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DOE-HDBK-1002-96
March 1996

DOE HANDBOOK

GUIDE TO GOOD PRACTICES FOR TRAINING AND QUALIFICATION OF CHEMICAL OPERATORS

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

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FOREWORD

The purpose of the *Guide to Good Practices for Training and Qualification of Chemical Operators* is to provide contractor training organizations with information that can be used as a reference to refine existing chemical operator training programs, or develop new training programs where no program exists. DOE contractors should not feel obligated to adopt all parts of this guide. Rather, they can use the information contained in this guide to develop programs that are applicable to their facility.

This guide, used in conjunction with facility-specific job analyses, will provide a framework for training and qualification programs for chemical operators at DOE reactor and nonreactor facilities. Recommendations for qualification are made in four areas: education, experience, physical attributes, and training.

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

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

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1. SCOPE

1.1 Purpose

This guide provides recommended education, experience, and training requirements for chemical operators. It is intended that the training identified by this guide develop an awareness of the impact chemical operations activities have on personal safety, facility safety, facility reliability, and the potential impact on facility conditions and operation.

Chemical operations department organizations, disciplines, titles, and responsibilities vary among DOE nuclear facilities. Therefore, portions of the programs outlined in this guide may not be applicable in all cases. DOE nuclear facilities should identify the pertinent subject matter applicable to their facility for all classifications of chemical operators and determine whether it should be included in the training program.

1.2 Background

This guide is based on industry best practices compiled from a DOE-wide informal analysis of chemical operator duties combined with input from DOE chemical operators, chemical operator trainers, training managers, and a task team made up of facility representatives. By modifying these good practices to facility-specific situations, users may develop training programs for each discipline. These programs should be logically sequenced and administered.

1.3 Application

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

1.3.1 Discussion

Each facility should use a systematic approach to training to analyze its training needs and develop a facility-specific training program. Analysis results should be used to establish training program learning objectives, test items, instructional methods, and instructional settings. Performance measures to evaluate employees' performance and assess training effectiveness can also be derived from the analysis.

After learning objectives and performance measures are established, the training materials can be developed. These materials should include instructor lesson plans, training aids, text, handouts, checklists, examinations, and evaluation guides/instruments for the selected instructional methods.

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

As in other facility programs, training activities must be carefully managed to produce effective results. Training plans should be developed, organizations should be staffed with qualified instructors, and sufficient controls should be applied to ensure delivery of an effective training program. Full implementation of quality training requires a long-term commitment. In the short-term, using these good practices (as adapted for the specific facility and individual chemical operator classifications) will enable DOE nuclear facilities to validate or improve existing training programs.

1.4 Chemical Operator

For the purpose of this guide, the term "chemical operator" refers to persons with direct and primary responsibility for chemical operations at DOE nuclear facilities. Because of the wide variation of duties included in this general classification, individual facilities have broken this title into facility-specific job titles. These good practices are intended to apply to as broad an

audience as practical, while still focusing on the people who work in chemical-related activities. In general, duties include product enrichment, isotope separation, production, fabrication, assembly, chemical handling, chemical analysis, processing, and waste storage activities that directly support facility operations or processes.

In addition to personnel with primary responsibilities for chemical-related duties, some facilities have personnel assigned to auxiliary positions with limited duties for operations with chemical processes. These positions may include functions associated with experiments/experiment (loop) operations, purification (loop) operations, and perhaps some power operations duties.

Facilities should review the positions and position titles that fall in the general classification described above and structure training programs according to individual position needs. The information contained in this guide should be applied on an as-applicable basis, depending on position needs.

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2. GOALS

2.1 Initial Qualification

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

2.2 Continuing Training

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

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

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3. INITIAL QUALIFICATION

3.1 Qualification Levels

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

3.1.1 Chemical Operator Classifications

These good practices should be taken as indicative of the training necessary to achieve the highest qualification level in each classification. Each individual may not need to qualify for every task. Training should include fundamentals applicable to the tasks for which the individual is being qualified. Fundamentals will ordinarily be defined by a job analysis. The trainee should demonstrate mastery of the tasks or type of tasks assigned under the direction of a designated qualified person prior to assuming independent responsibility for those tasks. Incumbents should be qualified at their present level before advancing to the next level.

3.1.2 Chemical Operator Trainers

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

- Education
- Training experience
- Knowledge of process theory
- Applicable job experience.

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

3.2 Education

Educational requirements should be consistent with those stipulated in DOE Orders. A high school education or GED equivalent is recommended for entry into these programs.

3.3 Physical Attributes

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

- Natural or corrected near-distance visual acuity
- Color vision sufficient to discern system and component color coding
- Hearing sufficient to respond properly to audible alarms and use communications systems
- Sufficient strength, motor power, range of motion, and dexterity to allow access to facility equipment and to meet job performance requirements
- Manual dexterity
- Ability to discriminate color hues
- Eye-hand-foot coordination
- Auditory discrimination
- Arm and shoulder mobility
- Eye-hand coordination
- Foot dexterity
- Able to wear a respirator
- Able to work in a prolonged standing position.

3.4 Prerequisite Training

All areas that are applicable to the facility should be included in the facility training program. Instruction should be given in the following areas prior to a trainee being assigned to work in the facility:

- Site or facility layout
- Interdepartment functions and responsibilities
- Facility or building indoctrination
- Facility communications
- Facility quality program
- Industrial safety
- Nuclear safety
- Nuclear material safeguards
- Hazardous waste operations and emergency response
- Hazardous waste facility training
- Hazardous communications
- Hazardous material handling
- Hazardous material safety
- Hazard communications laboratory standard
- OSHA
- RCRA
- AEA
- Fire safety
- Emergency response and alarm recognition
- ALARA
- Radiation safety
- Radiation worker
- Contamination control
- Personnel radiation monitoring devices
- Personal protective clothing
- Security indoctrination
- Respirator indoctrination
- Respirator and self-contained breathing apparatus training.

3.5 Training

The operating contractor is responsible for training personnel who work within their facility, for establishing written procedures which clearly define qualification requirements for personnel in each functional level, and for documenting and periodically reviewing all training activities.

Initial and continuing training programs should be developed and implemented to ensure that operating organization personnel are qualified to perform job requirements. This should be achieved using a systematic approach to training.

Training to support qualification programs should be conducted commensurate with the results of the position job analysis. Because of varied complexity and scope of job functions, the degree of analysis necessary to determine the skill and knowledge requirements may vary. For example, a job analysis should be conducted for operations personnel, whereas a less formal assessment of training needs may be appropriate for technical staff personnel. Results should be compared with these good practices to ensure that training programs include the knowledge and skills necessary for the incumbent to perform his/her assigned tasks.

3.6 Subcontractor Personnel

The operating contractor is responsible for establishing qualification criteria for subcontractor personnel who work in the operating organization.

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

4. ADMINISTRATIVE TRAINING

This section identifies the training program elements that will provide trainees with the knowledge necessary to locate, retrieve, and use applicable facility documentation. The training program should familiarize the trainee with all documents, regulations, and forms needed to perform their jobs. The trainee should learn what information is available and what kinds of information are included in each document. The items listed are examples that may or may not be applicable to the chemical operators at a particular facility. Other items may be added depending on requirements at the individual facility.

4.1 Administrative Requirements

Instruction should be provided that will enable the trainee to perform the following:

- Describe the records management system
- Name/list the applicable documents, records, and forms used
- Demonstrate the use of facility drawings, lists, tables, and vendor supplied documents
- Explain the procedure for obtaining replacement parts and equipment
- Demonstrate the use of facility work requests
- Explain the purpose of ALARA and radiological procedures.

4.2 Procedures

Instruction should be provided that will enable the trainee to perform the following:

- Name/list the types of procedures available
- Explain why procedures are used in nuclear facilities
- Explain the purpose of the following types of procedures
  - administrative
  - operating (normal and abnormal)
  - maintenance
  - surveillance/test
  - emergency
- Describe how procedures are prepared

- Describe how procedures are revised
- Describe administrative controls of procedures
- Demonstrate procedural compliance
  - explain the reasons for procedural hold points
  - explain what to do if conditions arise that are unexpected or outside the scope of a procedure
- Explain the filing system for procedures
- Explain the numbering system for procedures
- Explain how a temporary procedure change is obtained
- Identify procedure locations
- Identify procedure access authority
- Demonstrate chemical operations department personnel responsibilities for procedure use
- Explain what to do if a procedure is wrong.

5. INDUSTRIAL SAFETY TRAINING

This section identifies the training program elements that will increase the trainee's awareness of the hazards associated with the industrial environment, and with precautions that should be followed in the performance of daily activities. This training is applicable to all chemical operators. Additional training should be designed to cover those portions of the Facility Industrial Safety Manual not addressed by this section or by the general employee training program.

5.1 Lock and Tag Program

Instruction should be provided that will enable the trainee to perform the following:

- Describe the general requirements of the facility lock and tag procedure, and other related procedures
- Describe general requirements for using various types of locks/tags
- Locate the lockout/tagout log book and explain how to use it
- State who is responsible to place and remove locks/tags
- Demonstrate how to verify proper lockout/tagout prior to commencing work on equipment
- Explain the responsibilities assumed by individuals working within a locked/tagged boundary
- Explain the consequences of violating locks/tags
- Demonstrate the step-by-step procedure to initiate, post, and remove each type of lock/tag associated with job requirements at the facility
- Explain controls on electronic lockouts/tagouts (DCS users)
- Describe the types of magnitude of hazardous energy sources and the methods for energy isolation and control.

5.2 Industrial Safety Hazards

Instruction should be provided that will enable the trainee to describe safe work practices in the following situations:

- Working on or near
  - cranes and hoists (above, below or on)
  - rotating equipment
  - energized electrical equipment or panels
- Working in or near
  - high temperature and/or pressure environments
  - high radiation areas
  - radiologically controlled areas
  - areas where hazardous chemicals are stored, transported, or disposed
  - areas where welding or grinding is occurring
  - areas where activities are generating dust, debris, and particles
  - areas containing asbestos
  - water
- Working in
  - areas where work is being performed overhead
  - high noise area
  - adverse conditions, e.g., heat, rain, snow, wet surfaces
- Working with hazardous chemicals concerning
  - storage
  - transfers
  - disposal
  - containment of spills.

5.3 Chemicals, Gases, and Solvents

Instruction should be provided that will enable the trainee to perform the following:

- Explain information contained on a Material Safety Data Sheet (MSDS)
- Locate MSDSs in their area

- Name/list hazardous chemicals and gases located in their area
- Describe the proper storage of chemicals and gases
- Demonstrate the proper handling of chemicals and gases
- Describe the proper procedure for transporting chemicals and gases
- Explain the hazards of chemicals and gases encountered at the site
- Demonstrate the actions necessary to contain chemical spills
- Describe the proper disposal methods for chemicals
- Explain the reasons for avoiding chemical contamination of systems and components
- Explain the precautions associated with each group of chemicals and gases
- Demonstrate the proper application and use of chemicals and gases commonly used at the facility
- Demonstrate proper use of special protective equipment and emergency facilities for chemicals
- Explain the reasons for avoiding personal contamination with chemicals and solvents, including inhalation, ingestion, and skin absorption
- Describe the hazardous communication program requirements and associated procedures.

5.4 Electrical Safety

Instruction should be provided that will enable the trainee to:

- Define electrical shock and shock symptoms
- Demonstrate the proper response for freeing an electrical shock victim from the source of electricity and rendering first aid
- Identify electrical safety hazards
- Verify approved electrical equipment and properly grounded tools
- Take proper precautions when working around electrical lines, panels, and equipment
- Explain procedures for working in or near exposed energized parts
- Identify the clearance distances when working in or near exposed electrical parts.

5.5 Working in Confined Spaces

Instruction should be provided that will enable the trainee to:

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

5.6 Personnel Protective Equipment

Instruction should be provided that will enable the trainee to:

- Locate the special storage facilities for protective equipment
- Explain the inspection requirements for protective equipment prior to use
- Explain the procedural controls for protective equipment
- Identify faulty protective equipment
- Describe the application of each type of protective equipment
- Demonstrate the use of each type of protective equipment associated with job assignment
- Identify precautions to take during equipment use
- Explain the use of temporary radiation shielding
- Explain where first-aid supplies are kept and who can administer them
- Describe the protective equipment used by the emergency response team and explain who to notify in the event of an emergency
- Explain the cleaning, decon, and disposal of protective equipment
- Explain the limitations of the protective equipment.

Equipment should include items such as the following:

- Air-fed hoods and respirators
- Chemical handling clothing and equipment
- Ear protection
- Eye protection
- Foot protection
- Face protection
- Gloves
- High temperature clothing
- Self-contained breathing apparatus
- Protective clothing
- Respirators
- Respirator filters
- Rope grabs

- Safety line and rope
- Safety harness.

6. SPECIALIZED SKILLS TRAINING

Some tasks are typically performed by a few individuals who are specialists in these tasks or duties. Accordingly, training should be provided to an appropriate number of individuals to maintain an adequate number of trained specialists for each applicable task or duty. This training should be based on facility-specific job analyses and individual facility practices.

Procedures, operating experience, vendor-supplied documents, and job analysis results should be used to develop training guides for use by instructors or evaluators. Training should also include the selection and use of any special tools or equipment.

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7. ON-THE-JOB TRAINING (OJT)

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

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

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8. TRAINEE EVALUATION

The quality of training programs, course content, and instructional methods is best evaluated by monitoring trainee performance. This guide outlines training that occurs in multiple training settings.

Different methods of evaluating trainee performance during these training programs are appropriate. Among these methods are written examinations and quizzes, oral checkouts and examinations, and operational (performance) evaluations.

It is important that evaluation methods are consistent with the training setting. General guidelines for using these evaluation methods are given below.

8.1 Knowledge Evaluation

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

8.2 Operational Evaluation

Operational evaluations should be structured to measure a trainee's performance against established criteria. Areas that should be covered include the following:

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

The evaluation of each trainee should be conducted as the trainee either performs or simulates and discusses the complete task. The perform option is the preferred method of evaluation whenever practical. Job Performance Measures should be used to standardize trainee evaluations. When the trainee has completed the fundamental training, he/she may be considered ready for individual task qualification.

8.3 Exceptions

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

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

9. CONTINUING TRAINING

Continuing training needs should be identified from job analysis information and the results of ongoing training program evaluations. There should be close interaction between the training department and operations personnel to ensure that the training program is correct and appropriate. This evaluation ensures that the training program is current and relevant and that job performance does not degrade to unacceptable levels.

9.1 General

The continuing training program should be administered on a two-year cycle and should maintain and improve technical skills and knowledge. Since basic technical knowledge as well as specialized technical knowledge could be lacking for infrequently used procedures or concepts, instruction in selected fundamental topics should be provided on a continuing basis.

Written examinations, similar in difficulty and scope to initial examinations, should be administered in accordance with Section 8, Trainee Evaluation.

9.2 Facility-Specific Systems Training

Facility-specific systems training provides an understanding of overall facility operations. Since much of this subject matter is not reinforced by direct use, selected process equipment and theory of operations should be part of the continuing training program. At a minimum, safety-related systems identified in the facility's safety analysis report should be included. Lectures, seminars, computer-aided-instruction, and self-study are methods of presenting the material.

9.3 Special Training

Special training should be provided to address seldom-used skills, observed problems, or anticipated training needs. Infrequently performed tasks should be evaluated to determine if training is needed. It is recommended that difficulty, importance to facility safety, reliability, and ALARA be used to help determine training needs and required depth of coverage.

Special training should address the following situations at a minimum:

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

9.4 Scheduling and Attendance

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

10. TRAINING EFFECTIVENESS EVALUATION

To maintain an effective qualification program, a periodic evaluation of program effectiveness is necessary. A thorough evaluation process includes assessment of the training process and assessment of the qualified individual's performance on the job. The training should also be evaluated to ensure it includes DOE and commercial industry lessons learned.

10.1 Evaluation of the Training Process

In evaluating the training process, consider the content of the program, the training materials, and the quality and method of instruction. Instructional techniques should be evaluated periodically during the course of the training program.
Requirements for the conduct and frequency of these evaluations should be defined in appropriate procedures.

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

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

10.2 Evaluation of Post-Training Job Performance

The effectiveness of the training program can be measured only by evaluating the performance of trained individuals. At some facilities, formal performance appraisals may be conducted periodically as part of the salary review process. While some useful training feedback can be obtained from such an appraisal, a more effective training feedback system would focus specifically on training-related items. Several methods for obtaining training-related feedback can be used in a formal evaluation program, and should include one or more of the following:

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

To maximize the effectiveness of any technique used in a training evaluation program, the individuals responsible for gathering the information should be trained. A recommended method for structuring the evaluation program is to focus feedback on the stated learning objectives of the training program (e.g., was this learning objective valid, was it achieved, what objectives were missed?). Procedures should be utilized to ensure that evaluation findings are resolved.

The quality of the training program can be improved in the following ways:

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

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

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11. PROGRAM RECORDS

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

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

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

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

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

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

APPENDIX A
FUNDAMENTALS TRAINING

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FUNDAMENTALS TRAINING

This section identifies the training program elements that will provide the trainee with the fundamental knowledge and skills necessary to understand job related concepts and successfully apply them to the job. Subject topics are a result of an industry-wide survey. They show the applicability of topics to the various chemical operator classifications. The necessary level of knowledge and performance can be adjusted to reflect facility structure and responsibility assignments. Actual course content should consider personnel entry-level requirements as well as job analysis results.

Instruction may give the trainee a general knowledge and understanding of the following principles. Only the principles that apply to the facility should be included in the facility training program. Pre-tests may be administered to determine level of competency.

A.1 General Operator Tasks

- Perform general housekeeping
- Initiate revisions to instructions/procedures
- Maintain material identification and control
- Perform self-check inspections by procedure
- Properly use and care for measurement and test equipment (M&TE)
- Initiate non-conformance reports
- Identify process changes
- Respond to alarm conditions
- Fill out data sheets
- Maintain area operating logs
- Maintain sample log
- Identify and respond to abnormalities
- Respond to radiation alarms
- Explain precautions when entering valve boxes
- Take area readings
- Perform shift checks
- Take shutdown readings
- Perform glovebox maintenance and housekeeping
- Nuclear material accountability
- Test alarm panels
- Take routine samples
- Assist control room operators
- Control recovery equipment
- Operate a fork truck
- Move material in two- and four-wheel carts
- Read temperature and pressure gauges
- Monitor control equipment
- Transfer hazardous chemicals, solids, and liquids

- Work with furnaces
- Monitor and control equipment located in steel gloveboxes
- Operate counting systems
- Store and retrieve materials
- Read indicator dials and digital readouts
- Decontaminate controlled areas
- Handle radioactive materials
- Handle solvents and chemicals
- Perform various tasks in a glovebox
- Read strip charts
- Read ammeters
- Read flowmeters
- Read pressure gauges
- Read vacuum gauges
- Read meters
- Read thermostats
- Read instruments
- Use voltmeter
- Use digital scales
- Use computer keyboards
- Read schematics
- Read charts
- Interpretation of pounds per square inch (PSI)
- Subtraction of whole numbers
- Subtraction of decimals
- Metric weighing
- Note taking
- Interpretation of dry measurements
- Interpretation of linear measurements
- Interpretation of technical materials (twelfth grade level)
- Form completion
- Convert standard time to military time
- Interpretation of procedural data
- Contamination control
- Numeric chart reading.

A.2 Mathematics

Basic Concepts

- Basic arithmetic functions
- Percentage
- Square root
- Averages
- Exponents and powers
- Parentheses and powers
- Area and volume calculations
- Prime numbers
- Addition and subtraction of signed numbers
- Multiplication and division of signed numbers.

Fractions

- Introduction to fractions
- Addition and subtraction of fractions
- Multiplication and division of fractions
- Signed fractions.

Decimals

- Introduction to decimals
- Rounding numbers
- Addition and subtraction of decimal fractions
- Multiplication and division of decimal fractions
- Converting common fractions to decimals
- Percent
- Percentage base and rate.

Scientific Notation

- Conversion of numbers
- Application of scientific notation
- Calculating with scientific notation.

Ratio and Proportion

- Ratio
- Proportion
- Percent of proportion
- Variations.

Dimensional Analysis

- Unit conversions
- Unit modifiers.

Metric System

- Metric measurements
- Metric units
- Temperature
- Metric and English conversions.

Measurement

- Approximate numbers vs exact numbers
- Accuracy and significant numbers
- Precision and greatest possible error
- Precision vs accuracy
- Addition and subtraction of measurements
- Multiplication and division of measurements
- Relative error and percent of error
- Reading scales.

Algebra

- Basic equation solving
- Applications involving simple equations
- Equations with variables in both numbers
- Equations with parentheses
- Equations with fractions
- Equations with the variable in the denominator
- Formulas
- Substituting data into formulas
- Quadratic equations.

Trigonometry

- Basic relationships.

Geometry

- Basic relationships
- Vectors.

Calculus

- Concept of rate of change
- Concept of integration.

Analysis of Graphs and Control Charts

- Obtaining information from graphs
- Rectangular coordinate system
- Polar coordinate system
- Logarithmic coordinate system.

Nomographs

- Obtaining information from a nomograph.

Exponent Base

- "E" exponents (Natural/Napierian).

Numbering Systems

- Binary system
- Octal system
- Hexadecimal system
- Conversion of systems.

A.3 Chemistry

Fundamentals of Chemistry

- Structure of the atom
- Kinds of substances
- Chemical symbols
- The periodic table
- Molecular weight
- Chemical reactions (general and specific)
- Process chemistry
  - quality control procedures
- Chemical calculations
  - calculation involving molecular weight
  - concentration calculations
  - make-up calculations
- Mixtures, solutions, compounds
- Properties and uses of gases
- Ideal gas law
- Conductivity
- Acids and bases
- Corrosion chemistry
- pH
- Ionization
- Oxidation
- Reduction
- Reactivity
- Electronegativity
- Radiochemistry
  - analysis to be performed
  - quality control procedures.

Chemical Makeups

- Make-up requirements
- Valving
- Transfer
- Recirculated
- Agitated
- Control features
- Line flush
- MSDS (material safety data sheets).

Chemical Terms

- Potassium hydroxide (KOH)
- Hydrofluoric acid (HF)
- Sodium hydroxide (NAOH)
- Nitrogen dioxide (NO_2)
- Hydrogen peroxide (H_2O_2)
- Ferrous sulfamate ($Fe(SO_3NH_2)_2$)
- Sodium nitrate ($NaNO_3$)
- Ammonium thiocyanate (NH_4SCN)
- Aluminum nitrite ($Al(NO_3)_2$)
- Nitric acid (HNO_3)
- Phosphoric acid (H_3PO_4)
- Concept of normality and molarity
- Distillate
- Interpretation of pH
- Neutralize.

Chemical Safety

- Precautions
- Safety clothing

- Handling requirements for acids and bases
- Handling requirements for cyanide
- Handling requirements for tritium
- Response when acid comes in contact with skin.

Principles of Water

- Purpose
- Treatment methods
- Water quality/purity
- Grades of water.

A.4 Classical Physics

- Systems of units
- Pressure (vacuum/pressure differential/pressure) measurement
  - spring and bellows gauges
- Temperature measurement
  - thermocouples
  - resistance thermometers
  - bimetallic thermometers
- Periodic motion measurement
- Flow
  - differential pressure flow meters
  - variable area rotameter
  - electronic flowmeters
  - flow calculations
- Volume
- Mass
- Weight
- Density
  - density sensors
  - common probe
- Liquid level
  - purge-type level instrument
  - manometers
- Distance measurement
- Time measurement.

Mechanical Principles

- Acceleration
- Cams
- Conditions of equilibrium
- Conservation of energy
- Density, height, and temperature affects on process fluids
- Energy
- Force
- Friction
- Gear ratios
- Heat
- Hydraulics
- Inclined planes
- Laws of motion
- Mass
- Momentum
- Power
- Pulleys
- Simple machines
- Velocity
- Weight
- Work.

A.5 Electrical Science

Basic Electrical

- Electron theory
- Insulators
- Magnetism
- Conductors
- Static electricity
- Alternating current (AC)
- Direct current (DC)
- DC sources
- Units of electrical measurement
- Fundamental electrical laws
- Electrical hazards and safety
- Electrical grounds
- Basic electrical circuits
  - alternating current (AC)
- Basic AC theory
- Sources
- Simple circuits
- AC waveforms
- Series, parallel, and combination circuits
- Single-phase circuits
- Multi-phase circuits.

Facility Electrical

- Sources of commercial electrical power
- Sources of emergency electrical power
- Switchgear components
- Power distribution (AC and DC).

A.6 Instrumentation and Control

Definition of Terms

- Temperature
- Pressure
- Density
- Specific gravity
- Interface
- Conductivity.

Process Measurement

- Instruments for measuring chemical composition
- Pressure measurement
- Temperature measurement
- Fluid flow measurement
- Level measurement
- Analytical measurements
- Density
- Specific gravity
- Voltage
- Current
- Resistance
- Conductive
- Acidity
- Alkalinity
- Viscosity.

Process Control

- Automatic control fundamentals
- Manual control fundamentals
- Motor speed control
- Open-loop control systems
- Closed-loop control systems
- Closed-loop control operation
  - controlled variable
  - detector
  - transmitter
  - alarm high
  - alarm low
  - recorder
  - controller
  - variable manipulator
  - process (heat exchangers)
- Two-position control
- Proportional control
- Record controllers
- Function of auto-seal manual switch
- Operation of auto-seal manual switch
- Instruments scales and ranges
  - direct readout
  - percent of range indicators
- Instrument identification
- Terms
  - instrument heel
  - zero shift
- Reset action
- Rate action
- Routines
  - marking charts
  - checks for normal/abnormal conditions
  - calibration
- Instruments for measuring chemical composition
- Interface location.

A.7 Basic Print Reading

Print Reading

- Equipment identification
  - equipment designation
  - area designation
  - equipment category number
- Process line identification
  - line size
  - line service and material codes
  - heat trace and insulation
- Equipment symbols
  - fittings
  - print symbols
  - manual valves
  - control valves
  - equipment
  - heat exchangers
  - heating and ventilation
  - valve position (normally open, normally closed).

A.8 Principles of Radiation Detection

Detectors

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

A.9 Basic Atomic and Nuclear Physics

Atomic Structure

- Atomic mass unit
- Protons
- Neutrons
- Electrons.

Nuclear Interactions

- Ionization
- Radiation interactions
- Neutron interactions
- Radioactive decay process.

Health

- Body parts affected
- Detection
- Protection.

A.10 Heat Transfer and Fluid Flow

Basic Thermodynamics

- Temperature
- Sensible heat
- Latent heat-vaporization, condensation
- Properties of water and steam
- Specific volume
- Basic steam-water cycle
- Steam tables
- Specific heat
- Boiling
- Saturation
- Properties of gases, gas-liquid interfaces
- Heat transfer mechanisms
- Heat cycles (basic)
- Heat exchangers.

Properties of Fluids

- Flow rate
- Fluid statics
- Density
- Buoyancy.

Principles of Fluid Flow

- Pump theory
- Cavitation
- Fluid flow in a closed system
- Water hammer
- Heating a closed system
- Draining a closed system
- Filling and venting.

A.11 Facility Systems

Basic Theory

- Lubrication
- Pumps
- Valves
- Valve operators
- Strainers and filters
- Steam traps
- Heat exchangers
- Air compressors
- Motors
- Instrument and control.

Facility Protection

- Safety limits
- Technical safety requirements and limiting conditions for operation
- Automatic protection systems.

Air Systems

- Parameters
- Alarms
- Interfaces
- Operating pressures
- Bubble-suits

- Air line respirators
- Distribution subheaders
- Instrumentation
- Alarm response
- Operating range.

Kerosene Systems

- Set up to receive
- Transfer
- Purpose of the system
- Verification of contents
- System checks
- Safety precautions
- Monitor pressure
- Overfill tank
- Fire
- Vents
- Paperwork
- Valving
- Tank volume.

Oxygen Systems

- Liquid oxygen
- Gaseous oxygen
- Vaporizer
- Temperature probe
- Pressure regulator
- Safety equipment
- "Hot" tank
- "Cold" tank
- Content verification
- Fittings
- Low oxygen pressure
- High oxygen pressure
- Paperwork.

Nitrogen Systems

- Receiving
- Hazardous Chemicals Safety Manual
- Protective clothing
- Precautions
- Storage
- Vaporizers
- Equipment number
- "Hot" tank
- Level
- Uses
- Paperwork
- Priorities
- Dewars
- Rupture disk
- Transferring
- Instrumentation
- Evacuate the annulus
- Shutdown
- Start-up
- Demineralized water pots
- Solenoid valves
- Injection pumps
- Water fill timers
- Pulse timers
- Surge vessel
- Procedures
- Operating pressures
- Pressure control
- Sample system
- Sparges
- Purge lines

- Monitoring
- Lead glass window nitrogen purge
- Technical Standards
- Operating ranges
- Nitrogen interface.

Steam Systems

- Steam supply
- Steam trace
- Unit heater
- Utility stations
- Decon stations
- Jets
- Parameters
- Interface
- Alarms
- Start-up
- Shutdown
- Pressures
- Reducing stations
- Steam controller
- Normal control
- Condensate collection
- Condensate transfer
- Steam trap
- Bypass
- Distribution systems
- Isolation.

Water Systems

- Raw water
- Treated water
- Potable water cold
- Potable water hot
- Deionized water
- Parameters
- Alarms
- Hot water heaters
- Start-up
- Shutdown

Electrical Systems

- General equipment
- Breaker operation
- Emergency Control Center
- Loads
- Uninterruptable power supply (UPS) operations
- Normal power
- Emergency power
- Loss of power.

Fire Protection Systems

- Halon
  - halon abort button
  - halon control panel
  - photoelectric detectors
  - ionizing detectors
  - halon cylinders
  - fire protection dampers
  - under floor detection system
- Sprinkler system
  - fire alarm panels
  - manual pull stations
- Extinguishers
  - halon portable
  - dry chemical
  - CO_2 portable

- Fire hose stations
- Personnel safety
- Fire hoses.

HVAC Systems

- Intake louver
- Blowers/plenums
- Air washers
- Air conditioning system/chillers
- Filters
- Krypton detectors
- HEPA filters
- Fire protection chamber
- Pressure control.

Process Sample Systems

- Automatic sampler
- Encasement samples
- EPA samples
  - quality control procedures
  - conditions of possession
  - transfer logs
  - record keeping
  - sampling steps
  - overflow
  - EPA stickers
  - sampling sequence
  - chain of custody record
- Jets
- Monitoring
- Radiation detectors
- Ratemeters
- Alarms
- Alarm points
- Alarm response
- Condensate liquid sampler
- Precautions
- Automatic sampler
- Data sheets
- Liquid sampler
- Solid sampler
- Gas sampler
- Safety
- Parameters
- Pneumatic transfer
- Sample cell off-gas system
- Glovebox
- Radiochemical enclosure
- Transport into cell
- Transport out of cell
- Safety equipment
- Sample filters
- Clear plugged sample line
- Sample garage
- Contamination control
- Sparging
- Circulating
- Time requirements
- Flushing
- Bottle labeling
- Abnormalities
- Pressure indicators
- Sample cart
- Transfer area
- Transfer capsule
- Bulk density
- Sieve analysis.

Cadmium Liquid Waste Systems

- Sources
- Transfer routes
- Sumps
- Flush connections
- Off-gas system
- Controls
- Alarm response.

High Fluoride Liquid Waste Systems

- Chemical hazards
- First aid treatment
- Reagent
- Complexing
- Sources
- Chemical concentrations
- Problems
- Transferring
- Sumps
- Flush connections.

Chiller Systems

- Schematic
- Refrigerant
- Hot gas bypass
- Temperature ranges
- Lead/lag operation
- Anti-recycle timer
- Abnormalities
- Pressure
- Water circulation
- Chiller pump operation
- Closed-loop
- Open-loop
- Start-up
- Operation
- Shutdown
- Safety features
- Startup-delay circuit
- Low-flow switches.

A.12 Cranes and Hoists

- Designated signaler
- Electrical disconnects
- Controller
- Monthly checks/inspections
- Safety hazards
- Attach the load
- Lift the load
- Move the load
- Set the load down
- Park the unit
- Plug a load
- Electrical failure.

A.13 Liquid Waste Unloading

- Safety precautions
- Unloading station
- Types of waste
- Restrictions
- Unloading procedure
- Checks
- Monitoring
- Paperwork
- Proper connections
- Waste with I^{131} present
- Temperature below 32°F
- Leaks
- Low level sampling and transfer.

A.14 Remotes

Master-Slave Manipulators

- Precautions
- Problems
- Abuses
- Loss of air
- Loss of electrical power
- "Squeeze" force
- Visual alarm
- Audible alarm
- Lifting capacities
- Lock out
- Log book
- Indexing motions
- Booting.

Programmed and Remote (PaR) Manipulators:

- Physical restrictions
  - depth of field (sight)
  - dexterity
- Personnel required
- Training requirements
- Precautions
- Motions
- Air supply
- PaR control console.

A.15 Safety Training

- First Aid/CPR
- Acids/caustics
- Solvents
- Asbestos safety
- Radiation worker
- Generator hazards safety
- Self-contained breathing apparatus (SCBA)
- Respirators
  - cartridge identification
  - usage

A.16 Properties of Materials

- Metal properties
- Alloys
- Strength of materials
- Fractures
- Fatigue failure/work hardening
- Radiation-induced embrittlement
- Thermal stress
- Erosion.

APPENDIX B

PROCESS OPERATIONS

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PROCESS OPERATIONS

Instruction should give the trainee a general knowledge and understanding of the following principles. Only principles that apply to the facility should be included in the facility training program.

B.1 Transportation of Fuels and Wastes

- Typical shipping-cask design
- Material to be shipped
- Shipping requirements
- Control of radiation and contamination during unloading
- Decontamination procedures
- Criticality control during unloading and shipping
- Accountability control during shipping and unloading.

B.2 Spent-Fuel Receiving and Storage Facility

- General description
- Shipping-cask decontamination
- Cask unloading pool
- Fuel storage basin
- Criticality and accountability.

B.3 Fuel Disassembly and Size Reduction

- Description of typical fuel assemblies
- Description of a typical mechanical processing cell
- Description of typical mechanical processing cell operation equipment.

B.4 Chemical Makeup

- General
- Typical methods of making up solutions from solids
- Dilution of liquids
- Continuous methods
- Batch methods.

B.5 Fuel Dissolution

- Chemistry of fuel dissolution
- Fuel dissolution equipment
- Solvent extraction
- Definition of terms
  - aqueous
  - density
  - specific gravity (SG)
  - distribution coefficient (DC)
  - extraction factor (EF)
  - decontamination factor (DF)
  - separation factor (SF)
  - entrainment
  - flooding
  - salting agent
  - solvent saturation
  - solvent degradation products
  - pulse column
  - extraction column or section
  - scrub column or section
  - partitioning column
  - stripping column
  - compound column
  - coextraction
  - reflux
  - theoretical stage
  - multistage
  - valence
- Chemistry of solvent extraction
  - tributyl phosphate and normal dodecane
  - uranyl nitrate
  - plutonium nitrate
- Feed-adjustment step
- Extraction step
- Partitioning step
- Stripping step
- Solvent recovery
- Solvent-extraction contractors
  - pulse columns
  - pulsers
  - instrumentation
  - operating variables and method of control
  - typical startup and operation
  - common difficulties
    - -- flooding
    - -- entrainment and loss of product
    - -- low decontamination factors.

B.6 Evaporation

- Definition of terms
  - entrainment
  - disengagement section
  - reflux
  - fractionation
  - thermosiphoning
- Purpose
- Description of equipment
- Modes of evaporator operation
- Control of operating variables
- Instrumentation
- Recovery of nitric acid from solvent-extraction waste.

B.7 Ion Exchange

- Definition of terms
  - ions
  - anions
  - cations
  - valence
  - synthetic resins
  - diffusion
  - distribution coefficient (DC)
  - decontamination factor (DF)
- Basic chemistry
- Plutonium purification by ion exchange
- Ion-exchange equipment
- Operating variables and restrictions
- Safety precautions required.

B.8 Conversion of Uranyl Nitrate to Uranium Hexafluoride

- Conversion of uranyl nitrate to uranium trioxide
- Reduction of uranium trioxide to uranium dioxide
- Hydrofluorination of uranium dioxide
- Fluorination of uranium tetrafluoride and uranium trioxide
- Properties of uranium hexafluoride
- Equipment used for fluorination
- Fluorine generation and disposal
- Collection of uranium hexafluoride
- Purification of Uranium Hexafluoride
- Load-out of uranium hexafluoride product.

B.9 Product Withdrawal, Storage, and Packaging

- Product packaging and storage
- Product preparation
- Contamination control methods
- Criticality control methods
- Accountability methods.

B.10 Solution Transfer

- Pumps
  - positive displacement pumps
  - reciprocating pumps
  - rotary pumps
  - centrifugal pumps
- Jets
- Air lifts.

B.11 Gas Handling Equipment

- Fans
  - centrifugal fans
  - axial-flow fans
- Rotary blowers
  - two-impeller blower
  - sliding-vane blower
  - liquid-piston blower
- Jets
  - jet blowers
  - jet exhauster
  - jet compressors
  - jet vacuum pumps
- Compressors
  - centrifugal compressors
  - reciprocating compressors
  - vacuum pumps.

B.12 Fluidized Beds

- Purpose and uses in fuel processing
- Description
- Instrumentation
- Operating variables and methods of control
- Particle size of bed material
- Fluidizing-gas flow rate
- Temperature
- Concentration of reacting material
- Depth of bed material
- Pressure.

B.13 Calciners

- Uses in nuclear process
- Description of a fluidized-bed calciner
- Instrumentation
- Operating variables and common difficulties.

B.14 Waste Handling Systems

- Liquid Waste Systems
  - high-and intermediate-activity liquid waste handling systems
  - low-activity liquid waste systems
- Waste storage tank auxiliary equipment
- Solidification of high-activity liquid wastes
- Gaseous waste systems
- Solid waste systems
- Management of solid wastes.

B.15 Ventilation Systems

- Building ventilation systems
- Cell ventilation
- Process off-gas and high-level and intermediate-level waste off-gas
- High- and intermediate-level nuclear waste building ventilation
- Iodine and acid recovery building ventilation
- Miscellaneous ventilation systems.

B.16 Dissolution Systems

- Perform pre-operational checks
- Make up chemical solutions
- Sample chemical solutions
- Transfer fuel elements
- Charge fuel elements
- Add dissolvent to dissolver
- Monitor temperatures
- Monitor off-gas analyzers
- Monitor plant protection system
- Monitor corrosion detection equipment
- Complex dissolver product
- Sample dissolver product and waste streams.

B.17 Extraction Systems

- Perform pre-operational checks
- Makeup chemical process cold streams
- Fill columns and mixer-settlers
- Start pulser systems
- Start evaporator system
- Start hot feed
- Monitor process parameters
- Sample waste streams
- Make transfers
- Sample product for uranium accountability
- Make up cold stream solutions
- Shutdown and clean out process.

B.18 Denitrator

- Perform denitrator pre-operational checks
- Start off-gas system
- Start air systems
  - atomizing air
  - jet grinder air
  - fluidizing air
- Start fluidization heaters
- Start bed heaters
- Start glovebox off-gas system
- Charge bed
- Start filter blowback system
- Heat filter vessel and denitrator bed
- Start uranium feed
- Correct and maintain bed temperatures
- Clear restricted lines
- Operate size reduction equipment
- Sample, package, weigh, and store uranium product
- Transfer condensate
- Shutdown and acid flush the denitrator system
- Prepare product for shipment.

B.19 Low Level Liquid Waste Processing

- Neutralization
- Precipitation
- Filtration
- Immobilization
- Evaporation
- Transfer and shipment of waste.

B.20 Low Level Solid Waste Processing

- Package drum and crate counters
- Real time radiography equipment.

CONCLUDING MATERIAL

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AD	AL
DP	CH
EH	FN
EM	ID
ER	NV
FM	OR
NE	RL
	SF
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