

CH2M HILL Hanford Group, Inc.	Manual	Management Plan
INDUSTRIAL HYGIENE EXPOSURE	Document	TFC-PLN-34, REV D-2
ASSESSMENT STRATEGY	Page	1 of 49
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1.0 PURPOSE AND SCOPE

(6.1.2, 6.1.3)

The industrial hygiene program at the tank farms addresses non-radiological chemical and physical hazards that have the potential to adversely impact worker exposure, regulatory compliance, or company assets, especially potential hazards and concerns related to worker health. CH2M HILL is committed to optimize management of exposures to chemical and physical hazards beyond regulatory compliance through development and implementation of a comprehensive strategy known as the exposure assessment strategy (EAS).

The nature of the tank farm work environment is frequently changing and potential for exposure may vary with location, agent source, weather, and task. Evaluation of complex exposure scenarios requires a sound, logical, and comprehensive workplace exposure assessment strategy for optimization of industrial hygiene (IH) and other occupational health resources for those situations where potential exposures could have adverse health effects. Examples of historical exposure evaluations are listed in [Attachment A](#).

An exposure assessment strategy is an iterative process. It is expected that many elements will be refined as more information and experience is gained about potential exposures and as tank farm work progresses.

The overall approach links job hazard analysis, exposure assessment, and medical surveillance to reduce the risk of exposure and prevent adverse health effects. The methods and rationale that the tank farm contractor (TFC) uses to characterize and monitor workers' potential exposures to hazardous chemical, physical, ergonomic and biological agents are described here. The goal of the TFC exposure assessment strategy being protection of workers by controlling potential exposures to action levels of less than 50% of the established Occupational Exposure Levels (OELs).

The exposure assessment strategy applies to all TFC activities (including design, construction, operation, maintenance, decontamination, decommissioning, and environmental restoration activities) performed by the TFC and its subcontractors. To the extent that non-routine operations are undertaken by the TFC, this EAS must be adapted to identify potential health hazards and demonstrate compliance when task frequency is too low to warrant formation of similarly exposed groups (SEGs).

1.1 Source Documents

10 CFR 851, "Worker Safety and Health Program," establishes the requirements for a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites. Contractors must implement a comprehensive IH program that includes initial or baseline surveys and periodic resurveys and/or exposure monitoring as appropriate of all work areas or operations to identify and evaluate potential worker health risks. 10 CFR 851 codifies the requirements and enforcement of DOE O 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees," and incorporates the guidance provided by DOE G 440.1-3, "Implementation Guide for use with DOE O 440.1A."

DOE O 440.1A requires actions to assess and mitigate exposures to workers and coordinate with cognizant occupational medicine and other professionals. DOE G 440.1-3 expands on one order element, that of exposure assessment. It provides guidance to the TFC to implement a comprehensive strategy incorporating performance-based approaches for conducting IH

exposure assessments, an approach more conservative than a strict compliance strategy. The industrial hygiene exposure assessment strategy described in the DOE Guide is primarily based on a national consensus standard established in the American Industrial Hygiene Association publication, “A Strategy for Assessing and Managing Occupational Exposures” (AIHA Strategy). Additionally, guidance has been incorporated from other sources listed in the DOE Guide and in the reference section of the AIHA strategy and implementing procedures.

RPP-22491, “Industrial Hygiene Chemical Vapor Technical Basis,” provides a summary of the basic characterization of the vapor hazards associated with the waste tanks. The document includes the vapor phase evaluation and basis for the list of Chemicals of Potential Concern (COPC). The EAS is the implementing document for portions of RPP-22491 regarding exposure assessment planning, interpretation and judgment of exposures.

1.2 Design Objectives and Goals of the Exposure Assessment Strategy

The EAS is part of a comprehensive industrial hygiene program to reduce the risk of work-related disease or illness at TFC facilities. The EAS includes design objectives to:

1. Assess worker exposure to non-radiological chemical or physical hazards (identified in a job hazards analysis or other suitable qualitative hazard analysis) and other data to screen for exposure potential.
2. Use a hierarchy of controls, including:
 - Elimination of chemical and physical hazards (e.g., chemical substitution)
 - Engineering controls (e.g., ventilation)
 - Work practices and administrative controls that limit worker exposures
 - Personal protective equipment (PPE).

IH and Safety review will be ensured of designs for new facilities and modifications to existing facilities in accordance with [TFC ENG DESIGN C-01](#); operations and procedures; and equipment, product, and service needs.

3. Evaluate work place and activities by workers, supervisors, and managers through field activity observation and through the Worksite Hazard Analysis (WHA) and the Employee Job Task Analysis (EJTA) processes.
4. Provide updated baseline surveys of work areas or operations to identify and evaluate potential work related health risks; periodic resurveys and/or exposure monitoring, as appropriate; and documented exposure assessment for chemical, physical, and biological agents, and ergonomic stressors using recognized exposure assessment methods and American Industrial Hygiene Association (AIHA) accredited industrial hygiene laboratories, or equivalent as approved by the IH program manager (e.g., Environmental Protection Agency accredited laboratories).
5. Ensure compliance with worker protection requirements identified in 10 CFR 851.23, “Safety and Health Standards.” These include, but are not limited to, 29 CFR 1910, “Occupational Safety and Health Standards;” 29 CFR 1926, “Safety and Health Regulations for Construction;” and American Conference of Governmental Industrial Hygienists (ACGIH), “Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices,” (most recent edition) when the ACGIH

Threshold Limit Values (TLVs) are lower (more protective) than permissible exposure limits in 29 CFR 1910. (6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.7)

6. Document the descriptive and/or inferential statistics of exposure data for each SEG when sufficient data are available.
7. Use existing data about facilities, equipment, materials, and tasks for implementing strategies to identify potential hazards and to prevent or mitigate exposures.
8. Document exposure hazard analysis of jobs and tasks.
9. From exposure data, link similarly exposed individuals into groups (SEGs)
10. Link SEG exposure data to medical monitoring
11. Trend exposure measurements as an indicator of worker protection performance.
12. Use exposure information to focus worker protection efforts.

1.3 Action Levels and Administrative Control Levels

DOE G 440.1A defines an administrative control level (ACL) as follows:

“The airborne concentration of a chemical contaminant below which additional assessment may not be necessary. The ACL should be initially set at 10% to 25% of an OEL and should be confirmed or changed as monitoring data and hazard analyses become available. The ACL is intended to be used as a decision point for determining compliance with the OEL and whether additional monitoring is necessary to determine compliance. The ACL is not intended to be used as a modified OEL.” (6.1.1, 6.1.2)

The EAS establishes a system for additional monitoring of exposures exceeding 10% of the ACL to better understand and control sources, task-based exposure, etc. The system emphasizes prioritization for engineering controls, cost-benefit analyses, and exposure evaluation with increased statistical certainty. CH2M HILL intends to go beyond DOE requirements and adopt action levels at 50% of respective OEL for optimizing employee protection and for implementing the comprehensive goals of the exposure assessment strategy.

As a construct in exposure control, the action level is not a new concept. OSHA has set a number of actions levels in chemical-specific standards. Many proactive employers have adopted action levels as a tool to optimize exposure control. Table 1 illustrates the differences between administrative control levels and action levels. For additional discussion of averaging time for OELs, see [Attachment B](#).

The elements of the exposure assessment strategy are incorporated into [TFC-PLN-43](#) and other documents. Details of the implementation plan for each organization are found in Section 2.0 of this plan.

1.4 Relationship of Exposure Assessment Strategy and Exposure Control Levels

(6.1.2)

The TFC will implement an ACL of 10% of the OEL to determine if further information gathering is warranted, to establish frequency and extent of subsequent monitoring and, along with other methods, to decrease uncertainty of exposure assessment. CH2M HILL is committed to controlling exposures to the action level, defined herein as 50% of the OEL, provided that it is reasonably achievable. The relationship of administrative control levels to action levels is shown in [Table 1](#).

The industrial hygiene exposure assessment strategy process, including actions taken at administrative control levels (10% of the OEL), and control of exposures to the action level at 50% of the OEL is similar to the approach followed by the radiological protection program in limiting occupational doses to as low as reasonably achievable (ALARA). Effective exposure assessment strategy processes include consideration, planning, and implementation of physical design considerations (including engineering controls), and administrative controls to balance the risks of occupational chemical exposure against the benefits arising out of the authorized activity. Lessons learned are documented, institutionalized, and considered in planning and executing subsequent activities to further the goals of the EAS to provide optimal employee protection.

1.5 Exposure Assessment Strategy Records

For purposes of effective management and for internal assessments and external audits, records documenting EAS implementation include, but are not limited to:

- Written management policy and commitment (this document)
- Design records documenting industrial hygiene review and input for new or modified engineering designs
- Training records showing attendance of identified personnel responsible for implementing the EAS
- SEG personal sampling results database and supporting IH monitoring and direct reading instrument (DRI) Data Forms ([TFC-ESHQ-S IH-C-46](#)~~TFC-ESHQ-IH-STD-03~~)
- Documentation of statistical analyses of results (when sufficient sample numbers are available) including a discussion of uncertainty
- Written periodic exposure assessment reports from each organization, uniquely numbered and submitted in accordance with [TFC-BSM-AD-STD-02](#)
- Written periodic internal management assessments of the exposure assessment strategy, including results, lessons learned, changes made, etc.
- Periodic independent assessment of the EAS.

2.0 ROLES AND RESPONSIBILITIES

Responsibility for successful implementation of the EAS lies within IH and the supporting organizations. The IH Program manager may delegate some of his/her responsibilities. However, he/she is ultimately accountable for the following.

2.1 IH Program Manager

The IH Program Manager overseeing the EAS must be a Certified Industrial Hygienist (CIH), or, at a minimum, meet the requirements found in [TFC BSM-TQ-STD-01](#). The IH Program manager should perform or review the following activities:

- Review of designated SEGs
- Overall design of monitoring strategies
- Final interpretation of monitoring data, including statistical analysis
- Judgment of exposures to be acceptable, unacceptable or uncertain
- Identifying health-hazard control strategies.

Specifically, the IH Program manager is responsible for:

1. Establishing and directing the exposure assessment program, ensuring that key competencies are in place at the staff level. CH2M HILL IH staff must be qualified as described in [TFC BSM-TQ-STD-01](#).
2. Developing and managing the qualitative assessments, predictive modeling, and monitoring programs; coordinating with Process Engineering regarding monitoring and modeling performed to support the IH EAS program and ensuring incorporation and update, as necessary.
3. Reviewing qualitative assessments and resulting priorities for monitoring submitted by organizational managers.
4. Providing oversight for qualitative assessments performed by IH organizations within the TFC contractor (IH Programs, Waste Feed Operations, Closure Operations, and Analytical Technical Services), including but not limited to:
 - Data quality review
 - Statistical analysis review
 - Data interpretation
 - Exposure acceptability.

Such oversight may be delegated by the IH Program manager.

5. Ensuring the EAS is reviewed periodically, seeking input from managers, industrial hygienists, and workers and using other knowledgeable personnel/expertise, as necessary, to refine and improve the EAS.
6. Ensuring feedback receives a prompt response.
7. Ensuring periodic IH evaluation is performed to assess effectiveness of controls and estimate exposure.

8. Ensuring engineering and administrative controls are recommended on the basis of periodic IH evaluation
9. Ensuring performance of a periodic review of the toxicological literature to incorporate new information related to OELs and carcinogenicity.
10. Ensuring the COPC list in the most current version of RPP-22491, Industrial Hygiene Vapor Technical Basis, is updated as necessitated by periodic IH evaluations.
11. On a periodic basis, requesting feedback from the Hanford Site occupational medical contractor, on aggregate general medical monitoring results of SEG members.
12. Ensuring the sharing of information and interaction between the TFC contractor IH program and the Hanford Site occupational medical contractor

2.2 WFO, CO, and ATS Field IH Managers

1. Responsible for field industrial hygiene under the EAS.
2. Ensuring that the EAS is implemented in their organizations and that it meets requirements as outlined in this plan.
3. Ensuring that IH technicians in their respective organizations are qualified as described in [TFC-BSM-TQ-STD-07](#).
4. Providing appropriate employee education and training to managers, industrial hygienists, and workers.
5. Providing oversight and technical information required for the implementation of the respiratory protection and personal protective equipment (PPE) programs in their respective organizations.
6. Interpreting tank characterization, workplace, Worksite Hazard Analysis or Safety Plans, historical IH data, and task information to understand potential exposures and develop monitoring strategies. With assistance from the field industrial hygienists, proposing task-based, area-task, or condition-task SEGs.
7. Gathering qualitative potential exposure information.
8. Determining potential for predictive modeling amongst the operations.
9. Proposing and implementing approved quantitative monitoring strategies per SEG.
10. Providing documentation to the IH Program manager.

2.3 Industrial Hygienists

Industrial Hygiene SMEs:

- Ensure procedures are compliant with applicable DOE requirements
- Provide technical support
- Participate in scheduled assessments and follow-up as appropriate
- Provide program oversight.

Industrial Hygienists:

- Develop sampling plans and provide oversight for sampling activities
- Develop written hazard assessments
- Provide technical support
- Review data and prepare reports.

2.4 Engineering

(6.1.2, 6.1.3, 6.1.5, 6.1.7, 6.1.8)

Engineering, in collaboration with IH will:

- Provide technical support to IH in updating the Industrial Hygiene Chemical Vapor Technical Basis (RPP-22491)
- Involve IH in the design and installation of all engineering controls which may introduce or affect exposure to chemical, biological, physical or ergonomic hazards
- Provide technical support to IH for emission or source sampling campaigns to test specific hypotheses of utility to the EAS.
- Ensure that engineering controls for minimization of potential personal exposure are included in new designs or modifications to existing designs, by involving IH in the design those designs.
- Ensure proper industrial hygiene and safety reviews as outlined in [TFC-ENG-DESIGN-C-01](#).

3.0 EXPOSURE ASSESSMENT STRATEGY PROCESS

3.1 Implementation

An implementation plans (improvement plan) will be developed submitted annually via the Program group working with the by each IH Operational groups field manager (i.e., WFO, CO, and ATS) to the IH Programs manager. The purpose of this plan is to drive continuous improvement within the industrial hygiene process at the tank farms. Some of the areas that may be included are leadership, planning, procedures, training, data collection, and management and assessments. These plans will be reviewed periodically during the year for the purpose of tracking completion of action items. The industrial hygiene process should include oversight of subcontractors. Field organizations will include identification of similarly exposed groups (see Section 3.6 for information on identifying SEGs) in their respective implementation plans.

~~Implementation plans will also include planning for review of subcontractor oversight plans for existing contracts.~~

~~The organizational implementation plans will be rolled up to an overall industrial hygiene EAS implementation plan approved by the IH Programs manager.~~

Throughout this plan, references to “exposure assessment,” “exposure monitoring,” “exposure estimates,” etc., refer, without exception, to potential exposures.

Personal exposure monitoring will be performed in accordance with applicable standards and procedures, under the direction of the responsible industrial hygienist, in accordance with applicable organizational implementation plans.

Sampling and analytical methods approved by the National Institute for Occupational Safety and Health (NIOSH) or OSHA shall be used for collection of personal exposure data. In accordance with ~~TFC-ESHQ-S IH-C-46~~[TFC-ESHQ-IH-STD-03](#), data will be collected in the field and entered into the Tank Farm Industrial Hygiene (TFIH) database in accordance with other applicable standards and procedures.

Cognizant industrial hygienists shall perform appropriate statistical analyses and interpretation of collected data, and determine the acceptability of potential exposures, using recognized, consensus methods, in accordance with applicable standards and procedures.

Following approval of the Organizational Implementation Plans, the IH field managers will report implementation progress periodically to the IH Program manager.

3.2 Industrial Hygiene Baseline Hazard Assessments

A baseline hazard assessment is a culmination of initial hazard analyses during design review and periodic updates throughout the lifecycle of a facility. The initial baseline is a checklist item as part of the startup and testing process.

3.3 Training

The Industrial Hygiene field managers, industrial hygienists, and industrial hygiene technicians will receive initial and annual update training on implementation of the exposure assessment strategy. Communication to management and employees will be accomplished through staff meeting discussion, desk instructions, memos, tailgate meetings, and newsletter articles.

3.4 Metrics

Implementation effectiveness of this exposure assessment strategy will be measured and communicated periodically through metrics established by the IH Programs manager. The metrics will be established by the IH Programs manager and may include:

- The number of SEGs with completed exposure assessments and judgment decisions; Appropriateness and completeness of data collected per SEG
- The number of exposures estimated less than 10% of the OEL (Administrative Control Level)

- The number of exposures greater than the 50 % of the OEL (Action Level)
- The number of exposures greater than the OEL
- Recommendations for SEG revisions or EAS improvements.

3.5 Subcontractors

This scope applies to subcontractors performing work that potentially exposes employees to hazards covered by this exposure assessment strategy at the TFC facilities. Hazards include those inherent to the TFC facility and those introduced by the subcontractor. For hazards related to tank waste vapors, Industrial Hygiene will perform personal monitoring on subcontractor employees and provide notifications to individuals. Subcontractor compliance will be demonstrated using the processes established in [TFC-ESHQ-S_SAF-C-07](#). Implementation plans will include planning for review of subcontractor oversight plans for existing contracts, identification of appropriate SEGs for subcontractors, and reporting requirements for subcontractor management and subcontractor industrial hygienists. Where necessary, an appropriate level of training will be conducted for subcontractor industrial hygienists by the TFC.

3.6 Identifying Similarly Exposed Groups

A fundamental principle of this EAS is that SEGs will be identified among groups of employees who experience exposures similar enough that monitoring exposures of any worker in the group provides data useful for predicting exposures of the remaining workers. The similarly exposed groups in tank farms could be defined by any of the activities and support categories, or combinations of activities and categories listed below:

- Non-waste disturbing activities, not otherwise specified (large SEG)
- Non-waste disturbing activities, radiological routine
- Non-waste disturbing activities, operations routine
- Non-waste disturbing activities, area maintenance
- Waste-disturbing activities, headspace sample collection
- Waste-disturbing activities, valve/filter/gasket replacement
- Waste-disturbing activities, vent and balance
- Waste-disturbing activities, pit crew work
- Waste-intrusive activities, tank component removal (thermocouple, pump, etc.)
- Waste-intrusive activities, plumbing repair
- Waste-intrusive activities, waste sample
- Waste-intrusive activities, waste retrieval
- Support, carpentry
- Support, tool crib attendant
- Support, painting
- Support, welding
- Laboratory maintenance activities
- Laboratory analytical activities, outside hoods
- Laboratory analytical activities, inside hoods.

It is probable that some workers will be included in more than one SEG. SEGs will be established in accordance with guidance provided in Chapter 4 of "A Strategy for Assessing and Managing Occupational Exposures," 1998, AIHA.

3.7 Qualitative Exposure Assessments

Qualitative exposure assessments are performed by industrial hygienists during the process of a Worksite Hazard Analysis/Safety Plan and EJTA and in the preparation of a work package. Program requirements for performing these assessments can be found in [TFC-ESHQ-S SAF-C-02](#) and [TFC-ESHQ-S IH-C-17](#).

In general, personal monitoring to estimate potential exposures will be performed when the exposure source emits a hazard that could exceed the ACL, i.e., >10% of an OEL. Formal or informal qualitative exposure modeling may allow acceptability judgments to be made for certain exposures estimated to be <ACL. Examples of qualitative exposure assessments may include:

- Extrapolation of tank history and characterization (based on the latest revision of RPP-22491) or work area concentrations near emission sources to estimate personal potential exposure
- Review of qualified and applicable personal monitoring data
- Predictive physical-chemical modeling based on tank characterization and other data
- History of activities that DRI monitoring shows non-detects or very low levels over time
- Worker exposure scenarios based on process and work practice knowledge.

Models are of value in the initial prioritization of SEGs for quantitative monitoring. Because of the uncertainty involved with model use, it is important that models use conservative approaches and assumptions that overestimate potential exposure. Whatever the model technique used, if a clear outcome does not result, an acceptability judgment cannot be made, and quantitative personal air monitoring is required for that SEG. It is also possible to validate models through quantitative air monitoring and refine model inputs for their future use.

Dermal exposure assessments are typically qualitative. Dermal hazard evaluations will be made on a case-by-case basis, and will take into account waste composition, potential for waste contact, and waste contact controls.

3.8 Personal Monitoring

(6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.6)

Personal breathing zone sampling is the best means to quantitatively estimate personal exposure to industrial hygiene hazards that can be quantitatively measured and compared to a consensus standard such as an OEL.

Personal exposure results used for statistical analysis should be based on full shift data when practical, and shall be collected using sampling and analytical methods approved by NIOSH or OSHA or when no NIOSH/OSHA approved method is available, in accordance with other validated methods.

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Individuals within an SEG selected for sampling should be selected randomly, when practical, using principles discussed in [Attachment C](#) and [Attachment D](#).

For short term exposure limits (STELs) or ceiling limit samples, random sampling will not be used. Rather, a given task may be chosen to monitor compliance with the limit for the appropriate duration (see [Attachment E](#)).

The number of employees requiring personal monitoring in a similarly exposed group is based on the NIOSH Occupational Exposure Sampling Strategy Manual (see Table 2) (Leidel 1977). Documentation of field observations is necessary and critical to the uncertainty discussion and support of an acceptability judgment and should be performed in accordance with [TFC-ESHQ-S IH-C-46](#)~~TFC-ESHQ-IH-STD-03~~. All TFC and subcontractor personal monitoring data shall be validated and entered into the TFIH database, and shall be analyzed using appropriate statistical tools/software. It should be noted that most statistical software cannot handle results that are “less than” analytical detection limits (<DL). Such data must be entered as a positive value as described in [Attachment E](#). This attachment includes information on statistical distribution of results information for further statistical analysis.

3.9 Chemicals of Potential Concern

Personal monitoring will be performed for tank vapors identified as COPCs in the most current version of the Industrial Hygiene Chemical Vapor Technical Basis (RPP-22491). The rationale used by CH2M HILL for prioritizing the COPCs included two main criteria:

- Carcinogenicity (known and probable as classified by the International Agency for Research on Cancer (IARC) and/or regulatory/guidance agencies)
- A ratio of maximum headspace concentrations to the lowest OELs of 0.1 or greater (non- carcinogens).

The list of COPCs and additional details on the process of selecting the COPCs are available in RPP-22491. IH monitoring strategies should reflect the priorities followed in RPP-22491.

Determinations of exposures for chemicals listed in the OSHA expanded health standards (e.g., methylene chloride) are based on objective evidence. These determinations are documented and maintained as records.

Refer to procedures on performing source, area, and personal monitoring for specific hazards or categories of hazards or industrial hygiene direction.

3.10 Role of Exposure Assessment in Occupational Medicine and Medical Monitoring

Personal exposure monitoring data and/or exposure estimates for members of a SEG will be provided to the occupational medical contractor for comparison to the worker’s EJTA. The IH Program manager will receive feedback from the Hanford Site occupational medical contractor if health effects potentially related to one or more of SEG members are seen.

3.11 Occupational Exposure Limits

(6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.6)

The TFC has established OELs for exposure to occupational health hazards as the lower (more protective) of the OSHA permissible exposure limit (PEL) or the ACGIH threshold limit value (TLV) in accordance with 10 CFR 851.23 and DOE O 440.1a. OELs consist of both an exposure level and a time over which that exposure is to be averaged (see [Attachment B](#)). Personal exposure monitoring data is compared to the OELs to determine compliance. Further, CH2M HILL is committed to maintaining exposures to less than 50% of the OEL, also known as the action level, provided that it is reasonably achievable.

Additional controls (e.g., engineering, administrative, and PPE) will be implemented if monitoring data suggests that workers could be exposed at a level exceeding the action level for any one chemical present.

To ensure tank vapor exposures remain well below the OELs, DRI (screening) action levels are also monitored for planned and routine operations, maintenance, and construction activities and locations with greater potential for exposure. For example, if stable (five-minute) DRI readings for ammonia, nitrous oxide, or mercury indicates levels exceed 12 ppm ammonia as read by an ammonia specific DRI, 25 ppm nitrous oxide, or 0.013 mg/m³ mercury in a worker's work area, then controls will be immediately implemented. These may include changes in work area controls (e.g., changing a vapor control zone (VCZ) boundary, See [TFC-ESHQ-S IH-CD-35](#)). In accordance with [TFC-ESHQ-S IH-C-46](#)~~[TFC-ESHQ-IH-STD-03](#)~~, it is imperative that DRI monitoring data be recorded and all other information required on the IH Direct Reading Instrument Survey Form be completed. This information is vital to reduce uncertainty and support acceptability judgments.

Programmatic information on tank vapors can be found in [TFC-PLN-43](#), Section 4.2.2. These real-time readings cannot be directly compared to OELs. The most useful comparisons to OELs are statistically analyzed exposure estimates based on full shift personal monitoring on a sufficient number of randomly selected SEG members.

Because of the complexity of the tank vapor mixtures and the multiple target organ effects, the chemicals in the tank vapor mixture will be treated independently with regard to worker exposure limits and exposure assessments. However, if personal exposure monitoring results indicate estimated exposures to chemicals with the same target organ effect, a conservative composite exposure estimate will be calculated using the OSHA and ACGIH formula for mixtures (see [Attachment B](#)).

4.0 TANK FARM HAZARDS

4.1 Chemical Hazards

(6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.7)

There are several sources of chemical hazards at the tank farms. Sources include:

- Tank waste from weapons production processes stored in the tank farms
- Procured chemical products used in various tank farm processes (e.g., paint products, urethane foams, acids, caustics, welding rods, etc.)

- Materials related to legacy facility equipment (e.g., asbestos gaskets and insulation, raw lead shielding).

The exposure sources for tank vapors are emission points in the double-shell tanks, single-shell tanks, and miscellaneous underground storage tanks. Vapors from tanks are released from ventilation systems, breather filters, pump pits, tank monitoring equipment, and opened systems (e.g., risers, drains, manual tape devices). The Tank Farm Vapor Characterization Program was established to characterize tank vapor flammability and toxicity. Data generated, peer-reviewed, and released through this program are utilized by industrial hygienists to plan exposure assessment monitoring strategies. The IH Program manager can provide input to the characterization program if further headspace tank vapor characterization is identified as necessary to support employee exposure assessments.

4.2 Tank Waste Hazard Evaluation

Tanks are qualitatively evaluated based on available solid, liquid, and vapor phase characterization data (see RPP-22491). As part of the annual industrial hygiene EAS program review, exposure estimates will be compared to the various tank categorizations. Work done in the vicinity of tanks, or involving tank waste materials in any phase, should be evaluated in advance by the cognizant industrial hygienist to determine the appropriate controls. Hazard evaluations will be documented using the format of [Attachment F](#).

4.2.1 Tank Vapor Exposure Assessments

The results of the vapor phase evaluation were used to establish the COPC list. Three types of monitoring/sampling are currently used for tank vapor exposure assessment:

- Vapor source monitoring/sampling
- Work area monitoring/sampling
- Personal monitoring/sampling.

Modeling can be used to enhance exposure assessment.

Annually, the IH Program manager or a designee evaluates the EAS conduct, acceptability judgments, and recommendations on controls and future monitoring schedules. These data include source monitoring, screening, area and personal monitoring.

1. Tank Vapor Source Monitoring/Sampling

Tank farm source monitoring/sampling refers to monitoring/sampling at points where emissions could potentially expose workers (e.g., at the face of breather filters). Source monitoring/sampling is performed to establish or confirm source baselines and to evaluate changes in source emissions. Source monitoring/sampling is performed when there is potential for exposure as a result of transfer retrieval activities, break in containment activities, and other instances as directed by the responsible industrial hygienist. Source samples will be collected at the direction of the responsible industrial hygienist with results used to confirm or establish appropriate target analytes for personal exposure monitoring. Review of toxicological literature will also be performed to incorporate new information related to health effects or OELs.

Sources of fugitive emissions will be surveyed in response to employee reports of symptoms of exposure or unusual odors.

2. Work Area Monitoring/Sampling

Area monitoring/sampling provides valuable information for conducting chemical exposure hazard analyses used to establish VCZs, downpost existing VCZs or as the basis for Industrial Hygiene monitoring/sampling plans, ensuring that appropriate controls are put in place to protect workers from tank vapor emissions (see [TFC-ESHQ-S IH-CD-35](#)). Work area monitoring/sampling also provides information useful in selection of personal sampling analytes and locations.

[Work area monitoring/sampling may also provide useful data for evaluating worker exposure in the event of an abnormal condition. For those high risk operations identified in RPP-35562, continuous sampling/monitoring is required for the tank farm specific COPCs. Continuous sampling/monitoring will be conducted at those locations that present the greatest potential for failure and consequently release of vapors to the environment. Examples of waste moving activities that may require continuous sampling/monitoring are: tank retrievals, cross-site transfers, hose-in-hose transfers, and evaporator transfer operations.](#)

All DRI data shall be recorded on the Industrial Hygiene Direct Reading Survey Form and submitted with each Industrial Hygiene Personal Data Form (see [TFC-ESHQ-IH-STD-03](#)~~TFC-ESHQ-S IH-C-46~~).

3. Personal Exposure Monitoring/Sampling

Personal exposure monitoring for tank vapors within this EAS will be performed with a priority identified in the field organization implementation plans. More specific information is provided in [TFC ESHQ-IH-STD-12](#) for monitoring requirements during waste retrieval and waste intrusive work. Exposure monitoring during all activities will be performed at the direction of the responsible field Industrial Hygienist to complete data collection for each SEG.

4. Monitoring/Sampling During Abnormal Events

[In the event of a tank waste release during a waste moving event, re-entry into the area for investigation and habitability surveys shall be conducted following the guidelines in the tank farms re-entry monitoring/sampling plan, 7M500-DFE-07-051, "Initial Re-entry Plan for Abnormal Events." A more detailed monitoring/sampling plan may need to be developed for follow-up investigations.](#)

4.2.2 Dermal Exposure Assessments

Some of the chemicals in tank waste and associated tank materials can irritate the skin or be absorbed through the skin. RPP 34147 provides the technical basis for skin protection, and [TFC-ESHQ-S IS-C-02](#) (Personal Protective Equipment) describes worker protection and controls.

4.3 Other Chemical Exposure Assessments

(6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.7)

Asbestos, lead, beryllium, wood dust/additives, and nuisance dust are airborne particulate hazards associated with some tank farm activities. Purchased or introduced chemicals, such as paints, solvents, acids and caustics also pose potential chemical hazards at the tank farms. Exposure assessments are performed based on TFC programmatic requirements and where an industrial hygienist determines, through the Worksite Hazard Analysis and other qualitative exposure assessment techniques, that there is a potential for worker exposure. Program requirements for assessing exposure to some specific chemicals can be found in [TFC-PLN-24](#), [TFC-ESHQ-IH-STD-04](#), [TFC-ESHQ-IH-STD-05](#), and [TFC-ESHQ-IH-STD-08](#). Program requirements for handling materials that pose a potential carcinogenic hazard can be found in [TFC-ESHQ-IH-STD-11](#). Program requirements if assessing exposure during laboratory use of hazardous chemicals can be found in [ATS 310, Section 4.5, "222-S Laboratory Complex Chemical Hygiene Plan."](#)

SEGs include support activities where there are potential exposure to procured chemicals, e.g., painting or welding. Such activities can be assessed qualitatively to determine if quantitative exposure assessment is necessary to make an acceptability judgment. Use of chemicals with OELs will be assessed on a case-by-case basis during the WHA process and the field Industrial Hygienist will determine the need for quantitative exposure assessment to identified procured chemicals. Personal monitoring, if necessary, will be performed at a frequency to be determined based on the percent of the ACL estimated by the SEG's descriptive statistics and the acceptability judgment.

4.4 Physical Hazards

Typical tank farm physical agents include noise, illumination, and temperature extremes, laser light and non-ionizing radiation. TFC programs for assessment of the risk of injury from these agents are found in [TFC-PLN-43](#), [TFC-ESHQ-S IH-C-07](#), ~~and [TFC-ESHQ-IH-STD-03](#)~~, and [TFC-ESHQ-IH-STD-13-29 CFR 1910.120\(m\), table H 120.1, \(ATTACHMENT G TANK FARM ILLUMINATION REQUIREMENTS\)](#). Exposure assessments to physical agents should be evaluated by each organization and included in their implementation plans.

4.5 Ergonomic Hazards

Typical tank farm ergonomic hazards stem from non-ergonomically designed tools or work areas, uneven footing, improper lifting or reaching, repeated motions and awkward positions. ~~TFC programs for assessment of the risk of injury from ergonomic risk factors are found in [TFC-ESHQ-S IH-STD-03](#).~~ As strains and sprains have proven to be a major cause of injury at the tank farms, each organization should evaluate exposure assessments to ergonomic hazards and include this in their implementation plans.

4.6 Biological Hazards

Typical tank farm biological hazards stem from the desert environment of the field work site. These include insects and animals, as well as molds, bacteria, and fungi. Exposure assessments will be performed in response to employee concerns, medical requests, and assessments. A small number of TFC employees are potentially exposed to bloodborne pathogens through their roles as janitors or emergency medical responders. Program requirements can be found in

[TFC-ESHQ-S-STD-24](#). Exposure assessments to biological agents should be evaluated by each organization and included in their implementation plans.

4.7 Interpretation and Decision Making

(6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.7)

Employee exposure data will be analyzed periodically to determine:

- Compliance with DOE-prescribed exposure limits (OELs)
- Distributions of the SEG exposure data, to include the mean or geometric mean, the (geometric) standard deviation, and variance of the aggregate SEG data for each hazardous agent and for mixtures of similar target agents
- Trends in exposure or biological monitoring data for individuals and SEGs
- Recommendations for modification of this exposure assessment strategy or any of its elements
- Lessons learned
- Engineering or other controls that can bring the greatest benefit for exposure reduction.

Program requirements for notification of personal exposure monitoring results are found in [TFC-ESHQ-IH-STD-03](#).

Results of the annual exposure data analysis will be communicated to employees and management. Both personal monitoring results and the distribution of exposures within similarly exposed groups will be provided to the occupational medical contractor through periodic data transmittals.

The IH field managers (i.e., WFO, CO, and ATS) will report implementation progress periodically to the IH Program manager.

5.0 DEFINITIONS

Definitions of terms in this section are taken from AIHA 1998, DOE G 440.1-3 "Implementation Guide," 29CFR1910, the Industrial Hygiene Technical Basis (RPP-22491), and other sources. Some definitions have been adapted in the context of the Tank Farm Exposure Assessment Strategy.

Acceptable exposure. Occupational exposure to a chemical, physical, or biological agent judged to present a minimal risk for illness or disease, when all information, including qualitative and/or quantitative monitoring data supports this judgment.

Action level. The airborne exposure concentration (i.e., 8-hour TWA from personal sampling) of a chemical contaminant above which exposures will be controlled. The action level at the tank farm is 50% of an 8-hour TWA OEL.

Administrative control level. The airborne exposure concentration (i.e., TWA from personal sampling) of a chemical contaminant below which additional assessment may not be necessary,

and above which assessment will be prioritized according to an overall exposure rating. The ACL at the tank farm is initially set at 10% of an OEL; the ACL should be confirmed or changed as monitoring data and hazard analyses become available. The ACL is intended to be used for determining compliance with the OEL, for making resource allocation decisions, and for determining whether additional assessment or monitoring is warranted. The ACL is not intended to be used as a modified OEL (adapted from DOE G 440.1-3).

Area sample. An environmental sample collected at a fixed tank farm point that reflects chemical contaminant concentrations or levels of physical or biological agents present at that point. Results from area samples should be interpreted with caution because they do not represent employees' actual exposures to hazardous agents (adapted from DOE Guide). Area samples are useful to support judgment decisions within an EAS, to test efficiency of controls, to determine sources of vapors and gradients with distance, etc.

Basic characterization. Thorough characterization of the tank farm construction and chemicals, the work force, and chemicals of concern. This information is organized and used to understand the tasks being performed, tank headspace contents, materials being used, and controls in place so that a picture of potential exposure conditions can be made (adapted from AIHA 1998). The basic characterization is summarized in RPP-22491, [TFC-PLN-43](#), and the Tank Farm Documented Safety Analysis.

Biological monitoring. A technique to provide biological data (e.g., urine, hair, exhaled air, etc.) as an aid in indicating potential exposure to chemicals for which biological exposure indexes (BEIs) have been developed.

Breathing zone. A hemisphere forward of the shoulders with a radius of approximately 6 to 9 inches (i.e., an area as close as practicable to the nose and mouth of the employee being monitored for a chemical or biological hazard). Breathing zone samples provide the best representation of actual exposure. (DOE G 440.1-3)

Chemicals of potential concern. A list of chemicals identified in the tank farm headspaces, and classified according to their carcinogenicity, concentration compared to their OELs, prevalence in tanks and toxicity (adapted from RPP-22491). The list appears in RPP-22491.

Coefficient of variation. A measure of relative dispersion, also known as the relative standard deviation. The sample CV is calculated by dividing the standard deviation by the sample average.

Dermal exposure. Exposure which results from absorption of compounds through skin or eyes. Skin contact with substances exhibiting a relatively high degree of lipophilicity, high molecular weight and low volatility may constitute the principal route of exposure. Such substances are designated by various agencies with a "skin" notation qualifying its OEL.

Descriptive statistics. Parameters used to summarize data that should be calculated routinely for all monitoring data. Typically, statistics include calculations of central tendency (mean, median and geometric mean), spread (range, minimum and maximum, standard deviation, and geometric standard deviation). Other data manipulations, such as log transformation or determination of the percent over the OELs, are also possible. With a programmable calculator, computer spreadsheet, or the Tank Farms Industrial Hygiene Database, these data can be easily determined.

DRI action level. A calculated subset of an 8-hour time-weighted-average OEL for a specific chemical as read with a direct reading instrument. If a potential exceedance of DRI action level is indicated by stable (five-minute) direct reading instrumentation (DRI) measurements in the worker's breathing zone, controls will be immediately implemented to reduce potential exposures to less than the DRI action level. If DRI readings exceed STEL or Ceiling Limits even momentarily, controls will be immediately implemented to reduce potential exposures to less than the action level.

Exposure assessment. The systematic collection and analysis of potential exposures in the tank farm work place in view of all exposure determinants, e.g., task frequency, duration, variability, meteorology, etc. Exposure assessment outcomes include judgments about the acceptability of each exposure profile and the institution of appropriate controls, as well as linkages to occupational medicine and epidemiological information for the purposes of risk management and health surveillance (adapted from AIHA 1998 and DOE G 440.1-3).

Exposure monitoring. Personal or area monitoring in accordance with accepted, standardized methods, and the use of accredited labs for samples requiring analysis, to provide data for compliance purposes and exposure profiles.

Exposure rating. An estimate of the exposure level relative to an OEL, useful for beginning to characterize an exposure profile. Exposure rating often features assignment of factors, e.g., 1 to 5 or low to high, based on metrics such as toxicity of the chemical, vapor pressure, quantity of source chemical, percent OEL documented from historical data, modeling results, frequency and duration of exposure, number of persons potentially exposed, direct reading instrument data, etc. (adapted from AIHA 1998). Exposure ratings are found in the EJTA.

Exposure profile. A representation, commonly as a matrix or other means, of the most relevant exposure and hazard determinants of a SEG. This representation is an estimate of the exposure intensity and how it varies over time for an SEG. The exposure profile estimate may incorporate quantitative (monitoring data) or qualitative (relying on knowledge, experience and professional judgment) data. It is the vehicle for summarizing and judging exposures to environmental agents at the tank farms. Ideally, exposure profile evaluations should be conducted in collaboration with occupational medicine.

Further information gathering. Prioritized exposure monitoring or the collection of more information so that uncertain exposure judgments can be resolved with higher confidence.

Health effects rating. A relative measure of toxicity.

Health hazard control. Implementation of prioritized control strategies for unacceptable exposures. Prioritization criteria may include the highest exposure concentrations or toxicity, the degree of uncertainty associated with the judgment of unacceptable, large numbers of workers exposed, the most frequent exposures, etc. These controls should emphasize fundamental IH hierarchy, i.e., engineering controls, administrative controls, and personal protective equipment.

Marker substance. A selected chemical in a mixture assessed as an index to estimate exposure to other components in the mixture. Using a marker substance in this way constitutes surrogate data.

Occupational carcinogen. For purposes of the DOE G 440.1-3, a chemical substance utilized in the workplace that has been designated in the following sources as a carcinogen or potential carcinogen: (1) National Toxicology Program, Annual Report of Carcinogens (latest edition); (2) International Agency for Research on Cancer (IARC), Monographs (latest editions); (3) OSHA Standard 20 CFR 1910, Subpart Z, "Toxic and Hazardous Substances;" and (4) American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents. (DOE G 440.1-3)

Chemicals considered to be "known" or "probable" carcinogens by IARC or other regulatory/guidance agencies were included in the list of COPCs for prioritized exposure assessment by the ITP.

Occupational disease. A generally chronic and irreversible health effect associated with overexposure to chemical, physical or biological agents in the workplace. Examples include silicosis, bladder cancer, and berylliosis.

Occupational exposure limit. A generic term used to represent: (1) the concentration or intensity of an airborne agent that is allowable, (2) the time period over which workplace concentrations are averaged to compare with the allowable exposure, and (3) the allowable concentration of a biological exposure index (BEI) in a biological sample. Thus, each OEL consists of an exposure limit and an averaging time, which are set by the sponsor of the OEL and must be used together, as prescribed by DOE. Some substances have several OELs (e.g., 8-hours, 15-minute STEL and a not-to-exceed ceiling limit).

Within an EAS, an OEL is used to represent the limit selected for the purpose of judging exposure profiles as either acceptable or unacceptable. For the EAS and all work at the tank farms, the most protective conservative OELs have been selected for use from DOE regulated limits, e.g., OSHA permissible exposure limits (PELs), ACGIH Threshold Limit Values (TLVs). There are few exceptions to these sources for OELs. One is the DOE-set OEL for beryllium. Also, working OELs for the tank farm are set by toxicologists for those chemicals lacking a regulatory OEL.

Occupational illness. A generally transient and reversible health effect associated with overexposure to chemical, physical or biological agents in the workplace. Examples include metal fume fever, heat cramps, occupational asthma, and dermatitis.

OEL averaging time. The time duration over which an average airborne exposure is estimated. One or more of averaging times are set for the majority of OELs: 8 hours (full shift PEL), 15 minutes (STEL), and instantaneous (ceiling limit).

Personal monitoring. The process of measuring the concentration of a hazardous chemical in the breathing zone of an individual using a calibrated personal air pump to collect a sample on appropriate media or a direct reading, data logging monitor worn by the worker in the breathing zone. Larger direct reading instruments, held by others in the breathing zone, can be used to estimate personal exposure, but not for purposes of determining compliance with OELs.

Potential health effect(s). The capability or possibility of a chemical to cause adverse effects in sufficient concentration over a sufficient period of time as a function of its toxicity.

Predictive modeling. A technique, typically based on physical-chemical properties, used to estimate chemical exposure. Models range from simple and uncomplicated to sophisticated, but

to be an effective tool for evaluation of worker exposure, model inputs must be realistically conservative to overestimate exposure and risk. Models can also be used to estimate exposure ranges for new tasks or processes.

Professional judgment. The application and appropriate use of knowledge gained from formal education, experience, observation, experimentation, inference, peer review and analogy. It allows an experienced industrial hygienist with incomplete or a minimum amount of data to estimate worker exposure in nearly any scenario (adapted from DOE Guide and AIHA 1998).

Overexposure. An exposure exceeding the applicable OEL, when evaluated over the appropriate averaging time. Full-shift overexposure judgments made from partial shift samples are highly uncertain and must be made with great caution.

Qualitative assessment. The estimation of exposure determinants based on integration of available information and professional judgment (adapted from DOE Guide).

Quantitative assessment. The determination of exposure based on collection and quantitative analysis of data sufficient to adequately characterize exposures (adapted from DOE Guide).

Similar exposure group. Depending on the tank farm location and task variabilities, SEGs can be task-based, process-based, job description-based, craft-based, condition-based, etc. For example, a task-based SEG may include an unrelated group of workers who perform a similar defined task; a craft-based SEG may include a group of craft workers performing a variety of tasks throughout the work day or week; a job description-based SEG may include an unrelated group of workers whose job descriptions require them to perform similar tasks of similar frequency, using similar materials and processes throughout the work day and week; a condition-based SEG may include all workers performing work near an emission source. Individual workers or tasks may be members of more than one SEG.

Surrogate data. The use of quantitative data from assessment of similar chemicals or similar operations to estimate exposure. Using professional judgment, surrogate data must be adjusted for such criteria as relative quantities of the chemicals, controls in place, differences in work practices, frequency and duration of exposure, meteorological differences for outside work, etc.

Working OEL. An OEL established in the absence of a regulatory OEL, or when there is significant uncertainty about the adequacy of a regulatory OEL. A working OEL is based on existing toxicological and epidemiological data, structural activity relationships, and other data, etc. It includes appropriate safety (uncertainty) factors. Working OELs are derived to allow performance of quantitative exposure assessments, and are sometimes stated in ranges.

Unacceptable exposure. A condition in which a significant risk (occupational disease or illness) is associated with a SEG's exposure profile; the probability of adverse health effects is significant; or there is evidence of adverse health effects associated with exposure to an environmental agent.

Uncertain exposure. A condition in which acceptability of an exposure cannot be determined because of insufficient information regarding exposure, toxicity, field observations, supporting DRI data, etc.

Uncertainty. The individual or aggregate variability in any measurement, including analytical error, toxicological research, sampling error, interferences, meteorological impacts, unknowns, human error, etc.

6.0 SOURCES

6.1 Requirements

1. American Conference of Governmental Industrial Hygienists (ACGIH), "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices," (2005 or most recent, whichever is most restrictive)
2. 10 CFR 851, "Worker Safety and Health Program."
3. 10 CFR 851.23, "Safety and Health Standards"
4. 29 CFR 1910, "Occupational Safety and Health Standards." Excluding 29 CFR 1910.1096 "Ionizing Radiation."
5. 29 CFR 1910.94, "Ventilation"
6. 29 CFR 1926, "Safety and Health Regulations for Construction."
7. 29 CFR 1926.57, "Ventilation"
8. 29 CFR 1926.353, "Ventilation and Protection in Welding Cutting and Heating"
9. 29 CFR 1910.1000, "Air Contaminants."

6.2 References

1. AIHA 1998, "A Strategy for Occupational Exposure Assessment, American Industrial Hygiene Association," 1998.
2. ATS-310, Section 4.5, "222-S Laboratory Complex Chemical Hygiene Plan."
3. DOE G 440.1-3, "Implementation Guide for use with DOE O 440.1, "Occupational Exposure Assessment."
4. HNF-SD-TWR-RPT-001, "Tank Waste Remediation System Resolution of Potentially Hazardous Tank Vapor Issues."
5. Mackerer, C. R., C&C Consulting in Toxicology, "Preliminary Evaluation of Potential Inhalation Hazard From Exposure to Hydrocarbon Vapor Emitted by Underground Waste Storage Tanks at the Hanford Site," Letter Report dated February 8, 2005.
6. Occupational Exposure Sampling Strategy Manual, NIOSH Publication No. 77-173, Leidel, N.A., Busch, K.A., Lynch, J.R. 1977.
7. OSHA Technical Manual.

8. RPP-22491, "Industrial Hygiene Chemical Vapor Technical Basis."
9. [RPP-35562, "Postulated Waste Transfer Abnormal Events for Enhanced Industrial Hygiene Monitoring Consideration."](#)
10. TF-AOP-15, "Response to Reported Odors or Vapor Exposures."
11. TFC-ENG-DESIGN-C-01, "Development of System and Subsystem Specifications."
12. TFC-ESHQ-IH-STD-03, "Exposure Monitoring, Reporting, and Records Management."
13. TFC-ESHQ-IH-STD-06, "Hearing Conservation Program."
14. TFC-ESHQ-IH-STD-11, "Carcinogen Control."
15. TFC-ESHQ-IH-STD-12, "Industrial Hygiene Monitoring and Control Strategies During Tank Retrieval and Transfers."
16. TFC-ESHQ-Q_C-C-01, "Problem Evaluation Request."
17. TFC-ESHQ-S_CMLI-C-02, "Injury and Illness Events."
18. TFC-ESHQ-S_IH-C-17, "Occupational Medical Qualification and Monitoring."
19. [TFC-ESHQ-S_IH-C-46, "Industrial Hygiene Reporting and Records Management."](#)
20. TFC-ESHQ-S_IH-STD-03, "Ergonomics."
21. TFC-ESHQ-S_SAF-C-02, "Job Hazard Analysis."
22. TFC-ESHQ-S_SAF-C-07, "Subcontractor Oversight."
23. TFC-ESHQ-S-STD-24, "Bloodborne Pathogen Exposure Standard."
24. TFC-PLN-43, "Tank Farm Contractor Safety and Health Plan."

Table 1. Administrative Control Levels and Action Levels.

Quantified Exposure Level	Term	Action
Threshold Limit Value (TLV) or Permissible Exposure Limit (PEL) or other validated OEL	Occupational Exposure Level (OEL)	Demonstrate compliance with contractual requirements
10% of the OEL	Administrative Control Level (ACL)	If ACL is exceeded, focus exposure assessment; gather additional information; increase sampling to better understand range of exposures
>50% 8-hour OEL	Action Level (AL)	If AL is exceeded on personal exposure samples, implement controls consistent with IH hierarchy to maintain exposures to < action levels
See Section 3.10 of this document.	DRI Screening Action Level	If breathing zone concentrations exceed stable (five-minute) DRI ALs, ensure proper controls are in place

Table 2. Minimum Number of Samples for Statistical Analysis of Similarly Exposed Groups.

REQUIRED NUMBER OF SAMPLES ^a	
Size of similarly exposed group (N) ^b	Number of required samples (n) ^c
8	7
9	8
10	9
11-12	10
13-14	11
15-17	12
18-20	13
21-24	14
25-29	15
30-37	16
38-49	17
50	18

^aFrom Occupational Exposure Sampling Strategy Manual, NIOSH Publication No. 77-173, Page 35.

^b(N) is the population or number of employees in a SEG.

^c(n) is the number of required samples. If the number of employees (N) in a SEG is less than 8, then the number of required samples (n) is equal to (N) for that SEG.

NOTE: For statistical significance, collecting the required number of samples from this table ensures with 90% confidence that at least one employee sampled is in the highest 10% of all exposures for the SEG.

ATTACHMENT A – HISTORY OF TANK FARM INDUSTRIAL HYGIENE BASELINE HAZARD ASSESSMENTS

The initial industrial hygiene hazard assessment in 1993 was a comprehensive “wall-to-wall” evaluation, which has served as a baseline for subsequent evaluations. The scope of this baseline hazard assessment and update assessments include facilities and operations within the tank farm authorization basis. These hazard assessments have been conducted for the purposes of anticipating, identifying, evaluating, and controlling occupational health hazards. Periodic update assessments have been conducted based on risk and variability of the operations to ensure new or changing hazards are identified and controls are adequate. Some assessments have been focused to provide detailed analysis of potential exposures to specific agents. Baseline assessments have been conducted for new operations or facilities prior to operation. These assessments have been performed by worker protection professionals with the participation of affected employees and supervisors. Due to the nature of contract changes and scope changes at Hanford, the chronology and scope of the hazard assessments by facility is provided at the end of this section.

The documentation of these assessments is comprehensive and includes:

- Descriptions of the work or task performed
- Identification of the potentially exposed workers
- Identification and descriptions of potential sources of hazardous agents
- Evaluation of the controls used to prevent or minimize exposure
- Assessment of the level(s) of exposure
- Conclusions, with rationale, whether the identified agent(s), their use(s), and the potential exposures they cause pose a hazard to workers (i.e., generate a positive or negative exposure assessment)
- Recommendations of additional controls for hazardous agents where necessary
- Recommendations for the scope and frequency of further exposure monitoring, as appropriate.

Industrial hygiene assessments have typically utilized an integrated multi-disciplinary approach depending on the complexity of the workplace and operation. Other resources accessed include:

- Other worker protection staff (e.g., industrial safety professionals, health physicists)
- Occupation medical staff (including toxicologists)
- Environmental protection staff
- Line management
- Workers and worker representatives
- Existing chemical and hazard inventories
- Applicable written worker protection programs such as, respiratory, hazard communication, ergonomics, lead, beryllium, confined space, and hearing conservation
- Injury and illness logs/databases and trending tools like the Computerized Accident/Incident Reporting System (CAIRS) and Occurrence Reporting Binned Information Trending Tool (ORBITT)/ Occurrence Reporting and Processing System (ORPS).

**ATTACHMENT A - HISTORY OF TANK FARM INDUSTRIAL HYGIENE BASELINE
HAZARD ASSESSMENTS (cont.)**

Industrial Hygiene BHA Chronology:

Tank Farms General BHA, Updates and Procedures:

1992: The "Hanford Occupational Exposure Assessment Program" is implemented site-wide. The Program is based on "A Strategy for Occupational Exposure Assessment," 1991, American Industrial Hygiene Association, Akron, Ohio.

1993: The initial BHA covers the operations that were in the tank farm facilities at that time including the 242-A evaporator, all tank farms, maintenance shops, and administrative office buildings. The list of hazards included heat stress, chemicals, ergonomics, noise, biological, cold, walking/working surfaces, asbestos, mechanical/moving vehicles, equipment, electrical, confined space entries, and tank vapors. This became the basis for future revisions the "Tank Farm Health and Safety Plan" (HASP).

1993 - 2006: The HASP went through a major revision to incorporate the comprehensive BHA completed in 1993. The inventory of hazards and controls for tank farm operations were identified in the body of the HASP with an appendix for each tank farm facility listing specific hazards in that location. The HASP was updated periodically to incorporate new hazard and control information. In 2004, the HASP went through another major revision. The facility specific appendices were replaced with a reference to the new 2003 Tank Farm Documented Safety Analysis (DSA). The inventory of hazards is still maintained in the HASP and links to hazard specific procedures providing details on exposure controls were added.

1996: Over 350 personal samples were collected to assess exposures to tank vapors. The three volume data evaluation and white paper supported major revisions to tank vapor exposure controls. These revisions were incorporated in the HASP in 1997.

1997: A comprehensive BHA specific to the Characterization Project Operations (CPO) was performed to address the tasks performed by sampling crews.

1997: A comprehensive airborne chemical baseline hazard assessment was performed at 222-S Laboratory.

1998: The "Industrial Hygiene Monitoring Program Plan" (IHMPP) was implemented at tank farms. The Plan was written specific to tank industrial hygiene exposures and includes updated baseline exposure assessment information for sampling campaigns over the past several years. The Plan is based on "A Strategy for Occupational Exposure Assessment," 1991, American Industrial Hygiene Association, Akron, Ohio.

1998: A comprehensive baseline hazard assessment was performed at 222-S.

1999: The "Initial Beryllium Characterization Report" was released. It characterized all facilities with the potential for beryllium contamination across the Hanford site. The tank farm beryllium facility inventory is maintained by the Beryllium Program Coordinator and is available at www.hanford.gov/safety/beryllium/.

**ATTACHMENT A - HISTORY OF TANK FARM INDUSTRIAL HYGIENE BASELINE
HAZARD ASSESSMENTS (cont.)**

1998 - 1999: Tank vapor exposures were characterized during the waste retrieval sluicing operation at 241-C-106. Personal, area, and source samples were collected to identify specific agents that were released during the sluicing operation and to evaluate the effectiveness of exposure controls. As a result, more exposure sampling was performed during waste transfers and during the subsequent operations to remove the crust at 241-SY-101. The data for the subsequent sampling events can be found in the Tank Farm Industrial Hygiene Database.

2003 - 2006: The DSA, Chapter 2, "Facility Description," provides a detailed description of the facilities and operational processes performed by the Tank Farm Contractor. Chapter 8, "Hazardous Materials Protection," provides information on non-radiological hazards and was authored by the industrial hygiene program group in 2003. The DSA is periodically updated to include new operations or scope. For example, it now includes the 242-A evaporator and the 222-S analytical laboratory.

2004: The "Industrial Hygiene Exposure Assessment Strategy" is implemented. The Strategy replaced the 1998 IHMPP and is based on "A Strategy for Occupational Exposure Assessment," 1998, American Industrial Hygiene Association, Akron, Ohio.

2004: The "Industrial Hygiene Chemical Vapor Technical Basis" is developed to identify all that is known about the tank vapor exposure source. This recommends another comprehensive tank vapor exposure assessment.

2005 – 2006: A comprehensive tank vapor exposure assessment is launched. The first phase assesses tank vapor exposures during non-waste disturbing activities. The evaluation of A-prefix tank farms is completed in 2006 and results in major revisions to exposure controls. Evaluation of C-farm and S-complex is underway.

2005: An update to the 222-S baseline hazard assessment was performed (Draft).

2006: An update to the 222-S baseline hazard assessment was performed (Draft).

Tank Farms Specific Agent BHAs and Updates:

Industrial Hygiene Initial BHA Documents:

"Baseline Hazard Assessment, Hanford Tank Farms 200E/200W Areas," 1993, Don Quilici, Quilitek Services, Portland, Oregon.

"Comprehensive Baseline Hazard Assessment, Characterization Project Operations (CPO)," 1997, Robert Gilmore, Foster Wheeler Environmental Corporation, Richland, Washington.

"222-S Comprehensive Baseline Hazard Assessment," 1998, Dave Penfield, Waste Management Hanford, Richland, Washington.

"XX Cold Test Facility"

**ATTACHMENT A - HISTORY OF TANK FARM INDUSTRIAL HYGIENE BASELINE
HAZARD ASSESSMENTS (cont.)**

Updated Baseline Hazard Assessments:

DRAFT “222-S Comprehensive Baseline Hazard Assessment,” 2005, Ken Jaten, CH2M HILL Hanford, Richland, Washington.

DRAFT “222-S Comprehensive Baseline Hazard Assessment,” 2006, Robin Fogg, CH2M HILL Hanford, Richland, Washington.

“Tank Farm Health and Safety Plan,” 1993 and revisions through 1996, Westinghouse Hanford Corporation; 1997 and revisions through 2001, Lockheed Martin Hanford Corporation; 2002 and revisions through present, CH2M HILL Hanford, Richland, Washington.

“Tank Farm Contractor Documented Safety Analysis,” 2003 and revisions through present, CH2M HILL Hanford, Richland, Washington.

Specific Hazard Assessment Updates:

Tank Vapors:

“Final Report Exposure Monitoring Data Evaluation for the Hanford High Level Waste Tanks - Tank Farms B, T, and TY,” 1996a, Apex Environmental, Inc, Rockville, Maryland.

“Exposure Monitoring Data Evaluation for the Hanford High Level Waste Tanks Stage III: Tank Farms A, AX, BX, BY, C, S, TX, and U,” 1996b, Apex Environmental, Inc., Rockville, Maryland.

“Exposure Monitoring Data Evaluation for the Hanford High Level Waste Tanks Stage II: Tank Farms AN, AP, AW, AY, AZ, SX, and SY,” 1996c, Apex Environmental, Inc. Rockville, Maryland.

HNF-SD-TWR-RPT-001, “Tank Waste Remediation System Resolution of Potentially Hazardous Tank Vapor Issues,” 1996, Elton Hewitt, Westinghouse Hanford Corporation, Richland, Washington.

“C-106 Sluicing Hazard Characterization and Exposure Control Strategy,” 1999, Phil Bartley, Foster Wheeler Environmental Corporation, Richland, Washington.

“Industrial Hygiene Chemical Vapor Technical Basis,” 2004, Jim Honeyman, CH2M HILL Hanford, Richland, Washington.

“A-Prefix Tank Farm Vapor Hazard Characterization Report,” 2006, Tom Anderson, CH2M HILL Hanford, Richland, Washington.

TBD “C-Farm Tank Farm Vapor Hazard Characterization Report,” 2006, Markis Hughey, CH2M HILL Hanford, Richland, Washington.

TBD “S-Complex Tank Farm Vapor Hazard Characterization Report,” 2006, Markis Hughey, CH2M HILL Hanford, Richland, Washington.

**ATTACHMENT A - HISTORY OF TANK FARM INDUSTRIAL HYGIENE BASELINE
HAZARD ASSESSMENTS (cont.)**

Beryllium:

“Initial Beryllium Characterization Report,” 1999, Elton Hewitt, Westinghouse Hanford Corporation, Richland, Washington.

General Airborne Agents:

“Airborne Chemical Baseline Evaluation of the 222-S Laboratory Complex,” 1997, Phil Bartley, Foster Wheeler Environmental Corporation, Richland, Washington.

“Industrial Hygiene Monitoring Program Plan,” 1998, Nancy Butler, Lockheed Martin Hanford Corporation, Richland, Washington.

TBD “Compliance Determination of Exposure to Methylene Chloride; 1, 3-Butadiene; Chromium; Cadmium; Benzene; Formaldehyde; and Methylenedianiline” CH2M HILL Hanford, Richland, Washington.

Procedures for Industrial Hygiene Exposure Assessments to update BHAs:

“Hanford Occupational Exposure Assessment Program,” 1992, Westinghouse Hanford Corporation, Richland, Washington.

“Industrial Hygiene Monitoring Program Plan,” 1998, Lockheed Martin Hanford Corporation, Richland, Washington.

“Industrial Hygiene Exposure Assessment Strategy,” 2004 and subsequent revisions, CH2M HILL Hanford, Richland, Washington.

ATTACHMENT B – OELS AND AVERAGING TIMES

The Mixture Rule

This attachment is adapted from AIHA 1998 and Leidel 1977 and ACGIH.

Full Period (8-hour) OEL

For comparison to an 8-hour OEL, this means that 8 hours must be represented. Sampling pumps or instruments are shut off and covered during lunch. The measurement obtained is a full period consecutive sample measurement because it covers the entire time period appropriate to the OEL. Partial period (<8 hour) sample or consecutive samples would probably be best described as grab or short-term samples for purposes of analysis.

The full period consecutive sample measurement yields the narrowest confidence limits on the exposure estimate, i.e., there are small statistical benefits to be gained from larger sample sizes (e.g., eight, 1-hr samples versus 4-2 hour samples). However, that is seldom practical from cost-benefit and labor standpoints. One 8-hour sample is essentially as good, all factors considered.

Partial Period (<8 hours) samples

The major problem with this type of measurement is how to handle the unsampled portion of the period. Professional judgment may allow inferences to be made regarding potential exposure concentrations during the unsampled portion of the period. Reliable knowledge concerning the operation and activities of the worker is required, as well as a recognition of the increased uncertainty of the measurement. The sampled portion of the period should cover at least 70% to 80% of the full period. When the sampled portion is only a few hours, the results should be regarded as highly uncertain. Acceptability of judgment may still be possible if professional judgment and experience allows an estimate of the potential exposure during the unsampled period, and the balance of the information available to the IH supports a judgment.

If the potential exposure is not the same for the unsampled exposure period, the statistical decision tests used in the EAS are not fully valid. One can put confidence limits on a 6-hour exposure average, but it would not be proper to compare them with an 8-hour OEL, because the work practices must be identical during the sampled and unsampled portions of the work shift. This type of measurement should be avoided if possible.

If it is not possible to sample for at least 70% of the work shift with knowledge of work practices during the unsampled periods, it may be better to use grab samples. It should also be noted that analytical detection limits will increase with sample volumes that do not meet the method minimum.

Short Term Exposure Limits (STEL) or Ceiling OEL

Short-term and ceiling samples, usually, but not always, represent 15 minutes exposure duration. Such samples can be compared to STEL or ceiling OELs. For very large EASs, the appropriate exposure duration periods for determination of STEL or ceiling values are also selected randomly from the entire workday. However, for the objectives of the TF EAS, samples taken for comparison to STEL and ceiling standards are best taken in a non-random fashion. Rather, periods of maximum expected concentrations should be sampled.

ATTACHMENT B – OELS AND AVERAGING TIMES (cont.)

Ceiling limits are generally airborne concentrations which should never be exceeded. However, some chemicals have Ceiling limits that have averaging times, or cumulative (e.g., per day) criteria. For tank farm work, it is sound practice to insure controls are in place if Ceiling concentrations are approached on DRI.

Certain chemicals have STELs or ceiling limits that have unique sample duration periods. Averaging times for the TF COPCs are listed in Attachment B.

Grab Samples

In some cases it is impossible to collect a single sample or a series of consecutive samples whose total duration approximates the period for which the OEL is defined. While these samples may have other value, they are useful if they represent at least 15 minutes only for comparison to a STEL or ceiling limit.

Grab samples are the least desirable way of estimating 8-hour OEL potential exposures. This is because confidence limits on the exposure estimate are very wide. One must have a low potential exposure average to statistically compare to an 8-hour OEL, and a relatively constant potential exposure. Collecting 8-hour grab sample sets is also undesirable and infeasible from practical and cost perspectives.

The adequacy of analytical detection limits for grab samples should also be considered when planning a sampling strategy. Generally, such detection limits are too high to allow effective comparison to OELs at the tank farms.

Mixture Rule

When two or more hazardous substances which act upon the same organ system are present, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, the effects of different hazards should be considered as additive. That is, if the sum of:

$$C_1/T_1 + C_2/T_2 + \dots C_n/T_n$$

exceeds unity (one), then the OEL of the mixture should be considered as being exceeded. C_1 indicates the observed atmospheric concentration of a given chemical and T_1 indicates the corresponding OEL.

Exceptions to the above rule may be made when there is a good reason to believe that the chief effects of the different chemicals are not in fact, additive, but are independent as when purely local effects on different organs of the body are produced by the various components of the mixture. In such cases, the OEL ordinarily is exceeded only when at least one member of the series (C_1/T_1 or C_2/T_2) itself has a value exceeding unity.

When evaluating a task that has exposure potential to a number of chemicals, and it is only feasible to sample for a subset of these chemicals during any one sampling event, the OEL should be reduced by a suitable factor, the magnitude of which will depend on the number, toxicity, and relative concentration of the other chemicals which are ordinarily present.

ATTACHMENT C – UNCERTAINTY

Although uncertainty may only be apparent in terms of determinants typically measured, all assessment uncertainties contribute to the error bar around outcomes. In typical industrial hygiene exposure profiles, there are numerous sources of variability which contribute to uncertainty in the determinants, and hence, in the outcomes. The term “uncertainty” can also be considered “error” and includes both measurement variability and error due to lack of data. However, the term “error” can be confusing to lay persons. Therefore this EAS will use the commonly used term “uncertainty.”

Variability is the result of heterogeneity or actual difference of members of a population. It may be more accurately characterized, but not reduced, with additional data. Uncertainty arises from measurement limitations and may be related to study design, analytical techniques (called measurement error and typically provided with analytical methods), of application of data to non-sampled populations. Further measurements will ultimately reduce uncertainty in these cases.

Error can be reduced but not eliminated by systems intended to reduce it, e.g., calibration procedures, QA/QC programs, education of workers and samplers, etc. Sources of error may include, but are not limited to:

Sampling technique and media:

- Integrity of sampling train, including length and reactivity of tubing
- Fluctuations in pump flow rate over the sampling duration
- Accuracy of pump calibration
- Accuracy of sample duration determination
- Variability of filter pore size or tube media weight
- Sounding errors in sample volume determination
- Placement of sampling media in the “breathing zone” of the worker
- Collection efficiency of the analyte(s) on media
- Presence of positive or negative interferents
- Loss of analyte during handling or shipment of samples.

Analytical Method:

- Efficiency of extraction in the laboratory
- Accuracy of gravimetric determination
- Analytical error associated with instrumentation
- Analytical error associated with analytical methods
- Analytical error associated with human performance
- Error bar associated with direct reading instrumentation
- Statistics of surrogate recoveries
- Accuracy of calibrant gas concentration
- Non-source contribution of analyte.

ATTACHMENT C – UNCERTAINTY (cont.)

Worker and Workplace:

- The position/movement and techniques of each worker in a SEG relative to the source term
- Intraday variability of source term concentration
- Effectiveness of ventilation
- Length of breaks and activities during same
- Selection of “representative” or “most highly exposed” worker vs. random number.

Other:

- Extent of extrapolation of sample volume for comparison to OEL
- Error in interpretation of toxicological studies underlying OEL
- Effects of atmospheric and meteorological stability during the sampling period.

No physical quantity can be measured without error. The importance of understanding and communication of uncertainty is critical to the exposure assessment strategy. Communication of uncertainty and its sources convey the strengths and limitations of the data to management and to workers. Weighing these uncertainties, management can make more informed decisions about prioritization and utilization of resources. Workers can understand the error bar around exposure assessments and why conservative approaches are adopted.

Aggregating all data and understanding of sources and estimating the magnitude and direction of errors, uncertainty must be resolved using professional judgment. The larger sources of error can be reduced by collecting additional data to fill data gaps. (For example, collect personal IH samples on a larger number of workers in a SEG.) Two methods of uncertainty analysis for quantitative data are presented in AIHA 1998.

The first, and more traditional, is to look at predictions based on reasonable worst cases and the impact or sensitivity of the uncertainty for individual variables. “Reasonable” worst-case conditions are selected and plugged into simple models for industrial hygiene exposure estimates (usually air models for IH). When a single prediction for exposure potential is required, often only the worst-case estimate is reported and used. This single “worst-case” value represents the compounding of all the worst-case uncertainty in all of the predictors. When “average case” or best case” information is omitted, valuable information is essentially hidden because we have no knowledge of the error band around the prediction. However, a worst-case analysis can provide useful screening information.

The second method of uncertainty analysis uses computer simulation techniques and software, e.g., Crystal Ball™ and @Risk™, to estimate a range of outcomes and the sensitivity associated with each variable. Computer-aided stochastic (i.e., random, involving chance) probability analysis is typified by Monte Carlo techniques. This approach allows one to consider more information about exposure conditions and the associated uncertainty. Predictor variables are described as “distributions” rather than point estimates. This type of analysis is often used in risk assessments, as it avoids aggregating uncertainty as occurs in deterministic models.

ATTACHMENT C – UNCERTAINTY (cont.)

If a model can be validated, i.e., actual exposure data and the distribution of that data can be shown to fit within the predicted distributions, it provides a reality check on the assumptions used in the model.

TFC Exposure Assessment Strategy

In this exposure assessment strategy, the variability and uncertainty of all exposure determinants is recognized. Therefore, the TFC has selected an ACL at 10% of the OEL (out of the 10 to 25% range recommended by DOE), and an action level of 50% of the OEL as decision and control points, respectively, in the management of potential exposures.

In most cases, and in light of the ACL and action level, a qualitative uncertainty assessment of IH data will suffice. The IH lists the possible sources of uncertainty and variability and indicates the likely direction and magnitude of impact that each source will have to enable acceptability judgments to be made. Descriptive or inferential statistics will be calculated for all IH monitoring data to augment professional judgment in determining the acceptability of exposures.

ATTACHMENT D – STATISTICAL ANALYSIS

Information in this section is adapted from AIHA 1998, Leidel 1977, et al.

During qualitative assessments in the performance of the Tank Farm EAS, further information gathering will be necessary to make acceptability judgments regarding many exposures, i.e., quantitative assessments. Proper evaluation of randomly chosen employee exposures necessitates taking valid quantitative exposure measurements, documenting sources of uncertainty, reviewing field observations pertaining to the data collection, interpreting all information in the light of experience and exercising informed professional judgment.

An objective of the EAS program is to accurately assess worker's occupational exposures to airborne chemicals by exposure measurements following accepted methodologies. The use of statistics is necessary because all measurements of physical properties contain some unavoidable random measurement error. Any exposure average for an employee calculated from exposure measurements is only an estimate of the true exposure. Statistics deals with collecting, analyzing, and drawing conclusions from data.

A statistical population about which conclusions are to be drawn is all of the members of the SEG. The population is sampled by randomly selecting workers and generalizing conclusions about the whole population. In the comprehensive approach chosen for this EAS, as many workers as possible should be monitored over time. It is important to avoid monitoring the same individual repetitively, or choosing volunteers, or any other selection methods that might bias the exposure values. It is similarly important that monitoring dates be randomly designated with little or no regard for operating conditions and events that would directly bias the results.

Random sampling is necessary to help ensure an accurate estimate. All commonly used statistical tests assume random sampling. A practical way of defining random sampling is that any portion of the work force has the same chance of being sampled as any other, performing any part of the tasks that comprise the SEG, on any day that the tasks are being performed.

Sources of error (uncertainty) are discussed in [Attachment C](#). Some uncertainties are sometimes called statistical errors since they can be accounted for (but not prevented by) statistical analysis. Table 2 in the EAS gives the required sample size to ensure 90% confidence that at least one worker sampled will be in the highest 10% of all potential exposures for the SEG in a random sample drawn from a group of workers. However, if exposures are highly variable or results >>ACL, more measurements may be needed to adequately characterize the exposure of the SEG. Statistical sampling theory indicates that there is a point of diminishing returns in additional data to estimate exposure. Therefore, redesignation of the SEG may be indicated to estimate exposures with acceptably small uncertainty.

Only breathing zone samples are valid for measuring potential exposures (see Definitions, Section 5.0). All designated OELs (8 hour, STEL and Ceiling [C] values, as appropriate) should be quantitatively tested (see [Attachment E](#)). Working OELs are being developed for some priority tank chemicals. However, data from direct reading instrumentation can and should be used to estimate uncertainty around given measurements. In addition, DRI data are acceptable for STEL and C determinations, inasmuch as detection limits for many COPCs may be unacceptably high for very short term sampling in NIOSH, OSHA and other acceptable methods.

ATTACHMENT D – STATISTICAL ANALYSIS (cont.)

Results that are “less than” Detection Limits

Many data sets collected by Tank Farm IH contain concentration measurements reported as <detection limit, sometimes known as “below detection limits” (BDL). A simple definition of a detection limit is the concentration of an analyte below which an analytical method cannot detect that a result is different from zero. We do not know the true result because it is beyond the capability of the method (including technique) and/or the instrument to distinguish the true value from zero. Such values cannot be entered into the software used to determine descriptive statistics, although the shape of the distribution curve can be verified with such values.

Statistical methods for calculating detection limits involve determining the confidence intervals of datasets produced during the analysis of materials of known concentration (standards) with concentrations at or near that detection limit. The USEPA has published protocols for establishing detection limits for analytical methods and instruments. A discussion of the theory can be found in many college analytical chemistry textbooks, e.g., Analytical Chemistry, 4th ed. or later, Skoog & West.

A population of <DL sample results is actually a distribution of concentrations between the DL and zero. The mean concentration of such a population will be lower than the DL. This is true regardless of the shape of the curve of the dataset distribution. If the population has a normal distribution, the mean is an arithmetic mean and is 0.5 x DL. If the population has a lognormal distribution, the mean is a geometric mean and is 20.5 x DL (square root of 2 x DL).

If more than 50% of the samples in a data set are <DL, or the data set is small, it may not be possible to statistically determine the shape of the curve of the dataset distribution. According to AIHA 1998, “it is reasonable to presume that the underlying distribution for workplace exposure data is the lognormal distribution unless there is a compelling reason to believe otherwise; however the assumption of lognormality should be checked.” Uncertainty in the statistical analysis of a data set increases with the percentage of sample concentrations that are <DL. It is impossible to determine the nature of the distribution of a dataset where all concentrations reported are <DL.

Substitution of the detection limit as a concentration for sample results that are <DL in the calculation of an OEL is not acceptable as it introduces a positive bias in that calculation, because the mean concentration for those samples is <DL. However, it is conservative to assume that at some concentration may be present, even though it is not detectable. Therefore, the following strategies for statistically evaluating concentration values that are <DL should be adopted:

For data sets where the distribution of concentrations quantified are well below the OEL, and the DL is significantly less than the OEL or the action limit, it will be assumed that the distribution is lognormal, and the <DL data points will be divided by the square root of two prior to use in calculations. In such a situation, the risk of overexposure to an individual worker is remote, regardless of assumptions.

For data sets where the distribution of concentrations found are both above and below the OEL, assumptions on the shape of the distribution curve should be tested. Then the calculation on the <DL data should be performed as previously described. It is critical to document the rationale for the statistical analysis of the data, especially <DL data calculations.

ATTACHMENT D – STATISTICAL ANALYSIS (cont.)

If the DL is close to the OEL/action limit, the dataset may not be very meaningful, and further information gathering must occur. It may be necessary to redesignate the SEG and/or conduct sampling with a more sensitive method. Such a dataset might exaggerate potential overexposure if <DL data is handled incorrectly.

Confidence Interval Limits

The judgment of exposure acceptability is linked to the concept of confidence interval limits, i.e., to the calculation of the confidence interval expected to contain the true average exposure. When an employee is sampled and an average potential exposure calculated, the measured exposure average will rarely be exactly the same as the true average potential exposure. The term “accuracy” refers to the difference between a measured concentration and the true concentration of the sample. The discrepancy between the measured and true exposure averages results from random sampling errors and random source fluctuations during a work shift, some sources of which are discussed in [Attachment C](#). Thus, the sampling result is an “average potential exposure estimate” or “estimate of the true potential exposure.”

Statistical methods allow us to calculate interval limits for each side of the average exposure estimate that will contain the true potential exposure average at a selected confidence level (e.g., 95%). It is known that nineteen of twenty 95% confidence intervals would include the true average potential exposure between the lower confidence limit (LCL) and the upper confidence limit (UCL). The TFC is primarily interested in the UCL to ensure that safe exposure levels exist and will largely disregard the LCL. Examining the UCL (“upper tail”) is discussed below.

Descriptive Statistics

Descriptive statistics are used to summarize or “describe” data – typically their central tendency (mean, median, and geometric mean), and their spread (range, minimum and maximum, standard deviation, and geometric standard deviation). Calculating these summary statistics helps us to understand the exposures they represent. Many IH data sets can be interpreted simply by comparing the OEL with descriptive statistics. When most of the data are clustered well above or well below the OEL, the IH can generally make a decision on workplace acceptability by using descriptive statistics and professional judgment, after considering whether field observations and uncertainty sources support or do not refute that judgment. When the range of data approaches or includes the OEL, inferential statistics can be useful in decision making.

ATTACHMENT D – STATISTICAL ANALYSIS (cont.)

The software included AIHA 1998 or a programmable calculator can be used to generate descriptive statistics. The following descriptive statistics should be calculated routinely for all SEG personal monitoring data:

- Number of samples
- Maximum value
- Minimum value
- Range
- Percent above OEL
- Mean
- Median
- Standard deviation
- Mean of log-transformed data
- Standard deviation of log-transformed data
- Geometric mean
- Geometric standard deviation.

Understanding the mean in the SEG exposure profile is an important factor in judging acceptability of exposures. For example, if several full shift measurements are being used to estimate long term averages for a chemical with chronic toxicity, or data provided to epidemiologists for estimates of long-term dose, rely on the lognormal distributions' geometric means. In lognormally distributed data, the geometric mean is equal to the distribution median. Because the geometric mean is lower than the arithmetic mean in a lognormal distribution, using the geometric mean will underestimate the average exposure. The differences between the two grows as variance in the distribution increases. Thus, as the GSD gets larger, the geometric mean further underestimates the average exposure. Therefore, the best predictor of dose is the exposure distribution's arithmetic mean, not the geometric mean. Methods of estimating the arithmetic mean of a lognormal distribution are found in Appendix VI of AIHA 1998.

Probability Plotting and Measures of Goodness of Fit

The industrial hygienist must know the shape of the exposure distribution, whether normal or lognormal. The shape of the exposure distribution can be verified using probability plotting. If the data form an approximately straight line when plotted on lognormal or normal probability paper, they probably come from a normally or lognormally distributed population. If the data do not form an approximately straight line when plotted on probability paper, that indicates the data might not reflect with a normal or lognormal distribution. Then, the use of nonparametric statistics is indicated. However, it may well reflect that the SEG has not been well defined and needs to be redesignated.

Probability plotting will provide direct estimates of the distribution geometric mean (GM), geometric standard deviation (GSD) and various percentiles. It can handle below detection limit (BDL) data, although such values are excluded when determining the best-fit line. The Shapiro and Wilk Test ("the W-test") is one of the most powerful tests for determining goodness of fit for normal and lognormal data when the sample size (n) is <50. The W-test will verify whether sample data have been drawn from a normal distribution, or (if applied to log-transformed sample data) a lognormal distribution.

ATTACHMENT D – STATISTICAL ANALYSIS (cont.)

Whether plotting is done by hand or with software, the presence of outliers or double peaks should alert the industrial hygienist that the SEG may not be well defined. Review of field observations, uncertainty assessments, and DRI readings may also be indicated for insight into the shape of the distribution.

Examining the UCL – Tolerance Limits and Exceedance Tests

It is important to understand the “upper tail” of an exposure distribution, especially if the health risk is acute or if the analytical results are near the OEL. Parametric tools are included in the AIHA 1998 software to assist in this analysis, but it is important to understand what the software is doing and why. This understanding will aid in the acceptability judgment process. Only a summary is presented in this attachment - the reader is referred to AIHA 1998 and Leidel 1977.

There are two approaches – parametric tools for examining data that fit a distribution, and nonparametric tools for examining data that do not fit a distribution. Parametric tools require the industrial hygienist to know the shape of the exposure distribution, whether normal or lognormal. If the shape of the distribution has been verified by probability plotting and goodness-of-fit testing, the upper tail can be initially characterized by eyeballing the best-fit line through the plotted data.

The use of certain tools is more difficult with smaller sample sizes. For example, one tool is the point estimate of an upper percentile in the exposure distribution and its upper confidence limit - the distribution’s upper tolerance limit (UTL). UTLs have very low power with small sample sizes. With sufficient sample size; however, the UTL technique allows the industrial hygienist to state with known confidence that the UTL is greater than a known proportion of the distribution, e.g., it is 95% certain the 95% of the exposures are less than concentration x.”

The exceedance fraction is a tool that determines the proportion of the aggregate SEG exposure data that exceeds a given value, such as an OEL. For example, the industrial hygienist is able to determine, with known confidence, the percentage of exposures in the profile that exceeds that OEL.

For exposure distribution shapes that cannot be verified as normal or lognormal, the industrial hygienist should first review field observations, uncertainty assessments, and DRI readings that pertain to the assessment for insight into the shape of the distribution. The designation of the SEG should be verified, i.e., that all members of the SEG are performing similar tasks in similar ways under similar conditions. If both the data and the SEG definitions are valid, nonparametric tools beyond the scope of this summary attachment must be used to examine the data. The reader is referred to AIHA 1998.

**ATTACHMENT E – ESTABLISHING OCCUPATIONAL EXPOSURE LIMITS AND DRI
SCREENING ACTION LEVELS AT TANK FARMS**

The process to establish a TFC OEL starts with a review of the PEL and TLV for a COPC. If the more conservative of the existing PEL or TLV is deemed appropriately conservative, then the limit is adopted as a TFC OEL and placed in the EAS. If no TLV or PEL exists, or if the TLV or PEL is deemed not appropriately conservative for TFC applications, then the Safety and Health director convenes an OEL panel. The OEL panel will be chaired by the EH director and members will include a HAMTC safety representative, a senior industrial hygienist, an occupational medicine provider representative, a senior toxicologist, an analytical laboratory representative and a process engineering representative. The panel will operate under a specific charter. The panel will review other available limits (e.g., AIHA WEELs, NIOSH RELs, etc.) to determine whether one would be suitable as a TFC OEL. The panel may also utilize the services of toxicologists experienced in developing working OELs. The panel may utilize independent toxicologists (e.g., the independent toxicology panel (ITP)) to review any limits under consideration by the panel prior to establishment as a TFC OEL. This type of independent review is required for working OELs. Once the panel is satisfied that a limit is appropriate for TFC applications, the Safety and Health director will issue a white paper in accordance with TFC-BSM-AD-STD-02, on the decision making process establishing the new TFC OEL. Implementation of the new TFC OEL is effective upon revision to the EAS.

The process for establishing DRI screening action limits is similar to that of establishing OELs. To establish DRI action limits several factors must be considered. At a minimum, the COPC or mixture of interest, DRI to be used, the precision and accuracy associated with the DRI at the concentration of interest, the concentration deemed important for control considerations, and the actions to be taken are all factors for consideration. The Safety and Health director will review current screening action levels for appropriate conservatism. Recent work supporting the evaluation of DRI action levels includes PNNL-14967, "Performance Evaluation of Industrial Hygiene Air Monitoring Sensors." Work in progress includes a PNNL evaluation of photionization detector correction factors for the COPCs.

**ATTACHMENT E – ESTABLISHING OCCUPATIONAL EXPOSURE LIMITS AND DRI
SCREENING ACTION LEVELS AT TANK FARMS (cont.)**

The following are examples of work in progress for developing working OELs for tank farm applications where a TLV or PEL does not exist

DEVELOPING WORKING OELs FOR THE ~1400 CHEMICALS

There are two sets of compounds that comprise the ~1400 chemicals: Hydrocarbon fuel streams consisting of only carbon and hydrogen (no oxygen or nitrogen or other elements) and all the other organic compounds that do contain oxygen or nitrogen, or other elements along with carbon and hydrogen atoms. These are addressed separately below:

1. Working OELs Assigned by PNNL toxicologists

PNNL toxicologists have assigned working OELs to 669 of the ~1,400 chemicals without established OELs. The approach and all assigned values will be documented in a draft report for internal review and for distribution to the ITP for an independent review.

The PNNL effort involved assigning working OELs for screening purposes only. Specifically, the highest reported headspace concentration would be compared to the working OEL for each chemical to identify which ones warranted further attention. The assigned working OEL values may eventually be adopted for use as worker protection guidelines through the OEL panel process described earlier in this appendix. The priority for the PNNL effort is to review assigned working OELs and to give particular attention to those for which the maximum headspace concentration is at least 1% of the working OEL. Developing working OELs is an ongoing process that is related to ongoing headspace sampling.

**ATTACHMENT E – ESTABLISHING OCCUPATIONAL EXPOSURE LIMITS AND DRI
SCREENING ACTION LEVELS AT TANK FARMS (cont.)**

2. Hydrocarbon Fuel Stream OELs

The Independent Toxicology Panel recommended grouping the hydrocarbons into fuel streams so they could be treated as mixtures and addressed by established petroleum industry OELs. An expert on petroleum-related toxicology has written a report giving the bases of the approach, and has assigned 746 hydrocarbons to one of 6 fuel streams. The assignment to fuel streams was based solely on boiling points, so as new hydrocarbons are reported they are relatively easy to add to one of the fuel streams.

A compound may be addressed by a fuel stream mixture OEL (as a constituent of a fuel stream); however, if it has an established OEL of its own we are required to ensure that its OEL is met. For example, benzene is a constituent of the gasoline fuel stream, which has a mixture OEL of 1,127 mg/m³, it has its own ACGIH TWA TLV of 0.5 ppmv. Approximately 24 of hydrocarbons of interest in the tank headspace have an established OEL.

A second point in the use and application of fuel stream OELs is that it is based on there being a reasonably large number of constituents in each stream present. For example, if the only gasoline constituent in the worker's breathing zone was 2 methylheptane (which does not have an established OEL of its own), it is not justifiable that the mixture OEL for gasoline would apply. Only when there is a relatively large number of gasoline constituents is that OEL valid. The highest and second highest boiling fuel stream OELs that were assigned have only 4 and 25 constituents, respectively, identified in the headspaces. No tank has more than a small number of either. It appears that there are not enough of the high-boiling compounds to justify applying the assigned fuel stream OELs.

Given that conclusion, the PNNL toxicologists have assigned individual working OELs to each of the 29 chemicals in these two fuel streams. It appears these chemicals are not very toxic from the assignment of working OELs and concentrations are well below these working OELs in the headspaces.

**ATTACHMENT E – ESTABLISHING OCCUPATIONAL EXPOSURE LIMITS AND DRI
SCREENING ACTION LEVELS AT TANK FARMS (cont.)**

For those tank headspaces in which only a few of our common hydrocarbons are found at low concentrations, we intend to argue that there are almost certainly many of the others at levels below our detection limits. For example, although only a dozen or so gasoline constituents have been reported in the headspace of a tank, our understanding of waste chemistry and the origin of these gasoline constituents tells us that there are surely hundreds of other gasoline constituents present below our detection limits. On these grounds it will be argued that the gasoline OEL can be applied to the sum of these gasoline components. The validity of this approach has NOT been rigorously tested against actual data or undergone scrutiny by the ITP.

DEVELOPING OELS FOR OTHER COMPOUNDS (e.g., CARCINOGENS)

Intertox has been contracted to develop OELs for other compounds. The following is excerpted from a draft memo dated March 8, 2005. This text is provided in the EAS for information only and will be updated as necessary. The following outlines the process Intertox will use to develop OELs to support the Human Health Risk Assessment (HHRA) for the Vapor Solutions Project conducted for the CH2M HILL Hanford Group. As applied to this project, OELs are chemical concentrations in air that, using the best information and standardized practice available at the time of this writing, would not be expected to cause adverse health effects in workers following long-term (chronic) exposures. The following are the proposed steps Intertox will follow to identify or develop OELs for the chemicals of potential concern (COPCs) at the Hanford Tank Farms (in units of $\mu\text{g}/\text{m}^3$).

- Step 1: **Identify Existing OELs.** Search online databases to determine the existence of OELs set by U.S. federal, state, industry, agency, or non-U.S. entities. Types of existing OELs that will be identified if available include ACGIH TLVs, OSHA PELs, and NIOSH RELs, as well as values from other entities. Sources of information other than ACGIH, OSHA, and NIOSH websites and publications may include the Hazardous Substances Data Base (HSDB), Sax's Dangerous Properties of Industrial Materials), state regulatory agency websites (e.g., California), and foreign regulatory agency websites (e.g., European Union, Germany, Netherlands, Japan).
- Step 2: **Identify Existing Toxicity Criteria:** When existing OELs are not available, or OELs do not adequately consider evidence of carcinogenicity or effects of chronic exposure (based on review of the bases for these values and professional judgment), assess the availability of existing toxicity criteria that take into account carcinogenicity or other effects of chronic exposure. If criteria are available, use the criteria to develop an OEL using the identified acceptable lifetime excess cancer risk level and the default worker exposure parameters given in Table 1.
- Step 3: **Conduct a Search of the Toxicological Literature:** In the absence of existing OELs or toxicity criteria, search online databases and search engines (e.g., the National Library of Medicine's PubMed or the Dialog family of databases) to identify studies that examine the carcinogenic potential of the COPC, or other effects of chronic exposure. If appropriate and sufficient data are available, based on professional judgment, use the data to develop an OEL using the acceptable lifetime excess cancer risk level identified as appropriate by CH2MHILL and the default worker exposure parameters given in Table 1.

**ATTACHMENT E – ESTABLISHING OCCUPATIONAL EXPOSURE LIMITS AND DRI
SCREENING ACTION LEVELS AT TANK FARMS (cont.)**

Step 4: **Conduct Structure Activity Relationship (SAR) Analysis:** In the absence of data that examine the toxicity of the specific COPC, search online databases (e.g., the National Library of Medicine's PubMed or the Dialog family of databases) and/or use other search engines to identify the availability of toxicity criteria and data for structurally similar compounds that are likely to have similar toxicological characteristics (based on the professional judgment and knowledge of the effect of specific chemical moieties on chemical toxicity), and extrapolate these data to the COPC, as appropriate.

If appropriate and sufficient data are available on structurally similar compounds, use the data to develop an OEL using the acceptable lifetime excess cancer risk level identified as appropriate by CH2MHILL and the default worker exposure parameters given in Table E1. Where uncertainty exists about the toxicity of the COPC relative to the structurally similar compound, err on the side of conservatism based on professional judgment.

Table E1. Default Worker Exposure Parameters.

Exposure Factors	Value	Units	Source
Length of Employment	40	years	OSHA default (OSHA, 1989; 1997)
Inhalation Rate	10	m ³ /day	OSHA default (OSHA, 1989; 1997)
Exposure Frequency	250	days/year	Assumes exposure for five days per week for 50 weeks per year.
Weight	70	kilograms	U.S. EPA default for an adult male (U.S. EPA, 1989)

ATTACHMENT F – CHEMICAL EXPOSURE HAZARD ANALYSIS TEMPLATE

[This template has been developed to provide a consistent format for conducting tank farm chemical exposure hazard analysis. The description of the information to be provided in each section is the information at a minimum that should be included in the analysis. The level of detail included in each section is left to the discretion of the cognizant industrial hygienist and his/her manager.]

I. Work Activity/Task (Include Work Package/Procedure Title and Number if applicable)

[This section should include a detailed description of the task to be performed and the potential exposure points in the process. This should include at a minimum: 1) description of the work area, 2) tank waste/vapor sources that have the potential to contribute to worker exposures, 3) adjacent activities that may contribute to contamination/vapors in the work area, and 4) detailed description of work to be performed (waste transfer, chemical additions to tanks, analytical or sampling activities, installation of equipment, etc.)

The work activity detail should be in sufficient detail that an individual with basic tank farm knowledge would understand the exposure risks associated with the work activity.]

II. Comparable Activities

[A review of past activities/tasks similar to the task being evaluated should be presented. Included in this section should be a brief description of the similar activity, a list of any reference documents used for this evaluation (reports, plans), list of controls used and effectiveness of those controls, and any lessons learned from the historical activities.

This section should also include a justification as to why these activities are expected to produce a similar exposure potential to the task being evaluated. The processes being compared should be looked at in depth, taking into account such things as: 1) waste flow and volumes, 2) work process, 2) type and state (solid, liquid, gas/vapor) of material involved, 3) single shell tank vs. double shelled tank, and 4) other factors like sluicing, lancing, using air lift circulators, ventilated hoods, hot cells, etc. Every attempt should be made to use data from activities that took place in the 12 month period prior to the assessment.]

III. Hazard Identification

[A brief description of the tanks, containers, or other sources that may contribute tank waste/vapors to the work area should be included in this section. If chemical contaminants from other than tank waste are potentially present, a detailed description of the contaminant, its source, and the exposure potential must be included in this section.]

ATTACHMENT F – CHEMICAL EXPOSURE HAZARD ANALYSIS TEMPLATE (cont.)**IV. Data Review**

[The industrial hygienist conducting this evaluation should include all relevant data for the impacting tanks/sources in this section of the evaluation. This data should include, but is not limited to: 1) TWINS headspace vapor or tank waste concentrations for the effected tanks, 2) any sampling data pertinent to this evaluation, and 3) any personal sampling or monitoring associated with comparable activities.

As part of the evaluation process, compare TWINS headspace or tank waste data for the impacting tanks with the TWINS data for tanks that have been characterized. Only tanks with headspace/tank waste concentrations within four (4) times the impacting tank(s) can be used for the hazard analysis; if there are none, additional characterization is needed.

If there is no TWINS headspace/tank waste data available for the impacting vapor sources, a sampling plan for the impacting vapor sources must be developed.]

V. Controls

[In this section of the evaluation, the industrial hygienist conducting the evaluation should establish the minimum controls/monitoring/sampling required for the task being assessed. The industrial hygienist shall include in this section a detailed justification of the minimum controls/monitoring/sampling required for the task being evaluated. This justification should include a summary of any data used in the decision making process, comparison of tank headspace data for the effected tanks and characterized tanks, and the reason the activities in Section III are considered similar to the task being evaluated.]

For questions concerning this evaluation contact the industrial hygienist who developed this evaluation.

Industrial Hygienist _____ Date _____ Phone _____

IH Peer Review _____ Date _____

Responsible IH Manager _____ Date _____

Operations Manager _____ Date _____

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ATTACHMENT G — TANK FARM ILLUMINATION REQUIREMENTS

From ~~29 CFR 1910.120(m)~~:

Areas accessible to employees shall be lighted to not less than the minimum illumination intensities listed in the following Table H 120.1 while any work is in progress:

~~Table H 120.1. Minimum Illumination Intensities in Foot Candles.~~

Foot-candles	Area or operations
5	General site areas.
3	Excavation and waste areas, accessways, active storage areas, loading platforms, refueling, and field maintenance areas.
5	Indoors: Warehouses, corridors, hallways, and exitways.
5	Tunnels, shafts, and general underground work areas. (Exception: Minimum of 10 foot-candles is required at tunnel and shaft heading during drilling mucking, and sealing. Mine Safety and Health Administration approved cap lights shall be acceptable for use in the tunnel heading).
10	General shops (e.g., mechanical and electrical equipment rooms, active storerooms, barracks or living quarters, locker or dressing rooms, dining areas, and indoor toilets and workrooms).
30	First aid stations, infirmaries, and offices.