments  
Balance system as per specifications

## **MAINTENANCE:**

### **Repair/replacement of HVAC ductwork and accessories**

Review work package for work category (Safety Related or Non-Safety Related)  
Establish temporary ventilation as required  
Repair/replace ductwork as required  
Conduct post maintenance testing as required by work package

### **Repair and replacement of HVAC supports**

Obtain proper documentation for flame cutting and/or welding  
Set fire watch when cutting/welding  
Make HVAC support repair IAW work package  
Replace support(s) IAW work package  
Conduct post maintenance testing as required

### **Inspect ventilation filters**

Review work package for work category  
Conduct inspection IAW work package  
Replace filters or filter material as required  
Dispose of used filter material IAW work Package and Hazard Material Handling Procedure  
Conduct post maintenance testing

### **Air balance testing**

Conduct air balance test in accordance with work package specifications  
Make necessary adjustments (settings)  
Conduct post maintenance test  
Document final setting

### **Ventilation system leak testing**

Conduct system leak test in accordance with work package  
Identify and document leaks  
Make leak repair recommendations  
With approved work package, make repairs

### **Inspect lagging**

Conduction of lagging in accordance with work package  
Identify and document degraded lagging  
Make repair/replacement recommendations  
With approved work package make repairs

**Note:** This listing tasks is intended to be used in determining the training requirements for contracted craft labor personnel at a Nuclear Power Plant. The list *is not* designed or intended for determining jurisdictional work assignments. The contractor is responsible for supplying the utility with qualified craft. He is also responsible for making appropriate work assignments based on the applicable work agreement.

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