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1.0 PURPOSE AND SCOPE

(5.1.1)

This standard provides the requirements for consideration of human factors in design. This standard implements the human factors considerations for design provided in TFC-PLN-09. The scope of this standard includes design of new facilities or significant modification of existing facilities, and the evaluation of hazard analyses where human-machine interfaces are necessary for the prevention of the hazard or mitigation of the consequences. (5.1.2, 5.1.3)

The technical basis for the requirements in this standard, and approved deviations, can be found in RPP-RPT-28488, "Technical Basis Document for TFC-ENG-STD-01, Human Factors in Design."

2.0 IMPLEMENTATION

This standard is effective on the date shown in the header.

NOTE: Deviations to any requirements of this standard shall be requested from the standard document owner. Approved deviations shall be documented in the accompanying Standard Basis Document RPP-RPT-28488.

3.0 STANDARD

3.1 Human Factors in Design

3.1.1 Planning the Human Factors Engineering Role in System Development

A human factors engineering description appropriate to the level of importance of a facility or system is developed during the system development process. The description details the human factors engineering analyses and evaluations necessary for the design and reflects the integration of the human factors engineering effort with other disciplines having design input. The information inputs include a description of system objectives, applicable standards and specifications, and other project-specific information.

3.1.2 Requirements Analyses

A systems requirements analysis appropriate to the level of importance of the system and the level of risk associated with system failure is performed as an integral part of the design process and includes human factors engineering considerations.

The needs and requirements of the system user or operator are systematically examined as an integral part of the design process. Appropriate requirements are selected and analyses performed for systems that are important to safety to ensure that the public, the facility, and facility personnel risks are minimized. These analyses are directed primarily to the areas of human-machine function allocation and task analysis.

Decisions concerning which system functions to allocate to the human versus the machine are determined by analyses of system functions required, impact of error or no action on safety, and a comparison of human capabilities and equipment capabilities for the separate system functions. Factors that are considered during the function allocation decision process include system performance criteria, safety, cost, maintainability, scheduling, and training.

3.1.3 Process System Design Interfaces

The design or the selection of equipment to be operated and maintained by personnel includes the application of human factors engineering criteria together with other appropriate design criteria. These criteria include the list of information and control requirements developed from the task analysis.

Human factors engineering data, requirements, or other input to be incorporated into the design are made available at the beginning of the design process. Human factors engineering input to the system design process is presented as specific and quantitative design requirements where possible. Human factors engineering requirements are refined and design recommendations made more specific during the system design evolution. Refer to TFC-ENG-DESIGN-P-17, Attachment C, for a checklist of human-machine interface design considerations.

3.2 General Human Factors Implementation Criteria and Considerations

3.2.1 Human Dimensions

Equipment that is to be used by personnel shall be designed or selected to accommodate body dimensions. Equipment that is to be used by personnel shall be designed or selected to accommodate normal variations such as left-handed or right-handed personnel, color blindness (red-green, etc.) and depth perception, and disabilities as appropriate. This equipment includes control panels, work tables and counters, enclosures, seating, storage, special clothing, and any other equipment designed for an operator.

3.2.2 Environmental Considerations

The design consideration of human factors includes evaluation of environmental influences that impact design.

3.2.3 Temperature and Humidity

The majority of activities performed at the Tank Farms are done outside. (See TFC-ENG-STD-02.) An effective climate control system maintains temperature and humidity at an acceptable level between the human and the environment. Ambient conditions are suitable for the required access or occupancy, considering weather conditions (e.g., temperature, humidity, dust loading, wind speed and direction) or the controlled environment for designs housed in structures.

3.2.4 Lighting

Adequate light levels appropriate for the work assignment are necessary to ensure optimum performance in all work areas. Glare and shadowing shall be avoided. Lighting design considers environmental degradation effects, such as dust or radiation on viewing ports, to ensure adequate lighting intensities can be provided on a long-term basis.

Emergency lighting systems shall be provided as required by NFPA 101.

3.2.5 Noise

Acoustic design minimizes noise levels, where practical, and ensures that verbal communications are not impaired, that auditory signals are readily detectable, and that auditory distraction and irritation that can cause operator fatigue are minimized.

3.2.6 Vibration

Vibration shall be reduced to the extent practical to minimize operator irritation and distraction. Vibration considerations include equipment and tool design, potential effects of vertical and horizontal vibrations on seated and standing operators, and use of appropriate protective devices (e.g., isolation, damping materials).

3.2.7 Component Arrangement

The arrangement of controls and displays on a control panel should promote efficient use of task-related components, rapid location of any given component, and maximum operator awareness of plant conditions. Components should be grouped together on the basis of specific criteria appropriate for the required task or tasks. The groupings should be emphasized and defined by consistently applied graphic-spatial methods such as demarcation and spacing of components, particularly when there are many components.

3.2.8 Protective Equipment

Personnel who work in a hazardous environment (e.g., an environment subject to radiation or chemical hazards or who may be temporarily exposed to such hazards, should have convenient access to the appropriate protective equipment, including proper garments, equipment such as emergency showers and eyewashes, and any other protective equipment necessary for the successful and safe completion of their work.

The design or selection of protective equipment shall be such that it minimizes the impairment of operational and maintenance performance. It shall provide adequate tactile sensitivity and provide the ability to see, reach, move, communicate, and hear. Other considerations should include operability and accessibility of equipment by users of protective equipment, provision of an adequate level of safety for the user, and user comfort while working.

3.2.9 Display Devices

Operator task analysis results shall be the basis for establishing operator information needs. Displays provide only the information about system status and parameter values that are needed to meet task requirements in normal, abnormal, and emergency situations. Status, rather than demand information, shall be displayed for important parameters. Displays indicate whether they reflect demand or actual status. Each display device shall be formatted and designed to ensure that both the display and display content are readable, understandable, and accessible. Variables important to the adequacy of displays include letter size, font, contrast, viewing distance and angle, lighting, color, and complexity of the task. Failure of a display of any type should be easily recognized and should not affect equipment or system performance. Human-Machine interfaces for process control systems shall meet the requirements TFC-ENG-STD-23.

3.2.10 System Controls

The equipment used by an operator to control a complex system is often a composite of many systems. A control panel operator should be able to rapidly locate each component on a panel. To achieve this, the design should take full advantage of several techniques of control display integration including various component-grouping techniques, system mimics, system demarcation, and hierarchical labeling.

Spurious or ancillary information and data may contribute to operator information overload. Prioritized coding, organization of data by system and subsystem, demarcation of system and subsystem components, and removal or relocation of marginally useful data should be used to reduce operator information overload.

3.2.11 Component Controls

Each control device provides the appropriate control capability, range, and sensitivity for necessary control settings and manipulations. Control operating characteristics should conform to operator expectations. Controls shall not be prone to accidental activation. Selection of a control device shall fulfill any control requirements described in the task analysis of system functions.

3.2.12 Warning and Annunciator Systems

An effective warning system alerts personnel to a problem or abnormal condition and provides sufficient time to respond appropriately to the problem. When there are many annunciator alarms, priority coding, such as “first in/out,” shall be used to assist in determining message significance. False alarms and nuisance alarms should be removed. Set point determination shall allow sufficient response time to the operator.

Provision shall be made for active acknowledgment and for silencing of audible alarms after they have been acknowledged.

3.2.13 Communication Systems

A communication system should allow the users to transmit and receive information accurately and conveniently with minimum distraction from the user’s other tasks. Any special needs of the users (e.g., necessity to keep the hands free, inability to be at a constant location, classification of data) should be considered. The system shall have provisions for periodic maintenance tests, instructions for using each system, and procedures for handling emergency communications where applicable.

3.2.14 Maintainability

The design of equipment shall incorporate the objective of efficient maintainability, as appropriate, for the life of the facility. The surveillance, testing, and maintenance of a system and its restoration to operational effectiveness should be achieved at minimum cost with a minimum level of support services.

Design provisions shall include consideration of worker access requirements.

- Additional access space is needed for maintenance access. Examples include transformer work may require clear space access for use of extended reach tools, electrical switchgear requires clear space for workers in addition to the space required for racked breakers, clearance for access doors may require clear space to allow workers to move around the open doors.

- Systems that require maintenance activities while energized or that are in close proximity to systems that will be energized during a maintenance activity require additional human factors consideration.

- Energized electrical equipment poses hazards to the worker that should be considered. Panel arrangements should consider separation of circuits or partitions to allow worker access or manipulation near exposed energized locations.

- Hot or cold mechanical equipment should consider application of additional insulation where worker access is necessary to allow worker access or manipulations.

- Rotating equipment should consider installation of barriers to prevent worker injuries.

3.2.15 Labels

Equipment and any parts of that equipment to be used by personnel should be identified with appropriate labels. Label design shall be consistent and indicate clearly and concisely the function and purpose of the item being labeled. The label information shall be easy to understand. Words, symbols, and other markings in a label or instruction shall be unambiguous and accurate. The terminology used shall be commonly accepted and shall be the same for equipment, procedures, and training materials.

Permanent labels shall be attached to the specific component or equipment in such a manner that environmental conditions or usage by personnel will not remove or destroy the label. Temporary labels shall be used only when necessary and shall be controlled administratively.

3.3 Additional Considerations

3.3.1 Access

Ease of access shall be based on the frequency of access required for the task(s), worker sensory restrictions and speed of movement considering required personal protective equipment for the task(s), and the tools and equipment necessary for the task(s).

- Maintain radiological exposures as low as reasonably achievable (ALARA). Considerations are potential radiation and contamination sources from adjacent facilities and proximate systems, areas of contamination, physical proximity of structures and equipment, and the location and size of discontinuities (e.g., slopes, berms, on or above ground equipment in the access pathway, gates, doorways, stairways, and ladders).

- Maintain chemical exposures ALARA. Considerations are potential solid, liquid, gaseous, and vapor chemical (including toxicological) sources from adjacent facilities and proximate systems (e.g., pipe and hose connections, ventilation system exhausts and other potential sources of vapor emissions), areas of contamination, physical proximity of structures and equipment, and the location and size of discontinuities.

3.3.2 Habitability

The work location shall be designed considering frequency and duration of the task(s) and worker sensory and comfort restrictions.

- Maintain radiological exposures ALARA. Work locations shall be provided with appropriate design provisions (e.g., shielding, ventilation, air filtration) for the frequency and duration of work activities.

- Maintain chemical exposures ALARA. Routinely manned work locations should be protected from releases of hazardous or toxic materials contained within the design. Where exposure to chemicals from external sources is possible, the work location should be provided with suitable ventilation systems to prevent the intake of chemical vapors. Work locations that are not routinely manned should be considered for potential chemical exposures and protected from releases of hazardous or toxic materials contained within the design.

- Ambient conditions at the work location should be suitable for the required activities, considering weather conditions (e.g., dust loading, wind speed and direction). (See PNNL-15160, "Hanford Site Climatological Summary 2004 with Historical Data.")

- In controlled environments, the work location shall be suitably controlled for dust, and the air intake and discharge shall consider wind speed and direction in addition to temperature and humidity. (See PNNL-15160, "Hanford Site Climatological Summary 2004 with Historical Data.")

3.3.3 Monitoring

Design of monitoring systems shall consider the ambient lighting conditions (e.g., intensity of light under operating conditions, glare, backlighting, etc.).

- Displays shall be easily readable, located within normal standing or sitting eyesight as appropriate. Where located outdoors, display intensity shall be sufficient to provide readability in daylight or night-time conditions. Shields should be considered to avoid glare or interference with reading due to direct sunlight. Displays shall accommodate normal color-blindness, especially red-green color blindness by either indication colors or selection of labels.

- Displays necessary for operational control should be separated from those displays that are informational.

- If monitoring systems are located within an enclosure, the enclosure shall be designed to permit opening when workers are wearing required personal protective equipment for their task(s). The enclosures shall be isolated from potential radiological and chemical sources, where practicable. If isolation of the enclosure is not practical, the enclosure should be provided with ventilation to remove radiological and/or chemical aerosols and vapor contaminants. Enclosure temperature due to equipment and/or solar heat-up should be limited to permit necessary worker contact with exposed surfaces.

3.3.4 Manual Controls

Manual controls shall permit the worker to determine position while performing the control action.

- Mechanical controls such as valve handles shall be readily accessible and designed to allow operation by a worker of average strength and reach. Where remote manual operation is required, such as for valves located in pits, the remote handle shall be located at a height that permits the worker to operate the valve in a standing position.

- Electrical control hand switches and selectors shall be located at a height and orientation that allows the worker ready visibility of both the control and the indication of the equipment operating condition. The hand switch or selector shall be designed to permit operation when the worker is wearing required personal protective equipment. Hand switches and selectors shall be clearly identified and have sufficient physical separation by space or barriers to minimize the potential for inappropriate actions.

- If manual controls are located within an enclosure, the enclosure shall be designed to permit opening when workers are wearing required personal protective equipment for their task(s). The hand switch or selector shall be located with adequate clearance or protection from energized components and wiring. The enclosures shall be isolated from potential radiological and chemical sources, where practicable. If isolation of the enclosure is not practical, the enclosure should be provided with ventilation to remove radiological and/or chemical aerosols and vapor contaminants. Temperature due to equipment and/or solar heat-up shall be limited to permit necessary worker contact with the enclosure, hand switch, or selector exposed surfaces.

3.3.5 Automated Controls

Automated controls shall meet the requirements of TFC-ENG-STD-23.

3.3.6 Chemicals

For activities that require handling and use of solvents or other chemicals, the design shall consider the ventilating air flow, splash shields, etc., to minimize potential exposure to solid, liquid, and vapors from the chemicals used and any potential chemical reaction products.

Equipment, such as eye washes and showers shall be provided as appropriate for the specific chemical hazards present in the work environment.

3.3.7 Tools and Test Equipment

Tools and test equipment shall be designed to provide separation of the worker from potentially hazardous environments and conditions.

- Electrical test locations shall include consideration for use of plug and jack connections rather than exposed attachment points.

- Mechanical tool design shall include consideration of the worker’s ability to perform the activities (force application, worker position, etc.). Design consideration should include equipment design provisions for remote access, rather than “hands-on” access.

In addition to the requirements provided in Sections 3.2 and 3.3, a number of detailed items are included in Attachment A for detailed design consideration.

3.3.8 Spreadsheet and other Software Error Controls

Managers with direct responsibility for software, or software owners shall ensure human factors and related tools such as Human Performance Improvement (HPI) are appropriately addressed during implementation of the applicable software management procedure, as stated by TFC-PLN-132. Software programs most susceptible to human error during data entry are Utility Calculation software (spreadsheets, i.e. Excel workbook). Department of Energy HPI Handbook, Volumes 1 and 2 (DOE-HDBK-1028-2009) provide guidance on use of error reduction tools applicable to software, and recommend Peer Checking and/or Independent Verification tools to avoid human error traps.

Specific software guidance containing examples of common spreadsheet errors, and related practices for workbook error avoidance, is found within the attachments to TFC-ENG-DESIGN-C-32.

3.4 Change Trailers

The following ergonomic design recommendations and engineering controls are intended to reduce the amount of lifting during delivery and storage of laundry activities.

- Space within the Change Trailer should be large enough to allow dispensing of clothing from carts. A separate and designated storage area should be provided for carts containing clean laundry in sufficient amount to provide clothing for an entire business day.
- Lighting, Heating, Ventilation, and Air Conditioning (HVAC), and/or ventilation/vents should be available for designated clean laundry area for storage of clean laundry and carts.
- The loading dock for the clean laundry area of the Change Trailer is to be installed at the same level of height as the Change Trailer.
- Shelving for storage and dispensing laundry should be between 20 inches and 65 inches. Engineering controls should block the area below 20 inches and above 65 inches. The surface of the top shelf is at 65 inches, no portion of the material can be located above 65 inches. Separate shelving will have to be provided for non-clothing items and should follow the same guidelines.
- Doorways should provide ample clearance of 36 inches for cart usage. Threshold of doorways should be as smooth as possible for allowance of cart usage. Areas around the doorways should provide ample space for maneuverability of carts and surrounding areas should be kept free of items that could inhibit the movement of carts.
- Engineering controls for installation of doorways should be placed in locations where there is plenty of space to push carts out of the way for emergency ingress and egress, uninhibited transit of both cart and personnel simultaneously, and accessible to the loading dock.
- Carts should be used to transport clean laundry bags from the vendor vehicle to the designated clean laundry storage area. Carts should have at least one horizontal handle (preferably one at each end) at a minimum of 36 inches above the ground. Removable handles should be considered, to allow easier access to items, increase the ease of cart movement, and maximize storage space. The deck to the carts should be below the handle and low enough to facilitate easy loading of laundry but sufficiently high off the ground to reduce the amount of bending to retrieve items.

- Are the shelves and cabinets on the floor properly secured?

4.0 DEFINITIONS

No terms or phrases unique to this guidance document are used.

5.0 SOURCES

5.1 Requirements

1. DOE O 252.1A, "Technical Standards Program."
2. HNF-14755, Documented Safety Analysis for the 242-A Evaporator, Chapter 13, "Human Factors."
3. RPP-13033, Documented Safety Analysis, Chapter 13, "Human Factors."

5.2 References

1. PNNL-15160, "Hanford Site Climatological Summary 2004 with Historical Data."
2. RPP-RPT-28488, "Technical Basis Document for TFC-ENG-STD-01, Human Factors in Design."
3. TFC-ENG-DESIGN-C-32, "Utility Calculation Software Management."
4. TFC-ENG-DESIGN-P-17, "Design Verification."
5. TFC-ENG-STD-12, "Tank Farm Equipment Identification Numbering and Labeling Standard."
6. TFC-ENG-STD-23, "Human-Machine Interface for Process Control Systems."
7. TFC-PLN-09, "Human Factors Program."
8. TFC-PLN-132, "Software Life Cycle Documentation Plan."

ATTACHMENT A – DETAILED DESIGN CONSIDERATIONS FOR HUMAN FACTORS

Specific design considerations that impact design for Human factors are included in the table below:

Item	Issue
1.	Can the equipment be readily assembled/disassembled as designed?
2.	Are assembly clearances adequate?
3.	Has the design appropriately considered maintenance, operations, and reliability, including maintenance procedures and techniques, unique maintenance requirements, and frequencies?
4.	Can the design and its parts be easily inspected for conformance to engineering specifications and to support in-service inspection?
5.	Have personnel radiation protection requirements/ALARA been considered and properly addressed?
6.	Are physical design features the primary methods used to maintain exposures ALARA (e.g., confinements, ventilation, remote handling, and shielding)?
7.	Are optimization methods used (ALARA decision-making methods) to assure that occupational exposure is maintained ALARA?
8.	Does the design avoid, under normal conditions, releases of airborne radioactive material to the workplace atmosphere?
9.	Does the design control, in any situation, the inhalation of radioactive material by workers to levels that are ALARA?
10.	Does the design avoid, under normal conditions, releases of chemical vapors, aerosols, or solids to the workplace atmosphere?
11.	Does the design control, in any situation, the inhalation of chemical vapors, aerosols, or solids by workers to levels that are ALARA?
12.	Are equipment, controls, and traffic patterns located for accessibility and to minimize chemical and radiological exposure to personnel during all situations, including operations and maintenance?
13.	Are doorways and labyrinths wide enough to permit personnel, component, and equipment passage?
14.	Are adequate control devices used to reduce occupational exposures, including shielding, hoods, glove boxes, containments, interlocks, barricades, shielded cells, decontamination features, and remote operations?
15.	Are areas of the facility that exhibit high occupancy, or are presently uncontrolled, adequately protected from new or increased radiation sources?
16.	Is maximum distance provided between serviceable components and any substantial radiation sources in the area?

ATTACHMENT A – DETAILED DESIGN CONSIDERATIONS FOR HUMAN FACTORS (cont.)

Item	Issue
17.	Are permanent platforms, walkways, stairs, or ladders provided to improve accessibility?
18.	Are serviceable components capable of being isolated and drained?
19.	Is there adequate provision for rapid removal of equipment?
20.	Can surveillance be performed from outside a high radiation area through the use of TV camera, viewing port, or remote read-out?
21.	Does the design consider the use of built-in rigging to facilitate component handling?
22.	Does the design facilitate flushing and decontamination of components?
23.	Are components selected with consideration for long service life, ease of removal, and frequency of maintenance?
24.	Are serviceable components easily accessible with adequate workspace, lay-down areas, and lighting?
25.	Are equipment cover plates hinged or closed with captive quick-opening fasteners to facilitate routine personnel access or maintenance access?
26.	Does the design adequately consider life expectancy and reliability in selecting and locating equipment, to minimize the need for personnel access in the area?
27.	Are electrical, mechanical, or hydraulic quick release mechanisms used, where possible?
28.	Does the design adequately consider remote operators or robotics for use in high radiation areas?
29.	Are entrances and penetrations are adequately shielded (e.g., labyrinths or shadow shields)?
30.	Is permanent shielding employed, to the degree feasible, to avoid the need for temporary shielding or that provisions are made to allow temporary shielding during maintenance activities?
31.	Is shielding placed between serviceable components and any substantial radiation source in the area?
32.	Is ventilation designed to control airborne radioactivity and chemical vapors?
33.	Are pointed or other sharp projections avoided?
34.	Are covered pump seals used to contain contaminated liquids?
35.	Are canned pumps or pumps with mechanical seals instead of standard packing glands used?

ATTACHMENT A – DETAILED DESIGN CONSIDERATIONS FOR HUMAN FACTORS (cont.)

Item	Issue
36.	Does the design of piping, tanks, and pumps facilitate draining, cleaning, flushing and decontamination?
37.	Are vents and relief tail pipes routed away from manned work locations to drains?
38.	Are remotely operated valves used, where needed?
39.	Are manual valve operators used only for infrequently operated valves?
40.	Are instrument read-outs and control points located in the lowest radiation area feasible?
41.	Are instruments and controls grouped functionally to minimize time spent in the area?
42.	Are instruments selected for long service life and low maintenance requirements? Is remote calibration provided for?
43.	Do instruments that use radioactive or contaminated working fluid contain a minimum quantity of working fluid?
44.	Is the flow of air from areas of lesser contamination to areas of greater contamination?
45.	Are filter banks readily accessible for maintenance?
46.	Are filter banks separated or shielded from each other to permit working on one with the other operating?
47.	Does the ventilation system (exclusive of filters) minimize potential radioactivity build-up and accumulation of chemical vapors?
48.	Will the system provide the required level of protection from airborne contamination, giving particular attention to patterns of air flow and to the locations of air inlets, penetrations, and exhausts, to ensure releases of radioactive or hazardous chemical material to the workplace atmosphere are avoided under normal operating conditions and that inhalation of such materials by workers is controlled to the extent reasonably achievable?
49.	Are multiple filters or demineralizers housed in separate cubicles to permit maintenance with the system operating?
50.	Are filters provided with remote or shielded methods of filter removal?
51.	Are lifting lugs provided on equipment?

ATTACHMENT A – DETAILED DESIGN CONSIDERATIONS FOR HUMAN FACTORS (cont.)

Item	Issue
52.	Are displays, indicators, switches and actuators: • Arranged and grouped to ensure status and conditions are easily discernible? • Arranged to ensure standard conventions of order (e.g., "A" before or above "B"), direction and rotation (e.g., clockwise or counterclockwise)? • Placed at angles and heights that permit comfortable viewing? • Properly illuminated and easily visible in all expected normal lighting conditions? • Clearly and unambiguously labeled as to function? • Easily operated when wearing required PPE?
53.	Are lamp test switches/pushbuttons employed, when appropriate?
54.	Is color-coding of alarm and status indicators consistent with existing operational practices?
55.	Has the design appropriately considered the use of "latching" of status and alarm conditions to allow post event analysis?
56.	Have key-locked or protected switches been employed where actuation could result in undesirable or unsafe conditions?
57.	Are labels and markings: • Provided for all items that must be viewed, read or operated? • Clearly viewable and permanently marked? • Located so that they are correctly associated with the apparatus?
58.	Are similar names for different controls avoided?
59.	Are process parameters displayed in commonly used engineering units?
60.	Are audible warning signals of such intensity as to not cause discomfort? (Levels should not exceed 115 db at the ear of the listener.)
61.	Have communication requirements for operating and maintenance personnel been considered?
62.	Are valve positions clearly and unambiguously indicated?
63.	Are items requiring periodic inspection or replacement viewable and accessible?
64.	Is adequate space provided for personnel to perform normal operations and maintenance activities?
65.	Have adequate clearances been provided to open all doors including equipment cabinets and enclosures?
66.	Have captive fasteners been used where dropping or losing such items could cause damage to equipment or create difficult or hazardous removal and where frequent removal is required?
67.	Are the shelves and cabinets on the floor properly secured?