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DOE STANDARD

CHEMICAL PROCESSING QUALIFICATION STANDARD

DOE Defense Nuclear Facilities Technical Personnel

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

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Technical Standards Program

Web Site at

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APPROVAL

The Federal Technical Capability Panel consists of senior U.S. Department of Energy (DOE) managers responsible for overseeing the Federal Technical Capability Program. This Panel is responsible for reviewing and approving the qualification standard for Department-wide application. Approval of this qualification standard by the Federal Technical Capability Panel is indicated by signature below.

Karen L. Boardman, Chairperson
Federal Technical Capability Panel

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ACKNOWLEDGMENT

The Savannah River Operations Office is the sponsor for the Chemical Processing Qualification Standard. The sponsor is responsible for coordinating the development and/or review of the Functional Area Qualification Standard (FAQS) by subject matter experts to ensure that the technical content of the standard is accurate and adequate for Department-wide application for those involved in the chemical processing program. The sponsor, in coordination with the Federal Technical Capability Panel, is also responsible for ensuring that the FAQS is maintained current.

The following subject matter experts participated in the development and/or review of this qualification standard:

Patricia Suggs	DOE/Savannah River Site (Team Leader)
Dave Faubert	DOE/Savannah River Site
Chelsea Hubbard	NNSA/Y-12 Site Office
Don Alexander	DOE/Office of River Protection
Linda Quarles	DOE/Savannah River Site
Jeffrey Bentley	DOE/Savannah River Site
Julie Reddick	DOE/Office of River Protection

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U.S. DEPARTMENT OF ENERGY
FUNCTIONAL AREA QUALIFICATION STANDARD

Chemical Processing

PURPOSE

DOE O 426.1 *Federal Technical Capability*, commits the Department to continuously strive for technical excellence. The Technical Qualification Program (TQP), along with the supporting technical qualification standards, complements the personnel processes that support the Department's drive for technical excellence. In support of this goal, the competency requirements defined in the technical qualification standards should be aligned with and integrated into the recruitment and staffing processes for technical positions. The technical qualification standards should form the primary basis for developing vacancy announcements, qualification requirements, crediting plans, interviewing questions, and other criteria associated with the recruitment, selection, and internal placement of technical personnel. The U.S. Office of Personnel Management (OPM) minimum qualification standards will be greatly enhanced by application of appropriate materials from the technical FAQSs.

The technical qualification standards are not intended to replace the OPM qualification standards or other Departmental personnel standards, rules, plans, or processes. The primary purpose of the TQP is to ensure that employees have the requisite technical competency to support the mission of the Department. The TQP forms the basis for the development and assignment of DOE personnel responsible for ensuring the safe operation of defense nuclear facilities.

APPLICABILITY

The Chemical Processing FAQS establishes common functional area competency requirements for all DOE chemical processing personnel who provide assistance in, direction or guidance to, or oversight or evaluation of contractor technical activities that could impact the safe operation of DOE's defense nuclear facilities. The technical FAQS has been developed as a tool to assist DOE program and field offices in the development and implementation of the TQP in their organization. For ease of transportability of qualifications between DOE elements, program and field offices are expected to use this technical FAQS without modification. Needed additional office/site/facility-specific technical competencies should be handled separately. Satisfactory and documented attainment of the competency requirements contained in this technical FAQS (see the Federal Technical Capability Program [FTCP] Directives and Standards page at http://www.hss.energy.gov/deprep/ftcp/directives/directives.asp for an example of the Chemical Processing FAQS qualification card) ensures that personnel possess the minimum requisite competence to fulfill their functional area duties and responsibilities common to the DOE complex. Additionally, office-/site-/facility-specific qualification standards supplement this technical FAQS and establish unique operational competency requirements at the Headquarters or field element, site, or facility level.

It should be noted that the competency elements of management and leadership, general technical knowledge, regulations, administrative capability, and assessment and oversight are all embodied in the competencies listed in this standard. All of these factors have a bearing on safety. Although the focus of this standard is technical competence, elements such as good communication, recognized credibility, ability to listen and process information, and the ability to guide an effort to get it right the first time are recognized as important aspects of safety.

IMPLEMENTATION

This technical FAQS identifies the minimum technical competency requirements for DOE personnel. Although there are other competency requirements associated with the positions held by DOE personnel, this FAQS is limited to identifying the specific, common technical competencies required throughout all defense nuclear facilities. The competency requirements define the expected knowledge and/or skill that an individual must meet. Each of the competency requirements are further described by a listing of supporting knowledge and/or skill statements. The supporting knowledge and/or skill statements for each competency requirement are provided to challenge the employee in the breadth and depth of his/her understanding of the subject matter. In selected competencies, expected knowledge and/or skills have been designated as “mandatory performance activities.” In these competencies, the actions are not optional.

The term “must” denotes a mandatory requirement, “should” denotes a recommended practice that is not required, and “may” denotes an option in this standard.

The competencies identify a familiarity level, a working level, or an expert level of knowledge; or they require the individual to demonstrate the ability to perform a task or activity. These levels are defined as follows:

> **Familiarity level** is defined as basic knowledge of or exposure to the subject or process adequate to discuss the subject or process with individuals of greater knowledge.
>
> **Working level** is defined as the knowledge required to monitor and assess operations/activities, to apply standards of acceptable performance, and to recognize the need to seek and obtain appropriate expert advice (e.g., technical, legal, safety) or consult appropriate reference materials required to ensure the safety of DOE activities.
>
> **Expert level** is defined as a comprehensive, intensive knowledge of the subject or process sufficient to provide advice in the absence of procedural guidance.
>
> **Demonstrate the ability** is defined as the actual performance of a task or activity in accordance with policy, procedures, guidelines, and/or accepted industry or DOE practices.

Headquarters and field elements must establish a program and process to ensure that DOE personnel possess the competencies required by their position, including the competencies identified in this technical FAQS. Documentation of the completion of the requirements of this standard must be included in the employees’ training and qualification records. Satisfactory attainment of the competency requirements contained in this technical FAQS may be documented using the example Chemical Processing FAQS qualification card that can be obtained from the Federal Technical Capability Program Directives and Standards page at http://www.hss.energy.gov/deprep/ftcp/directives/directives.asp.

Equivalencies should be used sparingly and with the utmost rigor and scrutiny to maintain the spirit and intent of the TQP. Equivalencies may be granted for individual competencies based on objective evidence of previous education, training, certification, or experience. Objective evidence includes a combination of transcripts, certifications, and in some cases, a knowledge sampling obtained through written and/or oral examinations. Equivalencies must be granted in accordance with the TQP plan of the site/office/Headquarters organization qualifying the individual. The supporting knowledge and/or skill statements and mandatory performance activities should be considered before granting an equivalency for a competency.

Training must be provided to employees in the TQP who do not meet the competencies contained in the technical FAQS. Training may include, but is not limited to, formal classroom and computer-based courses, self-study, mentoring, on-the-job training, and special assignments. Departmental training will be based on appropriate supporting knowledge and/or skill statements similar to the ones listed for each of the competency requirements. Headquarters and field elements should use the supporting knowledge and/or skill statements as a basis for evaluating the content of any training used to provide individuals with the requisite knowledge and/or skill required to meet the technical FAQS competency requirements.

EVALUATION REQUIREMENTS

Attainment of the competencies listed in this technical FAQS must be documented in accordance with the TQP plan or policy of the site/office/Headquarters organization qualifying the individual and the requirements in DOE M 360.1-1B (2001), *Federal Employee Training Manual*, and DOE M 426.1-1A (2004).

The immediate supervisor shall ensure that the candidate meets the background and experience requirements of this FAQS. Attainment of the competencies listed in the Chemical Processing FAQS should be evaluated and documented by either a qualifying official or immediate supervisor (note: if the immediate supervisor is not qualified in the Chemical Processing Systems FAQS, it is expected the supervisor will consult with an individual who is qualified in the Chemical Processing FAQS), using a combination of the following methods:

- Satisfactory completion of a written examination
- Satisfactory completion of an oral examination
- Satisfactory accomplishment of an observed task or activity directly related to a competency
- Documented evaluation of equivalencies (such as applicable experience in the field) without a written examination

Field element managers/Headquarters program managers must qualify candidates as possessing the basic technical knowledge, technical discipline competency, and position-specific knowledge, skills, and abilities required for their positions. Final qualification should be performed using one or a combination of the following methods:

- Satisfactory completion of a comprehensive written examination. The minimum passing grade should be 80 percent.
- Satisfactory completion of an oral examination by a qualified Senior Technical Safety Manager (STSM) or a qualification board of technically qualified personnel that includes at least one qualified STSM.
- Satisfactory completion of a walkthrough of a facility with a qualifying official for the purpose of verifying a candidate’s knowledge and practical skills of selected key elements.

Guidance for oral interviews and written exams is contained in DOE-HDBK-1205-97, *Guide to Good Practices for the Design, Development, and Implementation of Examinations*, and DOE-HDBK-1080-97, *Guide to Good Practices for Oral Examinations*.

For oral examinations and walkthroughs, qualifying officials or board members should ask critical questions intended to integrate identified learning objectives during qualification. Field element managers/Headquarters program managers or designees should develop formal guidance for oral examinations and walkthroughs that includes:

- Standards for qualification
- Use of technical advisors by a board
- Questioning procedures or protocol
- Pass/fail criteria
- Board deliberation and voting authorization procedures
- Documentation process

INITIAL QUALIFICATION AND TRAINING

Qualification of chemical processing personnel must be conducted in accordance with the requirements of DOE M 426.1-1A (2004).

DOE personnel must participate in continuing education and training as necessary to improve their performance and proficiency and ensure that they stay up-to-date on changing technology and new requirements. This may include courses and/or training provided by:

- DOE
- Other government agencies
- Outside vendors
- Educational institutions

Beyond formal classroom or computer-based courses, continuing training may include:

- Self-study
- Attendance at symposia, seminars, exhibitions
- Special assignments
- On-the-job experience

A description of suggested learning activities and the requirements for the continuing education and training program for the Chemical Processing FAQS are included in Appendix A of this document.

DUTIES AND RESPONSIBILITIES

The following are the typical duties and responsibilities expected of personnel assigned to the Chemical Processing Functional Area:

A. Critically analyze system design-basis documentation and related safety documentation to ensure application of the principle of safety in design as described in DOE O 413.3-1 (2006), *Project Management for the Acquisition of Capital Assets* and associated guides.

B. Assess the management and technical oversight of design, construction, repair processes, modification processes, and decontamination/decommissioning associated with the Chemical Processing Functional Area.

C. Serve as a technical resource for the training of chemical processing personnel and for other technical matters.

D. Evaluate DOE facility and program-related chemical processes for safe and efficient process startup, operation, maintenance, and testing, including emergency systems.

E. Participate in establishing and/or reviewing DOE Orders and industry standards regarding the practices and requirements related to chemical processes.

F. Evaluate contractor compliance with relevant DOE Orders, standards, codes, contractor operating procedures, etc.

G. Verify the application of quality assurance, configuration management, and safety requirements to chemical processes.

Position-specific duties and responsibilities for chemical processing personnel are contained in their office-/site-/facility-specific qualification standard and/or position description.

BACKGROUND AND EXPERIENCE

The OPM *Qualification Standards Operating Manual* establishes minimum education, training, experience, or other relevant requirements applicable to a particular occupational series/grade level, as well as alternatives to meeting specified requirements.

The preferred education and experience for chemical processing personnel are:

1. Education:

   Bachelor of Science degree in chemical engineering from an accredited institution or meet the alternative requirements specified in the *Qualification Standards Operating Manual* for the GS-0800, Professional Engineering Series. At a minimum, educational requirements should include: thermodynamics, fluid mechanics, mass transfer, heat transfer, chemical process unit operations, reaction kinetics, mass balance, energy balance, general chemistry, organic chemistry, and physical chemistry.

2. Experience:

   Industry, facility, operations, or other related experience that has provided a background in chemical engineering and/or a Professional Engineer license. Specialized experience can be demonstrated through possession of the competencies outlined in this standard.

REQUIRED TECHNICAL COMPETENCIES

The competencies contained in this standard are distinct from those competencies contained in the General Technical Base (GTB) Qualification Standard. All chemical processing personnel must satisfy the competency requirements of the GTB Qualification Standard prior to or in parallel with the competency requirements contained in this standard. Each of the competency requirements define the level of expected knowledge and/or skill that an individual must possess to meet the intent of this standard. Each of the competency statements is further described by a listing of supporting knowledge and/or skill statements that describe the intent of the competency statements. In selected competencies, expected knowledge and/or skills have been designated as “mandatory performance activities.” In these competencies, the actions are not optional.

Note: When regulations, DOE directives, or other industry standards are referenced in the FAQS, the most recent revision should be used. It is recognized that some chemical processing personnel may oversee facilities that utilize predecessor documents to those identified. In those cases, such documents should be included in local qualification standards via the TQP.

General Technical

1. Chemical processing personnel must have a working level knowledge of the operation of chemical processes.

Supporting Knowledge and/or Skills

a. Identify the light and heavy phases, and discuss the direction of mass transfer or separations aspects of the following unit operations:

- Solvent extraction (extractant, raffinate, emulsions, coalescence, counter-current multistage contactor, extraction/scrubbing/stripping, partition coefficient, efficiency)
- Gas absorption/stripping
- Ion exchange
- Adsorption
- Filtration
- Evaporation
- Distillation
- Crystallization
- Sedimentation
- Leaching
- Drying
- Scrubbing
- Membrane separations
- Dissolution

2. Chemical processing personnel must demonstrate an expert level knowledge of mass transfer and mass balances.

Supporting Knowledge and/or Skills

a. Discuss the ideal gas law as it applies to pressure, volume, and temperature relationships.

b. Discuss the application of mass balances and demonstrate a mass balance in an existing facility's process flowsheet.

c. Define the following mass transfer terms and vapor-liquid equilibrium laws:

- Absorption
- Adsorption
- Partition coefficient
- Raoult's Law
- Dalton's Law
- Henry's Law
- Azeotropes
- Phase diagrams
- Vapor-liquid equilibrium
- Binary phase equilibria
- Multi-component vapor equilibria
- Bubble-point, dew point, relative volatility

d. Discuss how the vapor-liquid equilibrium laws may be applied to determine a Composite Lower Flammability Limit in a vessel vapor space.

Mandatory Performance Activities:

e. Perform an example calculation demonstrating the use of mass transfer coefficients to estimate a liquid to vapor mass transfer.

3. Chemical processing personnel must demonstrate an expert level knowledge of stoichiometry and a working level knowledge of chemical kinetics.

Supporting Knowledge and/or Skills

a. Balance a chemical reaction equation, and discuss the concepts of limiting reactant and theoretical product yield.

b. Discuss how a rate constant for a first order reaction may be determined from experimental data.

c. Discuss how varying parameters such as the effects of temperature, catalysts, agitation, concentration and other conditions will affect the following:
- Rate of reaction
- Rate constant (Arrhenius equation)

d. Discuss the following reactor types and the reaction kinetics, including applicable mathematical equations, associated with each:
   - Continuous stirred tank reactor
   - Plug flow reactor
   - Batch reactor

4. Chemical processing personnel must demonstrate an expert level knowledge of process safety.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1017/1-93, *Material Science* (vol. 1 of 2). DOE-HDBK-1139-2006 (vol. 1-3), *Chemical Management*.

a. Discuss key requirements of the process safety management (PSM) rule (29 CFR 1910.119).

b. Discuss the role of chemical processing personnel in performing process hazard analysis and other parts of PSM.

c. Discuss the following attributes of a personnel protection program:

   - Material safety data sheets (MSDS) and 29 CFR 1910.1200 (*Hazard Communication*)
   - Personal protective equipment

d. Discuss the startup/re-start requirements of DOE O 425.1C.

e. Discuss factors affecting integrity and performance of systems (age, pressure, service cycles, corrosion, etc.).

f. Discuss sources of information for chemical reactivity hazards, for lessons learned and for historical records of nuclear and chemical industry accidents.

g. Demonstrate knowledge of basic chemical incompatibilities and reactive chemistry including awareness of synergistic reactions.

h. Discuss tri-butyl phosphate (TBP) properties and hazards including decomposition products and “red oil” safety issues.

5. Chemical processing personnel must demonstrate a working level knowledge of DOE Safety Basis requirements.

Supporting Knowledge and/or Skills

a. Discuss the following aspects of 10 CFR 830, subpart B:

- Documented safety analyses
- Technical safety requirements
- Unreviewed safety question
- Safe harbor methodology
- DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for compliance with DOE O 5480.23 Nuclear Safety Analysis Reports*
- DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*

b. Discuss the function of the following documents which may be in a safety basis program:

- Justification for continued operation
- Basis for interim operations (DOE-STD-3011-2002)
- Potential inadequacy in the safety analysis
- New information
- Health and safety plan
- Authorization agreements
- Criticality safety evaluation and the double contingency principle (DOE O 420.1B)

6. Chemical processing personnel must demonstrate a working level knowledge of safety and relief devices.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1018/2-93, *Mechanical Science* (vol. 2 of 2).

a. Define the following terms as they pertain to safety and relief valves:

- Set point
- Accumulation
- Blowdown
- Weep
- Pilot-actuated
- Gagging device

b. Compare and contrast the purpose and operation of safety and relief valves.

c. Discuss how blowdown and accumulation are controlled in safety and relief valves.

d. Discuss the methods used to test relief valves.

e. Discuss the application of rupture discs.

f. Discuss an operational situation that would require use of both a rupture disc and relief valve.

Mandatory Performance Activities:

g. Using a cutaway drawing of a safety valve, identify the main components to include:

- Seat
- Disc
- Blowdown ring
- Main spring
- Set-point adjustment mechanism

7. Chemical processing personnel must demonstrate working level knowledge of general piping systems.

Supporting Knowledge and/or Skills

Suggested Reference Material: American Society of Mechanical Engineers, ASME B31.3, *Process Piping*; DOE-HDBK-1012/3-92, *Thermodynamics, Heat Transfer, and Fluid Flow* (vol. 3 of 3); John J. McKetta, Jr., Piping Design Handbook; Michael Frankel, *Facility Piping Systems Handbook*; DOE-HDBK-1017/1-93, *Material Science* (vol. 1 of 2).

a. Define the following terms as they relate to piping systems:

- Pipe schedule
- Water hammer
- Hydrostatic test pressure
- Laminar flow
- Turbulent flow

b. Discuss the potential hazards to personnel and equipment associated with water hammer.

c. Identify and discuss the typical causes of water hammer in piping systems.

d. Discuss the purpose of seismic restraints (whip restraints or snubbers) in piping systems.

e. Identify and discuss different methods of pipe joining (threaded, butt weld, socket weld, seal weld, etc.).

f. Discuss the importance of material selection with regards to corrosion.

8. Chemical processing personnel must demonstrate a working level knowledge of mechanical diagrams, including:

- As-built drawings
- Piping and instrumentation diagrams (P&ID)

- Process flow diagrams

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1016/1-93, *Engineering Symbology, Prints, and Drawings* (vol. 1 of 2).

a. Identify the symbols used in piping and instrumentation diagrams for:

- Types of valves
- Types of valve operators
- Types of eductors and ejectors
- Basic types of instrumentation
- Types of instrument signal controllers and modifiers
- Types of system components (pumps, etc.)
- Types of lines

b. Identify the symbols used in piping and instrumentation diagrams to denote the location of instruments, indicators, and controllers.

c. Identify how valve conditions are depicted.

d. Determine system flowpath(s) for a given valve lineup.

e. Discuss the origin and purpose of:

- As-built drawings
- Process flow diagrams

Mandatory Performance Activities:

f. Using an engineering print, read and interpret the information contained in the title block, the notes and legend, the revision block, and the drawing grid.

9. Chemical processing personnel must demonstrate a working level knowledge of the general construction, operation, and theory of valves.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1018/2-93, *Mechanical Science* (vol. 2 of 2).

a. Define the following terms as they relate to valves:

- Disc
- Seat
- Throttle
- Actuator
- Bridgewall mark
- Packing

b. Discuss why the design of a globe valve enables it to throttle fluids efficiently.

c. Discuss why gate valves, ball valves, and butterfly valves are generally not used to throttle flow.

d. Discuss how cavitation occurs in valves and state any harmful effects that can result from cavitation.

e. Describe the construction and principle of operation for the following types of valve actuators:

- Manual
- Electric
- Solenoid
- Pneumatic
- Hydraulic

f. Describe the principles of operation and applications for modulating and pressure reducing valves.

Mandatory Performance Activities:

g. Using a diagram of a globe valve body showing the bridgewall mark, identify how the valve must be oriented in the system related to flow.

10. Chemical processing personnel must demonstrate a working level knowledge of measurement, data collection, and analysis.

Supporting Knowledge and/or Skills

a. Discuss the types of instrumentation, typical applications, and the principles of operation for measuring chemical process parameters (e.g., pressure, temperature, flow) to include:

- Resistance temperature detector (RTD)
- Thermocouple
- Differential pressure detector
- Pitot tube
- Bourdon tube pressure gauge
- Duplex pressure gauge
- Manometer
- Mechanical flow meters
- Level Indicators (e.g., sight glass, bubbler, radar)

b. Discuss the following with respect to probability and statistics:

- Standard deviation
- Mean/median/mode
- Variance
- Sample size/frequency
- Error analysis
- Distribution curves
- Outliers
- Statistical testing

11. Chemical processing personnel must demonstrate a working level knowledge of pump theory and operation.

Supporting Knowledge and/or Skills

Suggested Reference: DOE-HDBK-1018/1-93, *Mechanical Science* (vol. 1 of 2).

a. Define the following terms as they relate to pumps:

- Head
- Net positive suction head
- Cavitation
- Shut-off head
- Run-out
- Centrifugal pump
- Positive displacement pump
- Pump curves

b. Describe the general principle of operation for centrifugal pumps.

c. Describe the general principle of operation for positive displacement pumps.

d. Discuss why centrifugal pumps should normally be started against a shut-off head and the hazards associated with continuously running against a shut-off head.

e. State the dangers to personnel and equipment associated with starting a positive displacement pump against a shut-off head. Discuss the importance and methods of providing over pressurization protection for positive displacement pumps.

f. Compare and contrast the principle of operation and typical pumped medium of the following types of positive displacement pumps:

- Reciprocating
- Rotary-screw
- Vane-axial

g. Discuss the concept of pump cavitation and describe its harmful effects.

Mandatory Performance Activities:

h. Given a cutaway drawing of a centrifugal pump, identify the following components and discuss their purpose:

- Impeller
- Packing or mechanical seal
- Volute
- Lantern ring
- Wearing rings (impeller and/or casing)

i. For each of the following system and/or pumped medium characteristics, identify the type of pump (e.g., centrifugal, reciprocating positive displacement, rotary-screw positive displacement) that is best suited for the application:

- Slurries
- Fluids with high viscosities
- Low volume, high head
- Low head, high volume
- Water
- Oil

12. Chemical processing personnel must demonstrate a working level knowledge of fluid mechanics and properties.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1012/3-92, *Thermodynamics, Heat Transfer, and Fluid Flow* (vol. 3 of 3).

a. Define the following:

- Temperature
- Pressure
- Viscosity
- Specific volume
- Specific gravity
- Capillarity
- Laminar flow
- Turbulent flow
- Uniform flow
- Surface tension

b. Explain the equation of continuity as it applies to fluid flow.

c. Discuss the Reynold's number and how it is used.

d. Discuss Bernoulli's equation as it applies to steady-state flow rate calculations.

13. Chemical processing personnel must demonstrate the ability to calculate flow rates in fluid systems.

Supporting Knowledge and/or Skills

a. For non-compressible fluids, calculate flow rates using the following methods:

- Volume flow rate
- Mass flow rate
- Steady-State continuity equation
- Bernoulli’s equation
- Darcy’s formula

b. Discuss the limitations of the above methods.

14. Chemical processing personnel must demonstrate a working level knowledge of thermodynamics.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1012/1-92, *Thermodynamics, Heat Transfer, and Fluid Flow* (vol. 1 of 3)

a. Define the following:

- Compression
- Isothermic
- Isentropic
- Adiabatic
- Heat of Dilution
- Specific Heat

b. Discuss entropy and enthalpy as they relate to chemical processes and performing energy balances.

c. Define and discuss the following:

- Carnot cycle
- Rankine cycle

Mandatory Performance Activities:

d. Read and interpret a Mollier diagram.

e. Using data from a steady-state system, calculate the following:

- Entropy change
- Enthalpy change
- Pressure
- Temperature

15. Chemical processing personnel must demonstrate a working level knowledge of steady-state heat transfer.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1012/2-92, *Thermodynamics, Heat Transfer, and Fluid Flow* (vol. 2 of 3).

a. Define:

- Conduction
- Convection
- Radiation
- Thermal conductivity

b. Discuss Fourier's Law.

c. Describe the factors that contribute to the co-efficient of thermal conductivity.

Mandatory Performance Activities:

d. Calculate the heat flux for one-dimensional, steady-state heat transfer through the following:

- Composite wall
- Series wall
- Parallel wall

e. Using data, calculate total heat transfer and local heat flux in a laminar flow system.

16. Chemical processing personnel must demonstrate a working level knowledge of the construction and operation of heat exchangers.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1012/2-92, *Thermodynamics, Heat Transfer, and Fluid Flow* (vol. 2 of 3); DOE-HDBK-1018/2-93, *Mechanical Science* (vol. 2 of 2).

a. Describe the principle of operation for the following types of heat exchangers:

- Shell and tube
- Fin and tube
- Cooling tower

b. Define the following terms as they apply to heat exchangers:

- Tube sheet
- Tell-tale drain
- Parallel flow
- Counter flow
- Cross flow

c. Explain the principle of operation of a forced-draft cooling tower.

d. Explain the principle of operation of a natural-draft (parabolic) cooling tower.

Mandatory Performance Activities:

e. Using a cutaway drawing of the following types of heat exchangers, show the flow paths of the cooling medium and the medium to be cooled:

- Parallel flow
- Counter flow
- Cross flow

f. Using data, calculate the log mean temperature difference for heat exchangers.

17. Chemical processing personnel must demonstrate a working level knowledge of the components, operation, and theory of pneumatic systems.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1018/2-93, *Mechanical Science* (vol. 2 of 2).

a. Define the following terms and discuss their relationship:

- Dew point
- Dehydrator
- Dew point indicator
- Actuator

b. Describe the basic operation of a pneumatic system.

c. Discuss how energy in a pneumatic system is converted to work.

d. Discuss the hazardous relationship between high pressure air and oil.

e. Identify and discuss the general hazards associated with pneumatic systems and their components and the over-pressurization of these systems.

f. Discuss the hazards associated with portable gases such as cylinders of oxygen, nitrogen, etc.

18. Chemical processing personnel must demonstrate a working level knowledge of the basic components, operations, and theory of hydraulic systems.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE-HDBK-1018/2-93, *Mechanical Science* (vol. 2 of 2).

a. Define the following terms and discuss their relationship in hydraulic systems:

- Force
- Work
- Pressure
- Reservoir
- Accumulator
- Actuator

b. Describe the basic operation of a hydraulic system.

c. Discuss how energy in a hydraulic system is converted to work.

d. Discuss the purpose and basic construction of a hydraulic reservoir.

e. Discuss the purpose and basic construction of a hydraulic accumulator.

f. Identify and discuss the hazards associated with hydraulic systems and their components.

19. Chemical processing personnel must demonstrate a working level knowledge of Project and Contract Management.

Supporting Knowledge and/or Skills

Suggested Reference Material: DOE O 413.3A (2006), *Program and Project Management for the Acquisition of Capital Assets* and associated Guides; DOE-STD-1189-2008, *Integration of Safety into the Design Process*.

a. Discuss the phases of a project lifecycle as described in DOE O 413.3A (2006). Briefly describe each of the critical decision points.

b. Using the guidance in DOE-STD-1073-2003, *Configuration Management*, discuss the system engineer concept as it applies to oversight of safety systems. Specifically address the following areas of configuration management:

- Assessment of system status and performance
- Technical support for operation and maintenance activities
- Technical support for documented safety analysis reviews
- Document control
- Change control
- Design requirements
- Assessments

c. Describe the quality assurance criteria of 10 CFR 830.122 which addresses the following:

- Management
- Performance
- Assessment

d. Briefly discuss the maintenance management requirements as described in life cycle assessment management (DOE O 430.1B, Chg 1).

e. Discuss the basic performance measurement tools used to monitor contractor performance.

20. Chemical processing personnel must demonstrate a familiarity level of knowledge of software quality assurance when addressing chemical process safety problems.

Supporting Knowledge and/or Skills

Suggested Reference Material: ASME NQA-1-2008, *Quality Assurance Requirements for Nuclear Facility Applications*.

a. Define and discuss the intended function of the following software quality assurance items:

- Safety analysis codes
- Chemical process design codes
- Traceability of design requirements within the codes

- Code verification and validation
- Data and data model integrity

b. Review a chemical process development project using safety analysis or design software. Explain how the software requirements trace to functional requirements, how the requirements are controlled, and how the software functions to address the development project.

c. Discuss ASME NQA-1 Subsection 2.7 and how it should be applied to projects.

21. Chemical processing personnel must demonstrate a familiarity level of knowledge of software quality assurance functional interfaces between safety system software components and the system-level design.

Supporting Knowledge and/or Skills

a. Identify how system-level requirements are established and then assigned to hardware, software, and human components of a digital instrumentation and control system.

b. Identify the typical requirements that define functional interfaces between safety system software components and the system-level design, as described in standards such as ANSI/IEEE 830, *IEEE Guide to Software Requirements Specifications* and IEEE 7-4.3.2, *Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations.*

c. Identify the specific records that must be maintained and the requirements for maintaining these records to document the development of safety system software as described in standards such as ANSI/IEEE 830, *IEEE Guide to Software Requirements Specifications* and IEEE 7-4.3.2, *Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations*.

APPENDIX A

CONTINUING EDUCATION, TRAINING, AND PROFICIENCY PROGRAM

The following list represents suggested continuing education, training, and other opportunities that are available for DOE personnel after completion of the competency requirements in this technical FAQS. It is extremely important that personnel involved with this program maintain their proficiency, primarily by regularly demonstrating their competency through on-the-job performance, supplemented with continuing education, training, reading, or other activities, such as workshops, seminars, and conferences. Subject publications and training include those offered by the American Institute of Chemical Engineers (AIChE), http://www.aiche.org, and by the Center for Chemical Process Safety (CCPS), http://www.aiche.org/ccps, a directorate of the AIChE. Additional safety information may be found at the DOE website http://www.hss.energy.gov/HealthSafety/WSHP/. The list of suggested activities was developed by the subject matter experts involved in the development of the FAQS and is not all-inclusive.

Based on the knowledge and experience of the subject matter experts, it is suggested that the following activities support the maintenance of proficiency in the Chemical Processing Functional Area after completion of the competencies in the standard and other requirements of the TQP.

LIST OF CONTINUING EDUCATION, TRAINING, AND OTHER ACTIVITIES

1. Complete continuing technical education and/or training covering topics directly related to the Chemical Processing Functional Area as determined appropriate by management. This may include courses/training provided by DOE, other government agencies, outside vendors, or local educational institutions. Continuing training topics should also address identified weaknesses in the knowledge or skills of the individual personnel.
2. Actively perform the duties of a chemical processing specialist at a DOE facility a minimum of 800 hours per year.
3. Attend seminars, symposia, or technical meetings related to chemical processing.
4. Engage in self-study of new regulations, requirements, or advances related to chemical processing.
5. Participate in practical exercises such as emergency or operational drills, simulations, or laboratory-type exercises.
6. Document specific continuing training requirements in an individual development plan (IDP).
7. Suggested training courses include the following:

    - *Distillation in Practice*, American Institute of Chemical Engineers (AIChE) CH004
    - *Flow of Solids in Bins, Hoppers, Chutes, and Feeders, Level 1*, AIChE CH032
    - *Pneumatic Conveying of Bulk Solids*, AIChE CH033
    - *Ion Exchange: Theory and Practice*, AIChE CH103
    - *Project Management for Chemical Engineers*, AIChE CH138
    - *Conceptual Development & Capital Cost Estimating*, AIChE CH139
    - *Project Evaluation: Operating Cost Estimating and Financial Analysis*, AIChE CH140
    - *HAZOP Studies and other PHA Techniques for Process Safety and Risk Management*, AIChE CH157

- *Hands-On Introduction to Statistical Quality Control and Design of Experiments*, AIChE CH202
- *Heat Exchanger Design and Operation*, AIChE CH294
- *Fundamentals of Process Safety*, AIChE CH500
- *Principles and Practices of Chemical Reactor Design and Operations*, AIChE CH522
- *Understanding and Preventing Explosions*, AIChE CH536
- *Six Sigma for Chemical Engineers*, AIChE CH611
- *Advanced Concepts for Process Hazard Analysis*, AIChE CH754
- *Multi-Disciplinary Process Development: From Lab to Plant*, AIChE CH757
- *Flow Induced Vibration with Applications to Failure Analysis*, American Society of Mechanical Engineers (ASME) PD146
- *Centrifugal Pump Design and Application*, ASME PD349
- *QA Considerations for New Nuclear Facility Construction*, ASME PD523
- *Robust Product and Process Design*, ASME PD571
- *B31.3 Process Piping*, ASME PD581
- *NQA-1 Requirements for Computer Software Used in Nuclear Facilities*, ASME PD606
- *Root Cause Analysis Fundamentals*, ASME PD618
- *Risk and Reliability Strategies for Optimizing Performance*, ASME PD619
- *Thermal Treatment Technologies*, ASME
- *Incident Investigation and Root Cause Analysis*, ASME
- *Introduction to Nuclear Fuel Cycle Chemistry*, The Consortium for Risk Evaluation with Stakeholder Participation (CRESP)

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DOE-STD-1176-2010

CONCLUDING MATERIAL

Review Activity:
EM
NNSA
NE
SC

Preparing Activity:
DOE-NNSA-SRO

Project Number:
TRNG-0072

Field and Operations Offices:
CBFO
CH
ID
OH
ORO
ORP
RFFO
RL
SR

Site Offices:
Argonne Site Office
Brookhaven Site Office
Fermi Site Office
Kansas City Site Office
Livermore Site Office
Los Alamos Site Office
Nevada Site Office
Pantex Site Office
Savannah River Site Office
Sandia Site Office
Y-12 Site Office