

Review of Hanford Tank Farm Worker Safety and Health Programs

**National Institute for Occupational Safety and Health
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Review of Hanford Tank Farm Worker Safety and Health Programs

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Executive Summary

In response to a June 20, 2016 request from the United States Department of Energy's (DOE) Office of River Protection (ORP) and Richland Operations (RO) regarding worker health issues associated with underground storage tanks on the Hanford site in southeast Washington State, the National Institute for Occupational Safety and Health (NIOSH) conducted a short-term, focused, programmatic review in four areas: Exposure Assessment; Exposure Control; Safety and Health Program Management; and Medical.

The program review included all workers and organizations that work within or in the proximity of the Hanford tank farms. All activities and communication (except for confidential interviews) included labor and management representation to ensure transparency in conformance with the NIOSH mission and relevant policies.

NIOSH reviewed documentation and reports from previous evaluations of worker health and safety at the tank farms and obtained information regarding the health and safety programs of DOE and Washington River Protection Solutions, LLC (WRPS), the contractor responsible for managing tank farm operations. NIOSH conducted an initial site visit on July 6–7, 2016, to meet with union, DOE, and WRPS representatives, obtain background information, and finalize the agenda for the program review. On July 25–28, 2016, the NIOSH review team conducted the program review site visit at the Hanford operations. During the site visit, NIOSH met with management and technical representatives from DOE ORP and RO, representatives from WRPS, and representatives from HPM Corporation Occupational Medicine Services (HPMC OMS), the contractor providing medical support to the DOE Hanford site. Discussions focused on programs and plans to address worker safety and health issues in and around the tank farms. The NIOSH review team also met with union leadership and held confidential interviews with workers, conducted a site inspection of the tank farms and perimeter areas, and collected and reviewed additional documentation and reports. Appendix A shows the NIOSH site visit agenda.

Key findings:

- DOE and WRPS have made significant investments in monitoring technology, hiring of industrial hygiene technicians (IHTs) and occupational safety and health (OSH) staff, forming technical worker-management groups, and establishing programs and procedures to address worker health and safety issues associated with the tank farms.
- DOE and WRPS efforts have been primarily focused on determining whether a health hazard can be confirmed via exposure monitoring or an epidemiological study.
- Thousands of area and personal breathing zone air samples have been, and continue to be, collected, but few, if any, exposures exceeding applicable occupational exposure limits (OELs) have been identified.
- Perceived unfairness of the workers' compensation system has long been and continues to be a contentious issue between tank farm workers and DOE/WRPS representatives assigned to address workers' compensation questions and issues.
- Considerable distrust among many workers and union leadership continues to exist with respect to DOE and WRPS management of tank farm vapor issues. Distrust is related to

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worker perceptions regarding lack of transparency, miscommunication between labor and management, and management skepticism that workers are being sickened from vapor exposures. High profile attention from the WA State Attorney General, Congressional representatives, the media, advocacy groups, and DOE Inspector General have intensified worker distrust and contributed to an adversarial and contentious relationship.

Overarching recommendations:

1. **Exposure Assessment:** Improve the management of the industrial hygiene (IH) program through a centralized manual or website that pulls together the disparate IH procedures and documents into a structure that management, IH staff, and workers can easily access and understand, and better explains what, how, and why specific IH activities and procedures occur.

The importance of initial and recurring training for IHTs should be emphasized to ensure familiarity with current technology, procedures, and how data are interpreted and explained to workers. A detailed policy document that delineates specific IHT training requirements, qualifications, and requalification should be developed and implemented.

2. **Exposure Controls:** Develop and implement engineering and administrative controls as a prudent precautionary approach for circumstances such as those found at the Hanford tank farms, where scientific uncertainty about the potential for complex and changing exposures and associated health effects may exist. Phase 1 of the WRPS Implementation Plan (IP) should be modified to emphasize engineering controls (e.g., emissions treatment, ventilation, automation) as a first priority.

Administrative controls can include minimizing the number of workers who enter the tank farms and relocating ancillary personnel and offices away from the tank farms whose immediate presence at these locations is unnecessary.

Use a precautionary and conservative approach to establish, as much as possible, an evidence-based rationale for the tank farm perimeter and adjust accordingly.

The use of respiratory protection for routine work should be considered a temporary control only and not an acceptable permanent solution. Where supplied air is determined to be necessary, utilize airline systems where possible. The need for respiratory protection should be determined by a qualified IH professional and based on objective data where possible. If exposures are known to be above applicable OELs or when performing specific job activities where there is the potential for a hazardous exposure to occur, respiratory protection may be appropriate as an interim control.

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- 3. Safety and Health Program Management:** Continue to focus on improving labor-management interaction, communication, transparency, worker inclusion in safety and health decisions, and implementation of recommendations from previous reports, such as the 2014 Hanford Tank Vapor Assessment Report and other reports provided to the NIOSH team with similar recommendations.

DOE and WRPS leadership and staff should acknowledge health and exposure concerns as legitimate and have a frequent presence in the field, particularly by management and supervisory IH staff, to ensure availability, provide leadership to IH technical staff, address worker questions, and demonstrate commitment to worker safety and health.

Utilize third party professional mediation/arbitration to resolve areas of conflict, find points of agreement, determine mechanisms for resolving issues, and establish a path forward on tank farm worker safety and health issues that is acceptable to all.

- 4. Medical:** To help address ongoing worker concerns with the workers' compensation program, organize meetings with tank farm workers and the Washington State Department of Labor and Industries' workers' compensation ombudsman in a forum where workers can ask questions and discuss their concerns.

Provide a thorough explanation of the return-to-work policy to all workers. This explanation should include addressing confusion about the return-to-work policy after reporting an exposure but before receiving results of medical tests.

Conduct a focused review of tank farm worker medical surveillance data to maximize the usefulness of current medical surveillance and screening activities and to help establish the most appropriate occupational medical care for tank farm workers.

Background

The 586-square-mile Hanford Site is located in southeastern Washington State. The site was used to produce plutonium for nuclear weapons from 1943 to 1987 and solid and liquid wastes remain. In 1989, the DOE, U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology entered into a Tri-Party Agreement (TPA) to clean up the Hanford Site.

The current contractor, Washington River Protection Solutions, LLC (WRPS), is responsible for retrieving, treating, storing, and ultimately disposing of the approximately 53 million gallons of waste stored in 177 underground waste tanks, some of which are leaking. These tanks, located in 18 different tank farms, contain a complex mixture of radioactive materials and hazardous chemicals. Over 1,800 chemicals have been identified in the tank waste, including about 1,500 chemicals in the headspace of the tanks. The tanks are vented to the atmosphere to prevent potentially flammable concentrations of gases from accumulating in the headspace. The vented vapors are filtered using high-efficiency particulate air (HEPA) filters to remove radioactive contaminants, but chemical gases and vapors are not removed by these filters.

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Concerns about chemical vapor exposure at the Hanford tank farms have been an ongoing issue for over 20 years. Numerous external and internal investigations have been conducted and reports and recommendations have been issued in response to these concerns, including a 2004 NIOSH Health Hazard Evaluation (<http://www.cdc.gov/niosh/hhe/reports/pdfs/2004-0145-2941.pdf>).

Recently (2013 –2016), a number of Hanford tank farm workers have sought medical attention from health symptoms they associate with chemical exposures and this issue has become more prominent. Two lawsuits were filed against DOE and WRPS over worker health concerns related to vapor exposure: one by a worker support group together with a labor union, and the other by the state of Washington.¹ On July 21, 2016, the Washington State Attorney General, along with the watchdog group Hanford Challenge and a labor union, filed motions for a preliminary injunction in federal court in Eastern Washington. The injunction seeks to prevent further harm to Hanford workers by implementing certain protections now, instead of waiting for the outcome of a trial. During the NIOSH site visit July 25–28, 2016, the Hanford Atomic Metal Trades Council (HAMTC), a coalition of 15 labor unions working at Hanford, had issued a stop work order until, among other things, all work within tank farm areas is performed with the use of self-contained breathing apparatus (SCBA) to protect workers from inhaling gases and vapors. Subsequent to the NIOSH site visit, on August 31, 2016, WRPS and HAMTC established a Memorandum of Agreement to lift the current stop work order. The agreement calls for workers to continue using SCBA until a program to test and verify the efficacy of respirator cartridges for protecting workers from tank emissions is completed.

Since December 2015, NIOSH has received multiple inquiries regarding worker health issues associated with the Hanford underground storage tanks. In response to these inquiries, NIOSH proposed conducting a short-term, focused, programmatic review in four areas:

Medical: Review of current policies and operational procedures for evaluating worker health concerns, including protocols for routine or targeted medical monitoring, clinical assessments performed in the event of health concerns associated with occupational exposures, recording of potential occupational health effects, management and analysis of collected health data, how individual and group medical information is communicated, and plans for clinical or epidemiological studies.

Exposure Assessment: Review of programs and technology in place for monitoring worker exposure to chemical contaminants, including the development of sampling strategies, use of real-time and integrated sampling, identification of unknowns, data interpretation, reporting of

¹ 1) UNITED STATES DISTRICT COURT FOR THE EASTERN DISTRICT OF WASHINGTON. Civil Case No. 4:15-cv-5086. HANFORD CHALLENGE and UNITED ASSOCIATION OF PLUMBERS AND STEAMFITTERS LOCAL UNION 598, plaintiffs, v. ERNEST MONIZ, in his official capacity as Secretary, UNITED STATES DEPARTMENT OF ENERGY, and WASHINGTON RIVER PROTECTION SOLUTIONS, LLC. Defendants. 2) UNITED STATES DISTRICT COURT FOR THE EASTERN DISTRICT OF WASHINGTON, STATE OF WASHINGTON’S COMPLAINT FOR DECLARATORY AND INJUNCTIVE RELIEF. STATE OF WASHINGTON, Plaintiff, v. ERNEST J. MONIZ, Secretary of the United States Department of Energy, the UNITED STATES DEPARTMENT OF ENERGY, and WASHINGTON RIVER PROTECTION SOLUTIONS LLC, Defendants.

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results, response to concerns regarding possible exposure, and management of data for trend analysis.

Exposure Control: Review of initiatives to develop, implement, and evaluate engineering controls, personal protective equipment (PPE) use, establishment of restricted areas, and other control programs (e.g., administrative).

Safety and Health Program Management: Review of policies and operational procedures regarding safety and health programs, risk communication and labor-management interaction on health and safety issues, how issues regarding exposure monitoring are communicated and resolved, and mechanisms for worker reporting of safety concerns.

On June 20, 2016, NIOSH received a letter from DOE ORP and RO management requesting that NIOSH proceed with conducting the Hanford tank farm program review (Appendix B).

NIOSH Activities

Prior to the site visits, considerable documentation regarding worker safety and health issues associated with the Hanford tank farms was provided to NIOSH by DOE representatives. This included a 2014 report (Hanford Tank Vapor Assessment Report) from an expert panel assembled by the Savannah River National Laboratory (SRNL) to evaluate Hanford tank farm worker chemical exposure issues. The WRPS Implementation Plan (IP) prepared in response to this report, and a DOE report evaluating progress on the SRNL recommendations, provided additional information. Appendix C lists selected key references NIOSH reviewed prior to and during the site visit.

On July 25, 2016, NIOSH investigators held an opening conference at the DOE ORP facility in Richland, Washington. Attendees at the opening conference included DOE and WRPS management and technical representatives, leadership and members of unions that represent DOE and contractor employees, and the occupational medicine director from HPMC Occupational Medical Services. During this meeting, information about NIOSH was provided, the site visit agenda and objectives were reviewed, background information regarding the current status of concerns regarding worker exposures to chemicals at the tank farms were discussed, and the following questions were posed to attendees:

- Was there an event that triggered the recent occurrence of 50–60 workers reporting symptoms and medical issues associated with exposure to vapors at the tank farms?
- Given the extensive actions, investigations, and reports with findings and recommendations, why do employees still feel compelled to seek help from outside the organization?
- What are the top 1–2 issues or biggest obstacles that need to be addressed to help resolve tank farm exposure concerns?

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Following the opening conference, NIOSH activities to evaluate the four programmatic areas (exposure assessment, exposure control, safety and health program management, medical) included:

- Conducting a tour of tank farm C-241, the evaporator plant, and the perimeter and other areas associated with the tank farms. WRPS, DOE, and a union representative participated on this tour. The tour was not intended as a comprehensive inspection of the areas visited; NIOSH personnel did not enter the controlled areas of the tank farm and no environmental samples were collected. Due to the HAMTC stop work actions, no workers were present inside the perimeter of the tank farms at the time. As a result, work practices and PPE use (including respiratory protection) were not observed. WRPS and DOE representatives provided information and answered questions on work practices, PPE requirements, current and planned tank emission controls, and other tank farm chemical exposure related issues. NIOSH toured the tank farm where exposure monitoring stations were being installed for a pilot project to evaluate new air monitoring technologies and strategies.
- Meeting with the DOE New Technology Chemical Vapor Solutions Team Chair and technical staff responsible for implementing the pilot IH monitoring demonstration project. NIOSH observed fixed sampling equipment and the mobile monitoring system, and discussed equipment selection, strategy, data interpretation, and utilization plans.
- Meeting with seven HAMTC safety representatives and the Chief Steward of the United Association of Plumbers and Steamfitters Local 598 to discuss roles, responsibilities, experiences, issues, and suggestions associated with tank farm vapor exposure concerns.
- Holding informal confidential interviews with 88 workers in groups and, when requested, individually. Interviews were conducted at the on-site WRPS building and at off-site union facilities. Interviews were primarily with craft workers from multiple unions and included former employees. Interviews were also held with salaried staff (managers, IHS) who requested to meet with NIOSH. During the interviews, discussions included priority health and safety concerns, experience with vapor incidents, reporting protocols, responsiveness to issues/odors, information provided by management and IH technicians (IHTs), understanding of explanations provided for data and results interpretation, medical support for symptoms, suggestions for improvement, and other health and safety concerns associated with the tank farms. Appendix G provides the checklist that NIOSH personnel used when discussing tank farm health and safety issues with workers.
- Meeting with IHTs to discuss training, qualifications, roles and responsibilities; response protocols; interaction with IHS and workers; interpreting and reporting results; and suggestions for improving the process for addressing worker concerns associated with chemical exposure at the tank farms.
- Meeting with the DOE Tank Farm Operations Manager, workers' compensation representative and others to obtain information and discuss interaction with HPMC

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medical staff, oversight of tank farm activities, role in responding to vapor concerns, the workers' compensation system and the determination of work-relatedness.

- Meeting with the HPMC occupational medicine director, HPMC management, HPMC risk communicator, the DOE-RO senior advisor responsible for the HPMC contract, and the WRPS industrial safety representative responsible for coordinating medical support with the HPMC clinic. Protocols/procedures for treatment and management of workers who experience symptoms and/or illness thought to be associated with tank farm vapors, including biomonitoring protocols and rationale, employee communication and follow-up, integration of IH data, and recordkeeping and analysis were reviewed and discussed. The meetings included tours of the two HPMC clinics.
- Meeting with WRPS and DOE IH Leads and OSH managers to discuss and review safety program management, including roles and responsibilities, employee involvement, priorities, plans, and policies. Protocols and procedures specifically associated with the tank farm vapor issues were discussed. This included reviewing event response and investigation procedures (Abnormal Operating Procedure-15 or AOP-15), sampling strategies, data interpretation and recordkeeping, reporting of results to employees, interaction with medical, and follow-up. Strategies and plans for engineering and other controls, and progress on the WRPS IP for addressing the SRNL report recommendation were reviewed with IP leads.
- Meeting with WRPS and DOE IH technical staff to review, discuss, and observe sampling and analytical capabilities, rationale for selection of Chemicals of Potential Concern (COPC), respirator program, and cartridge testing to determine the capability of air-purifying respirator cartridges to effectively filter COPCs.
- Participating in meetings with the DOE Vapor Management Expert Panel, the DOE Chemical Vapor Solution Team, and New Technology subcommittee to discuss current activities, progress, and plans for addressing worker chemical exposure concerns at the tank farms. This included meeting with the Engineering Chair of the Chemical Vapor Solution Team to review and discuss engineering options and plans for controlling tank emissions.

Upon completion of the site visit (June 28, 2016), a closing meeting was held at the DOE ORP facility with DOE and WRPS management and technical representatives, members of unions that represent DOE and contractor employees, and the HPMC occupational medicine director. During this meeting, information regarding NIOSH activities was presented. No preliminary findings or recommendations were provided at the closing meeting.

Findings and Discussion

Questions posed at Opening Conference and Interviews

- Was there an event that triggered the recent occurrence of 50-60 workers reporting symptoms and medical issues associated with exposure to vapors at the tank farms?

Union, DOE, and WRPS representatives indicated that in late April, 2016, there was an event associated with retrieval activities that has been attributed as a primary trigger for the recent occurrence of workers reporting symptoms. This entailed an odor incident(s) that impacted, among others, two IHTs. NIOSH was informed that during March and April, 2016, retrieval work on Tank AY-102 was planned to be accomplished during off-shifts and weekends to minimize the risk to workers housed in the near vicinity of the tank farms during waste disturbing activities. This work schedule was followed until a larger leak in the double shell tank, resulting in increased waste inside the annulus, was discovered. At that time, the schedule for recovery operations was changed to round-the-clock work in an effort to finish the job as soon as possible. In late April, an odor event impacting multiple workers in and outside the tank farms occurred in which some workers reported experiencing health effects they attributed to exposure to tank farm emissions. Union and WRPS personnel also indicated to NIOSH that related factors may have been that controls implemented for retrieval activities (i.e., establishment of expanded vapor control zones) were reduced after monitoring indicated the extent of these controls was not necessary. The NIOSH program review did not include conducting a detailed investigation of this incident.

- Given the extensive actions, investigations, and reports with findings and recommendations, why do employees still feel compelled to seek help from outside the organization?

It appears that distrust, concern, and skepticism by some workers regarding the willingness of DOE and WRPS management to acknowledge that exposures and health issues are occurring may be a primary reason for employees to seek outside assistance. Other factors include worker concerns regarding an over-reliance on exposure monitoring and not controls, perceived lack of management commitment to safety and health, and what is considered to be an onerous and dysfunctional workers' compensation system.

- What are the top 1-2 issues or biggest obstacles that need to be addressed to help resolve tank farm exposure concerns?

Multiple and diverse responses were received regarding this question from both worker and management representatives. Union leadership indicated there is a perception that production is valued over safety and this is a root cause of the ongoing tank farm exposure concerns. Additionally, some workers and union representatives believe that the combination of management skepticism, unwillingness to acknowledge the legitimacy of health and exposure concerns, and perception that actions are often motivated by interest

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in appeasement is a significant obstacle and source of conflict. There are also concerns that the exposure assessment strategy, including the determination of chemicals to monitor and timing of sample collection, does not encompass all chemicals that may be present or that measurements of individual compounds may not reflect hazards associated with a complex mixture of compounds. Related concerns include the unknown impact of waste disturbing activities on emissions and chemical constituents.

Some DOE and WRPS representatives indicated that despite significant investments and demonstration of a strong commitment to resolving concerns regarding tank farm worker safety and health, they perceive that some unions/workers are not interacting with management in good faith. Successfully addressing this breakdown in trust and credibility is essential to resolve these concerns. Another significant obstacle for DOE and WRPS is addressing the SRNL TVAT report regarding the potential for short term episodic emissions (i.e., bolus) as a possible cause of workers experiencing odors and health concerns. Evaluating the potential for short-term emissions and determining contributing factors pose significant technical and analytical challenges.

Exposure Assessment Program

There are 177 underground tanks at the Hanford site, with tank volumes ranging from 50,000 gallons to 1.3 million gallons. One hundred forty nine are single shell tanks (SSTs) and 28 are double shell tanks (DSTs). The tanks are arranged in tank farms that are surrounded by a chain link fence and have controlled entry. The tanks contain a complex mixture of radioactive materials and hazardous chemicals and more than 1800 chemicals have been identified in the tank waste. Of these, about 1500 are present in the headspace of the tanks, which are vented to the atmosphere to prevent potentially flammable concentrations of gases in the tanks. Tank emissions pass through HEPA filters to remove radioactive contaminants, but chemical vapors and gases are not removed and have the potential to enter the breathing space of workers. SSTs are passively vented and DSTs have forced air ventilation.

According to DOE and WRPS personnel, chemical reactions are continually occurring inside the tanks. When tank contents are moved, mixed, and concentrated, the chemical compositions and concentrations in the tanks can change. Hydrogen is known to be produced within the tanks, and the pH of tank contents continuously drops with time. Sodium hydroxide must be added to tanks periodically to compensate for this drop in pH. Some chemical species emitted from the tanks may be highly reactive and may not persist long enough to be characterized by subsequent analytical chemistry techniques.

Chemicals of Potential Concern

Chemicals of Potential Concern (COPCs) comprise a subset of the chemicals that may be present in the waste tanks and these compounds are used by DOE and WRPS as the foundation of the IH exposure assessment program. Chemicals monitored during exposure assessments or responding to odor events, and when establishing controls for worker protection are derived from the list of COPCs. The technical rationale for determining COPCs is based on a characterization of

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chemicals in the tank waste and headspaces by an independent panel of experts in toxicology and risk assessment. The rationale is detailed in the panel's Technical Basis document that identified chemicals within a waste vapor source (e.g., tank headspaces, ventilation stacks and the 242-A Evaporator) that are potentially hazardous and might be released into worker breathing zones. Appendix D is the list of COPCs provided to NIOSH.

According to the Technical Basis document, it was determined that any chemical present at or above 10% of its OEL at a tank farm source (e.g., a breather filter or exhaust stack) should be evaluated for addition to the COPC list. Appendix E provides information on OELs, including definitions and sources of information. Chemicals having maximum reported concentrations below 10% of an established U.S. OEL were considered to not pose a significant risk to tank farm workers. IH exposure monitoring is not routinely conducted for all chemicals that may be present and a subset of the COPCs is typically assessed during an odor event.

The independent panel of experts, using the above criteria and a characterization of chemicals in the tank waste and the tank headspaces, identified 59 COPCs. For chemicals without an established U.S. OEL, a process was developed to evaluate potential occupational exposure hazards using alternative occupational exposure standards and toxicological data and is described in the Technical Basis document.

Upon review of the Technical Basis document, it appears standard toxicological practices to derive OELs were used. However, the assessment does fall short on one of the most important aspects which is how to apply these limits in the field (or in risk assessment) given such a wide array of potential mixtures and possible additive or synergistic effects. As such, the health effects associated with a single compound may not be applicable to all exposure situations.

The determination of COPCs was a source of concern to some employees interviewed during the NIOSH site visit. Concerns included appropriate identification of the chemicals to be monitored, changes in chemical composition and concentration during waste disturbing activities, use of appropriate monitoring techniques and strategies, and the unknown health implications of exposure to chemical mixtures.

Review of Technical Documents

To better understand DOE and WRPS efforts to evaluate potential chemical exposures to tank farm workers, NIOSH reviewed a number of IH programs and technical documents, including:

- RPP-22491, REV 1 "*Industrial Hygiene Chemical Vapor Technical Basis*" (05/2006): identifies all chemicals within a waste vapor source (i.e., tank headspaces, ventilation stacks and the 242-A Evaporator) that are potentially hazardous and might be released into worker breathing zones and provides the Industrial Hygiene program with the basis to make decisions, designate COPCs and set controls that ensure worker protection
- *TFC-PLN-34, REV E-6 "Industrial Hygiene Exposure Assessment Strategy"* (02/22/2013): sets forth methods and rationale used to characterize and monitor workers' potential exposures to hazardous agents

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- *TFC-PLN-64, REV B-5 “Industrial Hygiene Instrumentation Plan” (03/01/2016)*: summarizes industrial hygiene instrumentation elements and responsibilities for developing and implementing the program
- *TFC-ESHQ-H_IH-C-48 “Managing Tank Chemical Vapors” (04/17/2012)*: provides directions for managing potential exposures to tank waste chemicals with the commitment to As Low As Reasonably Achievable (ALARA)
- *TF-AOP-15 “Industrial Hygiene Investigation Report” (04/28/2016, AP Farm)*: describes a reported odor event and summarizes actions taken in response to the event
- Tank Vapor Information Sheets
- Tank Farm Chemical Exposure Hazard Analyses

Each document describes important aspects of IH programmatic activities performed at Hanford. As part of this review, NIOSH met with DOE and WRPS representatives to discuss technical information contained in the documents and the status of the described programs. The IH Chemical Vapor Technical Basis document provides sound guidance and rationale for the IH actions that have been taken since the document was developed in 2006. However, it does not appear that the document is updated on a recurring basis to include new scientific findings and enhanced understandings of potential exposures gained since the document was originally developed.

The documents “Industrial Hygiene Exposure Assessment Strategy” and “Managing Tank Chemical Vapors” describe the use of similar exposure groups (SEGs), groups of workers who have similar exposures based on location and work activities. This is an appropriate and traditional IH approach for characterizing exposures and making evidence-based decisions. The procedures described in the “Managing Tank Chemical Vapors” document call for producing two types of reports: Tank Vapor Information Sheets and Tank Farm Chemical Exposure Hazard Analyses. The Chemical Exposure Hazard Analyses are intended to provide specific assessments of occupational exposures for groups of workers during activities of concern at specific locations. However, it appears that no written chemical exposure hazard analyses, as described in the *TFC-ESHQ-H_IH-C-48* document, have been produced since 2012. When questioned regarding the lack of such documented exposure hazard analyses since 2012, NIOSH was informed that a management decision was made at that time to discontinue that activity. This decision may have had an unintended consequence of not providing specific guidance for WRPS IH exposure assessment activities in the last four to five years.

The IH investigation report from the reported exposure event on April 28, 2016, indicates that the IHTs who were present were equipped with considerable sampling capability. Carrying this array of sampling equipment was described as typical when sampling worker tasks in the tank farms. Although the sampling related to the exposure event was conducted over a short period of time rather than a full-shift, it appeared in the report that concentrations were extrapolated to 8 hour time weighted averages to compare against full-shift OELs. This averaging practice may result in an appearance of very low average exposures and may not be representative of short term higher concentrations. It is more appropriate to compare short-term activity concentrations to short-term exposure limits or ceiling limits. This is complicated by the lack of short-term

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OELs for many of the compounds of potential concern. Despite the lack of short-term limits, it is important to record the levels for comparing with other short-term exposure events, evaluating relative concentrations, and possibly aid in identifying the source.

NIOSH was informed by WRPS and DOE staff that developing such limits (short-term/ceiling OELs) where necessary is under discussion by scientists at Pacific Northwest National Laboratory. Developing evidence-based exposure limits requires considerable research, dealing with uncertainty, scant and possibly conflicting toxicological information, and determination of appropriate safety factors. Furthermore, it is generally a lengthy process that cannot be accomplished in the near term. Given the number of chemicals potentially present in the tanks that do not have a science-based OEL, developing OELs for all of these compounds in a timely manner is problematic and likely not practical or feasible.

IH sampling at the tank farms has resulted in a very large database of monitoring results for a variety of compounds, work activities, and locations. When individual sample results are obtained, a WRPS industrial hygienist reviews the data to identify contaminants at concentrations of concern, perform quality checks, and determine if further action or investigation is needed. Evaluation of data trends, how such trends impact previously identified SEGs, and statistical analysis of the data would likely provide important information regarding exposure characterization, determination of appropriate controls (including PPE), and ensuring workers are protected. However, it does not appear that such further analysis of the data beyond the initial brief evaluation occurs to any great extent. This was a suggestion provided several years ago by an evaluation performed by the Hanford Concerns Council which found that “they (WRPS) have allocated limited resources to analyzing and interpreting the data necessary to support all the requirements of an industrial hygiene program...” This recommendation for a more extensive analysis of past data to better characterize and understand exposures is still valid.

Industrial Hygiene Response to Tank Farm Odor/Exposure Events

When an odor or other abnormal event occurs at a particular location, a communication system has been established to inform management operators and supervisors, and provide for rapid IH response. The exposure assessment protocol for responding to an odor event is appropriate, consistent with good IH practice, and utilizes state-of-the-art monitoring technology. Upon notification of an odor or symptom possibly associated with chemical exposure in or near the tank farms, the protocol entails responding as quickly as possible with direct reading air-sampling instrumentation and the collection of an air sample in an evacuated container or sampling bag for subsequent analysis via gas chromatography and mass spectroscopy (GC/MS). Although not every chemical that could be present would be identified by this protocol, this protocol appears to be as comprehensive as practical.

It is important that any limitations to this response protocol be acknowledged and considered when making determinations about exposure and risk. The absence of detectable levels of known chemicals does not mean that no exposure has occurred. Due to the large number of chemicals potentially present in the tank farms, not all species that could cause an odor or result in a health symptom would be detected with the sampling techniques in use. Instruments have different sensitivities to different compounds, and may be subject to interferences in the presence of other

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compounds. Additionally, although the need to respond quickly to an odor/symptom event is emphasized, there is usually a time delay; thus a chemical release resulting in an intermittent/short-term exposure may not be detected. During worker interviews, NIOSH was informed there are times when the individuals may not be in possession of their phones, radios, or other communication devices and therefore messages may not be received in a timely fashion.

Based on interviews, there appears to be continuing frustration among IH staff, including IHTs, with the difficulty in identifying chemical species following an odor event. The AOP-015 procedure details the actions to be taken in the event of an odor or health symptom that may be associated with exposure to tank farm gases or vapors. However, there is a perception by some tank farm workers that air monitoring is often focused on finding alternative explanations for odors – such as a septic tank or generator, or that sampling is not conducted for the appropriate chemicals. Additionally, some workers are concerned that conclusions regarding exposure are based on sampling that was conducted after the event occurred and are not representative of conditions when the odor or symptom was experienced.

Tank Farm Tours

WRPS and DOE staff provided the NIOSH team a tour of several areas of the tank farms, the Evaporator plant, perimeter designations, and other associated areas. In particular, the 241-C tank farm was reviewed from the fenced perimeter areas (Figure 1). As noted above, NIOSH did not enter the tank farms or conduct environmental monitoring. The NIOSH team discussed operations and work practices typically performed at the site. However, due to a stop-work order, worker activities were not observed. Extended stacks for better dispersion of tank vapors had been installed at the 241-C farm.

Trailers that house WRPS and other staff are located in the near vicinity of the tank farms, and the number of workers present in these areas at any time is variable. NIOSH was informed that workers in areas outside the periphery of the tank farms have reported odors believed to come from within the tank farm perimeter.



Figure 1: Tank Farm 241-C

Pilot Monitoring Program

Accompanied by WRPS, DOE, and Union representatives, the NIOSH team was shown the AP tank farm (visual inspection from the perimeter fencing). While not yet fully operational at the time of the NIOSH site visit, a state-of-the-art pilot scale demonstration project for a continuous chemical monitoring system was being established at this tank farm. As noted above, a weakness of the current response strategy for reported odors is the lack of IH sampling that provides information about exposure while the event is occurring. WRPS and DOE representatives indicated that IHTs typically arrive to collect air samples as quickly as possible but still after a period of time had elapsed after the reporting of the event, and thus the results may not accurately reflect short-term intermittent exposures that dissipated prior to sampling. Objectives of the pilot monitoring project are to enhance the capability to collect real-time data during an event, and identify releases at an early stage.

Additionally, the TVAT report hypothesized that short, intermittent, high-dose (acute) concentration (bolus) vapor exposures are a likely cause of reported worker health effects. This pilot monitoring project is part of the Phase 1 WRPS Implementation response to the TVAT report and is intended to determine if these bolus exposures are occurring.

For these reasons, a large number of fixed area continuous exposure assessment technologies have been acquired and installed at the AP tank farm site to allow for comprehensive and real-time characterization of chemical exposures (Figures 2a and b), including:

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- Ultraviolet-Fourier Transform Infrared (UV-FTIR) spectrometer
- Open Path-Fourier Transform Infrared (OP-FTIR) spectrometer
- Ultraviolet-Differential Optical Absorption Spectroscopy (UV-DOAS)
- ToxiRAE Pro photoionization detector (PID) for total volatile organic compounds (VOCs) detection
- MultiRAE Pro multi-gas meter and PID
- AreaRAE multi-gas meter and PID
- MeshGuard direct reading instrument (DIR) for ammonia detection
- Primary Met Station for meteorological data
- HazScanner DRI for meteorological data and multi-gas monitor
- Gastronics Fixed Instrument Skid (FIS) for meteorological data and multi-gas monitor
- Grab Autosamplers and Area/Stack Autosamplers including sorbent media tubes/cartridges and Summa sampling canisters, triggerable locally or remotely
- Forward Looking Infrared (FLIR) camera for optical visualization of potential emissions



Figure 2a and b. Air Samplers and Monitoring Equipment on the Periphery of the Tank Farm

In addition to these fixed sampling technologies, WRPS and DOE representatives indicated that worker exposure data will be collected through the use of personal Summa whole-air sampling canisters and Cub IonScience PIDs. These newly acquired technologies are intended to provide real-time and continuous data on selected COPCs in an integrated system with wireless communication. The Summa whole-air canisters are intended for real-time collection of a personal air sample during an odor event for subsequent laboratory analysis via GC/MS. The Cub IonScience PIDs detect volatile organic compounds (VOCs) and other compounds as a class but are not specific to any one single contaminant that may be present.

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WRPS and DOE were pilot testing a mobile van (Mobile Organic Monitoring Laboratory) with real-time exposure assessment technology at the time of the NIOSH site visit. This van uses state-of-the-art air monitoring instrumentation, including proton-transfer reaction mass spectrometry (PTR-MS) that is capable of monitoring for a wide range of chemicals at very low limits of detection. Data from the mobile lab are mapped with indicators of the route taken, stops where stationary monitoring took place, and the data that were collected. WRPS prepares the maps and publishes these on a publicly available web site (<http://hanfordvapors.com/research/data-and-sampling-results/>). This web site also includes details on each of the implemented monitoring technologies.

While no one technology can provide assessment data on all exposures of concern, the combination of these monitoring systems provides a very comprehensive state-of-the-art approach to better understanding the potential for chemical exposures at this particular tank farm. This includes the potential to provide actionable information regarding sources, compounds present, contaminant migration, trends, and possible explanations or predictors of odors/health symptoms. The combination of both meteorological and vapor concentration data will provide important characterization information, particularly on the impact of weather patterns on contaminant migration and dispersion. A system to collect the data and perform dispersion modeling (SAFER) obtained by WRPS will provide important information for ensuring appropriate spacing is allocated for vapor control and reduction zones. The SAFER system allows for live plume monitoring and integrates real-time weather and gas-sensor data, including map visualizations. Additionally, the FLIR camera can be particularly useful in visualizing emissions as they occur so action can be taken to protect workers from exposure when a release is detected.

Although considerable resources have been committed to this new analytical instrumentation project and IH personnel, it is a valid concern that the ability to sample for all potential constituents is not possible with currently available technology, that OELs have not been developed for all chemicals that may be present (particularly for short-term exposures), and that the effects of exposure to a mixture of chemicals are not known. These concerns are reflected in opinions expressed by some workers who perceive the focus of this effort is to prove that no, or minimal, exposure is occurring, rather than improving conditions with a greater emphasis on implementing controls.

Industrial Hygiene Infrastructure

During the site visit, NIOSH toured the main IH laboratory and respirator lab in WRPS Building 2704. In addition to viewing equipment stored in these respective spaces, equipment maintenance and work practices and procedures were discussed with IH and other lab staff. Both locations appeared to be well-organized and well-equipped. IH lab staff were knowledgeable about established practices for equipment maintenance, calibrations, and repairs; respirator lab staff have established protocols and procedures for inventory control and cleaning and inspection of equipment for signs of damage or malfunction.

NIOSH was provided a review of the site-wide IH database (SWIHD) and its capabilities for IH data collection and storage. The SWIHD allows sharing of information for sampling plans,

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samples collected (including direct-reading instrument data), chain of custody, laboratory analyses performed, and sample results. This is a good system for tracking vital IH data and documenting results from exposure assessments at the Hanford site, and reflects an impressive implementation effort by the IH staff.

Some IH and IHT staff were concerned about the available space allocated to IHTs, and that there was insufficient office space to accommodate the large number of recently hired IHTs. At the time of the NIOSH visit, 4 to 5 IHTs were assigned to single cubicles for their work space. Such a configuration may limit productivity and diminish morale among the impacted IHT workforce.

Industrial Hygiene Personnel

Currently, WRPS and CH2M Hill Plateau Remediation Company (CHPRC) are the only two contractors at Hanford that have IH staff. Recently, the WRPS workforce at the site has increased the number of IH staff. In particular, a large number of IHTs were hired to address recommendations in the TVAT report and establish a greater presence in the tank farms. A common complaint heard during worker interviews was that the level of trust, respect, and seriousness shown to the IHTs has not been commensurate with that shown to health physics technicians (HPTs). Additionally, interviews with IH and IHT personnel indicated their technical knowledge and abilities, and appropriate level of education were frequently questioned by workers. This may stem from a lack of general understanding by workers of IH staff roles and activities, and that complex IH sampling challenges often preclude the ability to provide a satisfactory answer when questioned about sampling strategies or results. The idea of ensuring parity between the IH and radiation control programs as recommended in the TVAT report was described as beneficial, but that implementation of such parity will be difficult because of the greater levels of experience and time (and resulting trust from the workers) that HPTs have at the site compared to many of the IH staff.

Retention of IH program management was identified as a weakness. Over the course of the past several years, a number of IH managers and program leads were hired only to leave for other jobs or programs shortly thereafter. While the reasons behind this “revolving door” pattern may vary, the lack of sustained IH leadership affects the ability to consistently respond to personnel and communication issues and build an effective and successful program.

WRPS representatives indicated that a new initiative was being implemented that incorporates all field IH staff under one management structure led by an experienced IH manager. This would replace a system that had separate groups and separate supervisory lines for various IH staff functions. The NIOSH team believes that the successful implementation of this new unified IH staff structure should have a positive impact on the work environment, communication, and consistency.

Industrial Hygiene Technician Training

As described by both program administrators and participants, the IH training program continues to evolve to better address the needs for both initial and recurring training and educational requirements.

The importance of training IHTs on the use of monitoring equipment and how to articulate results to workers in an understandable and consistent fashion, including analytical limitations (e.g., non-specificity of PID monitors), is essential to an effective IH program. IHTs are the “face” of the IH program and have the closest and most frequent interaction with tank farm and periphery workers. WRPS and DOE are to be commended for their efforts to significantly increase the number of IHTs to support the tank farm IH program. However, it appears (similar to a finding in the TVAT report) that many of the IHTs hired in the recent past were inexperienced or did not have an educational background specifically in IH. This is understandable as the available pool of IHTs with appropriate expertise is likely insufficient to fill the demand. This lack of training and field experience necessitates a period of thorough educational development that allow IHTs to gain essential knowledge and hands-on practice. According to WRPS representatives, each IHT is provided in-class training, including an introductory 40-hour Fundamentals of Industrial Hygiene class. In this class, technical topics were covered and discussed, and IH calculations were performed and reviewed. However, consistency of the quality of the course was questioned as some IHTs interviewed indicated to NIOSH there was little review of the technical book, no calculations, and no examination when they took the course.

IHT training includes instruction in the use of IH monitoring equipment to better understand its operation and the strengths, weaknesses, and usefulness for evaluating specific exposures. This is a key component of the IHT function as monitoring requires understanding the analytical principles of detection, limitations (e.g., sensitivity, specificity, interferences, range) and how to accurately communicate monitoring results to workers. Some IHTs interviewed were concerned that past in-field equipment training for IHTs was insufficient. WRPS representatives indicated that, as part of the qualifications for IHTs to be recognized as fully qualified and field ready, they must receive and pass On Job Training (OJT). After OJT is successfully completed, an individual evaluation of competency is conducted at a later date through an On Job Evaluation (OJE). This individual training and assessment is intended to ensure a complete understanding of technical information by the IHT. If successful, the IHT would receive a signed OJE card. In practice, however, some IHTs indicated to NIOSH that OJT and OJE cards may be signed off on the same date, indicating that a valid assessment of how the IHT puts his/her knowledge and skills into practice was unlikely. Additionally, some IHTs were concerned that, in an effort to expedite more IHTs into the field, some of these one-on-one requirements are conducted in groups with less opportunity to identify strengths or weaknesses of individual IHTs. These issues may have resulted in some insufficiently trained/qualified IHTs being put in the field.

Interviews with IHTs indicated different experiences and interactions with IH staff in the field. Some reported that very positive and daily interactions in the field occurred with IH personnel and that these opportunities were vital for learning and gaining experience. These IHTs indicated this helped to answer worker questions, and provided appropriate direction for responding to events and issues encountered in the field. However, it appears these mentoring opportunities do

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not occur consistently for all IHTs. Lack of in-the-field mentoring may impact both the quality of the work provided by IHTs as well as their ability to provide sound IH guidance in the field. Some of the IHTs interviewed indicated to NIOSH that DOE facility representatives (FacReps) often observe their work, and this is welcomed.

Continuing education (CE) is an important component of IHT training and development; successful CE ensures that new skills are incorporated into practice and that previously learned material is refreshed, and this is a very positive enhancement to the WRPS and DOE IHT program. However, some workers interviewed indicated a recent lapse in CE opportunities for IHTs, particularly those focused on field work activities. Consistent retraining on specific instrumentation, especially those used infrequently, was described by some IHTs as lacking.

Tank Farm Worker Training

Personnel who work in the tank farms are required to successfully complete training in a number of areas regarding safety and health, and must be respirator trained, cleared, and fit-tested, and have OSHA 1910.120 Hazardous Waste Operations and Emergency Response (HAZWOPER) training. Chemical Hazards Awareness Training (CHAT) has been the mechanism used in the past to train WRPS workers on the potential chemical hazards in and around the tank farms. CHAT training presentations reviewed by NIOSH included characterizations of tank waste, COPCs, OELs, potential health effects of COPCs, IH chemical hazard assessments, exposure controls, event response actions, and plans for improving tank farm safety and health. In response to TVAT recommendations, CHAT training has been enhanced and training programs are being developed entitled CHEM1 (a general training about chemical hazards) and CHEM2 (more specific in regards to work done at tank farms) that are modeled after training programs for radiation control workers. The development and successful implementation of these new trainings will be a positive effort in ensuring that all workers receive timely and accurate hazard communication training.

While a 2-year refresher course of 2–3 hours was provided, the 4-hours of initial training was criticized by some workers as being insufficient to cover the topics in the training, potentially resulting in an inadequate understanding of tank farm chemical safety and health issues. Given the high level of concern with potential exposures and health effects at the tank farms, it is important that adequate time be allocated in the CHAT or upcoming CHEM1 and 2 courses to ensure all topics are sufficiently covered.

In reviewing the CHAT presentations provided to NIOSH, it was noted that further development of important concepts may be needed. As an example, the CHAT4 slide set “Characterization”, describes the characterization of gases and vapors from A and C tank farms. In these slides, sample locations are depicted on maps and broad statements made regarding air sample results. These included which gases and vapors were detected at or above 50% of their OEL at emission sources or breather filters and that no gases or vapors were detected at or above 10% of their OEL at 5 feet or more from these point sources. Such statements, which may accurately reflect the results in the samples collected, may still leave several questions unanswered or allow misunderstandings to occur. Important information to convey in such a training could include the extent of the sampling, when samples were collected and if they were collected during times of

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highest potential exposure (e.g., waste disturbing activities), if they were instantaneous or integrated samples, and if they were personal breathing zone samples which more accurately reflect worker exposures. Some of these concepts were further developed in CHAT6 “Chemical Hazard Assessment”, but statements such as “18,970 air samples were evaluated for over 668 different employees on over 1,490 different days” may benefit from additional details, such as what percentage of these sample results were short-term versus full-shift and if they reflect just a few compounds of interest or are fully representative of the entire spectrum of COPCs. Communication of such information may provide the workers a more robust and complete picture of the IH program for hazard assessment.

Independent Program Review and External Expertise

Issues with IH exposure assessment, toxicology, and data management and analysis at Hanford are very complex and require a high degree of expertise by in-house scientists and professionals. DOE and WRPS IH and other technical health and safety professionals have considerable expertise and experience, and have a history of conducting evaluations, preparing reports, and developing programs that are scientifically appropriate. However, external experts with a fresh perspective can provide valuable contributions to current knowledge and practices and help address worker concerns regarding objectivity. DOE and WRPS have utilized highly qualified nationally recognized outside experts in IH, toxicology, epidemiology, occupational medicine, and risk communication to help address and resolve issues associated with worker exposure to tank farm emissions. These outside experts have conducted in-depth assessments and provided evidence based recommendations, including the TVAT Report.

NIOSH personnel met with members of the Vapor Management Expert Panel (VMEP), a group of experts brought together to monitor DOE oversight of the TVAT WRPS IP. The panel provides an independent voice to speak to the DOE oversight team and DOE ORP managers on how Phase 1 of the IP is being completed. The VMEP is comprised of members from academia, industry, and government agencies, and includes a representative from HAMTC. This multidisciplinary group is involved in several TVAT implementation activities, including engineering controls, technical workshops, health effects, risk communication, IH and modeling. Areas which VMEP members described to NIOSH as improving but in need of further emphasis were understanding health effects, renewed efforts for engineering controls, and improved communications. Members of the VMEP also expressed interest in pursuing case-series studies of health effects and evaluating workers’ compensation records, particularly through the assistance of the occupational physician member of the VMEP. They also stressed the importance of improving the credibility of IH staff among the workforce to better ensure workers have confidence in the data collected, interpretation, and actions taken.

WRPS has contracted with the Center for Toxicology and Environmental Health, LLC (CTEH®), a nationally recognized IH, toxicology and environmental consulting company. WRPS provided NIOSH the statement of work (SOW) developed for CTEH in June 2016 for review. The objectives described in the SOW are for CTEH to provide an independent technical review of the existing WRPS IH program and recommend improvements for identification, monitoring, and control of tank farm vapors. Discussions with CTEH staff members and review of the SOW revealed a number of specific tasks requested of CTEH. These include:

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- evaluating the adequacy of the available IH and air dispersion modeling data
- assessing the available exposure assessment and medical/epidemiological data specifically to evaluate the potential for adverse health effects
- improving on-site communications between IH programs and workers
- evaluating the technical basis for the currently implemented IH program, including analyzing key technical documents such as the COPC selection document, derivation of OELs document, current standard operating procedures (SOPs), and the TVAT report, amongst others
- evaluating the tank farm odor response program
- analyzing previously collected air quality data for completeness of the data and the relation of results to applicable OELs

Successful completion of these tasks would help considerably in answering important and pertinent questions regarding potential exposure to tank farm chemicals. CTEH will provide a formal report to WRPS upon completion. Until that time, WRPS has requested informal reports of interim findings and recommendations from CTEH as appropriate. CTEH staff indicated to NIOSH that WRPS has been open with their previously collected data, has responded appropriately to requests for needed information, and has maintained professional distance between WRPS and CTEH staff to allow for independent review and analysis.

In addition to the currently contracted work, WRPS indicated they are considering continuing work with CTEH into 2017. This work would focus on addressing communication needs regarding the IH program. Tasks associated with this work are anticipated to include:

- developing communication materials regarding the nature of the IH program, its size and technical validity, and the extent of activities performed
- improving communication of issues related to sample results, exposures, and applicable OELs
- improving communication of issues related to toxicology, odor perception, and individual sensitivities
- developing and implementing a comprehensive plan for verbal, written, and online worker communication

Many of the tasks described in this SOW are central to worker concerns and issues regarding tank farm chemical exposures and potential health impacts. NIOSH considers contracting with a recognized and reputable outside organization such as CTEH to be a very positive step on the part of WRPS.

Exposure Control Program

The SST Farms have passive ventilation systems with HEPA filters that vent into the ambient environment. Some of these vent stacks are approximately the height of a worker while others have been modified to increase stack height. The DST Farms have active ventilation systems

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with HEPA filters and blowers connected to a stack that emits tank gases and vapors greater than 10 feet above the height of a worker. Using HEPA filters in the vapor stream will remove particulates but gases and vapors are not removed. Fugitive emissions could also potentially occur from other sources such as valves and tank penetrations.

Per DOE, long-term capital equipment solutions are under evaluation at this time, but the extent of this effort is largely dependent upon information gathered during Phase I of the WRPS IP prepared in response to TVAT recommendations. Decision making on many controls is reserved for the Phase II of the WRPS TVAT Report IP. As such, the current emphasis is on determining if exposures are occurring, if the bolus theory is valid, how to better characterize/anticipate exposures, and not on controls to prevent releases from occurring.

Personal respiratory protection used by workers at the site includes SCBA for entry into the tank farms. Although airline respiratory protection is more desirable for non-emergency work that requires supplied air, WRPS and DOE representatives indicated the risks for slips, trips, falls, and entanglements due to the quantity of equipment, material, hoses, pipes, workers, etc. at the site, precluded the use of airline respirators. The use of supplied air for work inside the tank farms is not evidence-based, such as having valid air sampling data that indicates this level of respiratory protection is necessary (e.g., immediately dangerous to life or health conditions). Rather, it appears the decision to use SCBA was based on worker concerns regarding offensive odors, symptoms potentially associated with exposure to tank farm emissions, and lack of confidence in the air sampling data. DOE and WRPS safety and health representatives indicated concern that the use of SCBA presents inherent risks that need to be considered, a concern shared by NIOSH, and may outweigh the perceived benefits from using this level of respiratory protection. These risks include the potential for a higher frequency of accidents from slips, trips, falls; communication impedance; heat stress; impaired visual acuity; and ergonomics issues. Safety concerns regarding extended use of SCBA were also discussed in the TVAT report.

DOE is evaluating the efficacy of respirator cartridges to remove tank farm COPC vapors and gases. If successful, air-purifying respirators, in lieu of SCBA, will be used. For a program utilizing air purifying cartridge respirators to be successful it is necessary, among other program elements, to have knowledge of the potential exposures that could be incurred (chemical species, concentrations, duration of exposure). Respirator cartridges have a service life and Maximum Use Concentration (MUC) that are chemical specific, and this information is necessary to understand limitations and determine an appropriate cartridge change-out schedule. Given the complexity of characterizing the potential for exposure and cartridge efficacy for different scenarios, mixtures, and concentrations, this will, if successful and scientifically defensible, be a significant achievement. It will be important to ensure that these different variables (scenarios, mixtures, concentrations, seasonal variations, and changing tank conditions over time) are included as an evaluation component of this effort.

PPE such as the use of respiratory protection is considered the last option in the well-established hierarchy of controls (<http://www.cdc.gov/niosh/topics/hierarchy/default.html>) as it puts much of the burden of protection on the worker. Engineering controls are favored over PPE for controlling worker exposures in the workplace because they are designed to remove the hazard at

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the source or before it comes in contact with the worker. Well-designed engineering controls can be highly effective in protecting workers and are typically independent of worker interactions. Reliance on respiratory protection (either SCBA or with cartridges should the respirator cartridge study prove fruitful) as a long-term control for routine tank farm work is not ideal and not a replacement for effective engineering controls.

Safety and Health Program Management

Both DOE ORP and WRPS have established comprehensive OSH programs. DOE provides an oversight function to contractors, including WRPS, to ensure compliance with DOE requirements, policies, and procedures. As described above, DOE and WRPS have professional IH and other staff who are involved in addressing exposure issues associated with the tank farms. According to DOE representatives, DOE IH staff, other OSH staff, and the above mentioned DOE FacReps interact frequently with WRPS on issues associated with the tank farms. The FacReps have an oversight and audit role for the tank farms and function to ensure contractor compliance with DOE requirements. The FacRep manager indicated to NIOSH that it is a priority to observe abnormal operating procedures or activities that may be considered high-risk work.

As described above, DOE and WRPS have made significant investments in monitoring technology, hiring of IH staff and technicians, forming technical worker-management groups, and establishing programs and procedures to address worker health and safety issues associated with the tank farms. The procedures and protocols for responding to health and odor events are positive developments and appear technically appropriate and comprehensive.

Risk Communication

Risk communication involves the exchange of information among workers, management, and other stakeholders regarding the likelihood and consequences of exposure and health effects, and the steps being taken to manage the risks. A number of outside expert reports, including the TVAT report, have discussed risk communication issues in detail and provided guidance and recommendations. These include recommendations to address issues of distrust, ensure more routine, timely, and transparent communications between DOE and WRPS management and workers, improve the degree of employee involvement, provide risk communication training to IHT staff, and improve communication regarding worker compensation claims. Many of these are included as action items in the WRPS IP report.

The complexity of risk communication issues at Hanford, including uncertainty of exposure characterization, disagreement regarding hazard and health effects, approaches for mitigating risk, and litigation are a significant challenge. To help address these challenges, DOE and WRPS have utilized leading risk communication experts to review and provide management training on appropriate techniques to effectively, transparently, and accurately discuss tank farm safety and health issues with workers.

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HPMC OMS has a Risk Communication program with a full time Risk Communicator (RC) to support the Hanford site. The program is described as “a research-based approach for communicating effectively in high concern, sensitive, high-stress, emotionally charged and/or controversial situations.” The goals of this program of "assisted dialogue among stakeholders" are to enhance trust and credibility, increase knowledge and awareness, and resolve conflict. The HPMC OMS RC provides guidance, recommendations and outlines for effective communication among the many stakeholders involved with Hanford operations. The RC also gives trainings in risk communication and can act as facilitator at meetings planned by and for groups who wish to achieve consensus on a controversial topic.” Although the HPMS OMS RC is aware of the worker-management communication issues regarding the tank farms, it does not appear that there has been significant involvement of the RC in addressing these problems.

One action taken by WRPS in response to recommendations regarding communication is the establishment of a publicly available website (<http://hanfordvapors.com/>) that is intended to provide data, news and background information to interested parties. The website provides sampling results from the tank farms, information on the IH program, background on how chemicals are identified, updates, and reference materials. This is a positive step in helping ensure that information regarding tank farm worker safety and health is disseminated in a timely fashion.

Labor-Management Interaction

There continues to be complex and persistent issues of suspicion, distrust, and apprehension regarding transparency and motivations between employees, union leadership, and DOE and contractor staff and management regarding exposure to tank farm vapors and gases. Some workers perceive DOE and WRPS management to be skeptical of worker motivations, and that they believe issues are specific to a small subset of workers and it has not been demonstrated that a hazard exists. However, unexplained odors still occur and some workers feel they are experiencing exposures and symptoms related to these odors or exposures that are not detectable by smell, that management emphasizes production over safety and is dismissive of health/exposure concerns, and the workers compensation program and claims management system is onerous and dysfunctional.

In interviews conducted with a variety of workers, one overriding theme was a concern with timely and accurate communication. Poor communication of information was described on multiple organizational levels, including between different on-site contractors. One example given was that pesticide sprayers employed by one contractor may not be told by another contractor that there is a stop work in the area of interest resulting in workers entering and working in areas where other workers have been told not to enter.

Within the WRPS organization, it appears that effective communication has also been a challenge, with different organizations/contractors within the company described as not coordinating or informing others of activities that may affect their job. Additionally, some workers interviewed indicated that past efforts by WRPS management to explain odor issues to workers were unsuccessful, with the end result being damaged credibility rather than improved understanding of the issues.

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Specific areas where disagreements, skepticism, uncertainty, concern, and perceived lack of transparency have heightened employee-management tensions include:

- the rationale for the selection of COPC and limitations of this approach, including headspace sampling conditions for making COPC determinations,
- exposure to other non-COPC chemicals that may be present, including those with little or no health effect data, mixtures and potential synergistic effects, and effects of past exposures,
- interpretation of results from a toxicological perspective (e.g., are the determined OELs sufficient for protecting workers) and how exposure monitoring results are/are not utilized for determining worker exposure and making medical determinations of work-relatedness, including the legitimacy/relevance of post-event monitoring results as an indicator of exposure when the odor or health symptom was experienced,
- understanding and communicating the limitations of sampling strategies and analytical capabilities, particularly from IHTs in the field,
- potential for undetected emissions to occur during non-routine events,
- the process for medical triage and physician determinations of work-relatedness,
- the workers' compensation process, timeliness, mechanisms for processing claims, roles, and responsibilities,
- rationale for approaches being taken to resolve the tank farm vapor issues, including the selection of chemicals to monitor, reliance on respiratory protection, the establishment of tank farm perimeters, and justifications for locating personnel offices in close proximity to the tank farms,
- balancing of risk regarding the use of SCBA, and that the potential adverse impact of use (heat stress, vision, ergonomics, communication) should be weighed against the potential inhalation hazard,
- the perception that production is valued over safety.

DOE and WRPS have taken steps to address some of these issues and improve overall labor-management interaction. For example, several members of the NIOSH team were able to attend a meeting of the Chemical Vapor Solutions team (CVST) and found it to be a very positive forum for communication between labor, management and DOE. Among the approximately 60 attendees were managers, industrial hygienists, technicians, labor representatives, and engineers. Management and DOE made presentations on current situations and ongoing projects, and there was an opportunity to ask questions.

Despite well intentioned efforts, ineffective management-employee communication regarding worker safety and health is a problem that NIOSH has found to be common in many investigations. Listening and responding to workers are critical for achieving successful resolution of issues. It is important to respond to all complaints promptly and seriously and to establish credibility through open communication and visibility with employees. Significant problems occur if workers believe that no or inappropriate action is being taken, management is skeptical, or that important information is being withheld. Without open communication between management and workers, and a commitment to resolving issues, health and safety concerns can

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become complicated by anxiety, frustration, and mistrust. This results in an atmosphere of distrust that further complicates efforts to evaluate and correct problems.

Medical Program

Onsite Occupational Health

HPM Corporation Occupational Medical Services (HPMC OMS) has been the Hanford onsite occupational medical provider since October, 2012. They operate two clinics; the “Main” clinic at 1979 Snyder Street in Richland, WA, and the “2-West” clinic in the 200-West Area of the Hanford tank farm site. HPMC OMS provides services to approximately 8,500 employees working for Hanford Site contractors and DOE offices, and others working on site. Services include medical qualifications examinations, medical surveillance examinations, first aid care for occupational injuries and illnesses, return to work and fitness for duty evaluations, and behavioral health and wellness. Frequency and type of medical examinations are based on the Employee Job Task Analysis (EJTA).

During the NIOSH site visit, we were informed that, as of July 27, 2016, there were 2,077 workers enrolled in the tank farm Hazardous Waste Worker Program. The workers enrolled in this program are workers whose jobs, based on the EJTA, involve potential work around the tanks. These workers receive baseline and annual medical monitoring, which includes many of the lab tests collected when a Hanford worker reports a possible exposure to tank farm vapors.

Medical Procedures for a Vapor Exposure Event

If a Hanford worker reports to HPMC OMS that exposure to tank farm vapors may have occurred (with or without health symptoms), an “Exposure Response Team” (ERT) is activated. This team includes the Site Occupational Medical Director, Clinic Director, Principal Manager, Nursing Director, a Certified Industrial Hygienist, Emergency Preparedness Specialist and Nurse Case Manager. The team functions as a medical resource/liaison to the employee’s personal provider(s); workers’ compensation physician(s); and the safety, health and IH staff in the field who responded to the event at the tank farms when it occurred.

Medical protocols for workers who report a possible exposure to tank farm vapors have been developed, in part, on a review of COPCs within the tank headspaces. Based on these, workers are offered the following:

- pulmonary function test (PFT);
- chest x-ray (CXR);
- liver function tests (LFTs), including alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyltransferase (GGT), and prothrombin time (PT);
- kidney function tests, including blood urea nitrogen (BUN) and creatinine (CR);
- complete blood count (CBC) with differential to evaluate overall health;
- urinalysis to screen for kidney disorders, liver problems, diabetes or other metabolic conditions;

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- mercury in blood and urine;
- urinary S-phenylmercapturic acid (S-PMA), a biomarker for exposures to benzene; and
- other tests that the provider feels are indicated.

In addition, 100 milliliters (ml) of urine and 30 ml of blood are obtained and preserved for 45 days in the event exposure data or other information indicate a need for additional tests. Emergency departments in local area hospitals are also provided with this protocol to be followed when an incoming patient reports a potential occupational exposure to tank farm vapors.

Individuals may be referred by HPMC OMS for further evaluation or triaged to a higher level of care, if indicated. Employees with minimal or no symptoms and a normal exam may be returned to work with or without restrictions while the results of lab tests and environmental exposure monitoring are still pending. If any results are found to be of concern, the lab will call HPMC OMS, who can immediately notify the employee.

All Hanford workers who report a possible exposure to tank farm vapors are contacted the following work day by the HPMC OMS Nurse Case Manager or another Registered Nurse to inquire as to his/her wellbeing. In addition, workers are scheduled to return to the clinic within five working days for follow up and lab review with the provider, during which individuals receive copies of their medical test results verbally and in writing. Workers are also encouraged to report for additional medical evaluation at other times if necessary.

Some of the workers interviewed during our site visit expressed confusion about the policy concerning ‘return-to-work’ – specifically regarding the issue of being returned to work before the results of all tests are available. The interviewed workers indicated that a more thorough explanation of this to all workers would be very helpful.

Evaluation of Medical Data

Medical information on workers is entered by HPMC OMS into an electronic medical database called Occupational Health Manager (OHM). Non-medical information, such as demographics, work location, company, and other human resources data, are contained in “PeopleCORE,” a central repository of data for all DOE workers that captures information supplied by all DOE contractor human resource systems. The data from PeopleCORE and OHM are linked and can be used to evaluate individual and group health trends.

Medical Screening for Former Workers

A DOE Former Worker Medical Screening Program (FWP) provides ongoing medical screening examinations, at no cost, to all former DOE Federal, contractor, and subcontractor workers who may be at risk for occupational diseases. The intent of the FWP is to identify diseases or conditions at an early stage and to refer individuals with suspicious findings to their personal

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physician or a specialist for further testing, diagnosis, and treatment. Follow-up care is not covered by the FWP. Information about this program can be found at: <http://energy.gov/ehss/services/worker-health-and-safety/former-worker-medical-screening-program>.

Two nationwide screening projects within the FWP provide medical screening to former Hanford workers: the National Supplemental Screening Program (NSSP) and the Building Trades National Medical Screening Program (BTMed). The NSSP provides medical screening exams to production workers, and BTMed provides exams to construction/building trades workers. Annual reports are generated from these screening projects (<http://energy.gov/ehss/downloads/2015-former-worker-medical-screening-program-annual-report>), but the results presented in these annual reports are summary results for all program participants and are not specific to Hanford tank farm workers.

The FWP Program Manager indicated to NIOSH that it would be possible to evaluate FWP data specifically for former Hanford tank farm workers who have participated in that program. This would require assistance from Hanford (e.g., to help identify specific tanks, provide employee rosters, etc.). The FWP collects data to help identify diseases or conditions that need additional follow-up; not to necessarily identify the cause(s) of those diseases or conditions. As such, data from this program would be limited to medical exam and test results (e.g., chest x-ray, pulmonary function testing, blood/urine analysis, etc.) and would not provide information to link these findings to any particular exposure. Despite these limitations, the data could provide information about medical issues currently being experienced by former tank farm workers.

Workers' Compensation

When a worker reports an exposure, that worker is eligible to file a workers' compensation claim. Penser North America, Inc., (Penser) administers the Workers' Compensation Program at DOE's Hanford Site. The Washington State Department of Labor and Industries (L&I) has oversight authority over the workers' compensation claims process and DOE is required to follow all Washington State rules and regulations that govern the L&I process. L&I reviews all information before allowing or denying a claim, and only L&I (not Penser or DOE) has this authority. All workers' compensation claims are subject to evaluation by established criteria. Among the relevant criteria used to evaluate workers' compensation claims is a physician's opinion that a work-related illness can be attributed to work conditions.

Unlike injury, attribution of a health condition/chronic illness to work is challenging and diagnosis is often difficult as symptoms experienced may be nonspecific and can mimic those associated with non-work-related causes.

Interviewed workers reported that, despite training and assistance offered by the Hanford Workers' Compensation Representatives (http://www.hanford.gov/files.cfm/WC_Representatives_List-071316.pdf), the Workers' Compensation Program is a long-standing area of frequent employee concern and contention. Workers feel the system is onerous, with an extensive burden on the worker to demonstrate work-relatedness of health conditions and are frustrated when work-relatedness is disputed by

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the insurer because of insufficient proof of exposure or because a particular health effect cannot be sufficiently attributed to work.

NIOSH contacted L&I and was informed that workers can contact L&I directly for questions about claims as well as a variety of other workers' compensation issues. Contact information can be found at <http://www.lni.wa.gov/ClaimsIns/Insurance/SelfInsure/ContactUs/Default.asp>. In addition, L&I provides the specific criteria for allowing an occupational disease claim on page 13 of their L&I Attending Doctors Handbook (<http://www.lni.wa.gov/IPUB/252-004-000.pdf>).

Epidemiology Study Considerations

As a component of this review, NIOSH was asked to comment on the feasibility of an epidemiological study of tank farm worker health effects. A draft summary proposal prepared by occupational medical professionals from the University of Washington (Appendix F) was provided to NIOSH for review. The draft proposal entails a descriptive study to review medical provider notes in workers' compensation case files related to tank farm exposure. The study will summarize exposures of concern, presenting symptoms, objective findings (physical exam and diagnostic tests), and diagnoses.

Based on the findings, upon completion the study team will make recommendations regarding additional steps that DOE ORP may consider for further study or to protect worker health. A report will be provided that describes the workers' compensation claims in aggregate that will add a systematic review of objective findings, description of the specialist seen, any causality trends, and extent of diagnostic work-up performed.

There are several criteria NIOSH uses to determine if an epidemiological study is feasible, is likely to be successful, and would help answer important occupational health questions. At a very broad level, NIOSH uses criteria of burden, need, and impact to guide our research (<http://www.cdc.gov/niosh/programs/bni.html>). Burden provides evidence of the health, safety and economic burden (or potential burden) of workplace risks and hazards. The assessment of burden is based on: magnitude of the problem, health impact severity, exposure to workers, societal costs, new or emerging issues, and relationship to the work environment. Need is intended to help define the knowledge gap that would be filled by the proposed research. Impact considers how well the research is conceived and if it is likely to address the need, including its potential to create new knowledge; lead others to act on findings to promote practical intervention, adopt a new technology, or develop evidence-based guidance; aid in setting standards; lead to a decrease in worker injury, illness, disability or death; or enhance worker well-being.

At a more specific level, several factors would be used to determine if an epidemiological study would be appropriate. These factors include:

- What are the specific study objectives and key questions that need to be answered; how would that information be used?

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- What type of study would need to be conducted; can the questions be answered with an epidemiological study; is this the most productive and efficient way to answer these questions?
- Is there sufficient information available to allow for statistically valid conclusions to be made, including:
 - Is there a sufficient number of workers?
 - Are there documented health effects in the study population?
 - Are sufficient exposure data available for the study population?
 - Is an adequate control population available?

These are important considerations that should be addressed when determining the utility of conducting an etiologic epidemiologic research study among Hanford tank farm hazardous waste workers.

Upon review, NIOSH is not convinced of the utility and feasibility of the study described in the University of Washington draft summary proposal. Some specific questions/concerns include:

- The ability of a study such as this to provide a statistically valid association with any health outcome seems doubtful and NIOSH cautions against unrealistic expectations that this study could answer questions regarding causality.
- It is not clear how this study and collected data will be used, interpreted, and communicated, particularly given the limitations. Whether the study suggests a negative, positive, or indeterminate association, how will this be interpreted and communicated? This should be considered and resolved prior to embarking on any study.
- From the information gathered to date, it does not seem feasible to construct a job exposure matrix that would allow for a better understanding of any links between health effects and chemical exposure at the tank farms. Although considerable sampling has been conducted, some of the exposure data may be misleading as data were collected after the incident occurred and may not be representative of conditions when odors/health effects were experienced.
- The workers compensation data represent: (1) a small percentage of workers with health concerns; and (2) a selected subset of data. NIOSH is concerned whether there are sufficient workers compensation data available to provide valid information with applicable health findings.

Conclusions

WRPS and the DOE have taken positive steps, invested considerable resources, created a comprehensive OSH program, developed detailed procedures, hired staff, and established technical worker-management groups to help resolve concerns regarding exposure to tank farm vapors and gases. DOE and WRPS have also collected a significant amount of data they believe demonstrates worker exposures are very low (i.e., well below OELs), not toxicologically significant, and provide evidence there is no, or minimal, health risk to workers in the tank farms. However, some workers have experienced odors and symptoms that they attribute to exposure to tank farm chemicals and either do not believe the data that DOE presents or that the data does not accurately characterize exposures because DOE is not monitoring for the

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appropriate contaminants or using appropriate sampling approaches. This has led to disputes regarding the work-relatedness of health symptoms and compensation claims, considerable distrust and anger, and workers seeking assistance from outside the organization (e.g., Washington State Attorney General, congressional representatives, media).

There appears to be considerable turnover in safety and IH program leadership and staff. As such, given the complexity of the IH program it is difficult for incoming new leadership and IH staff to understand in a timely fashion how the IH and safety programs function, and that legacy issues and lack of institutional knowledge impacts the ability to establish and sustain an effective OSH program.

DOE and WRPS have taken the position that determining the potential for exposure and validating the TVAT bolus hypothesis is necessary before making significant investments in engineering or other permanent controls. Long-term engineering solutions are under evaluation at this time, but decisions on many controls is reserved for Phase II of the WRPS TVAT Report IP. As such, the current emphasis is on determining if exposures are occurring, and not on controls to prevent releases from occurring. Despite this position regarding the lack of evidence indicating the need for engineering controls, workers are using SCBA for entry into the tank farms and a project is underway to evaluate the efficacy of air-purifying respirator cartridges to remove tank farm gases and vapors. Additionally, the medical response to an odor/symptom event includes biological monitoring to assess worker exposure.

DOE has established an exposure and emissions monitoring program and continues to obtain and utilize leading edge sampling technology to better evaluate exposure to chemical gases and vapors. However, due to the complexity and changing nature of the chemical constituents, comprehensively characterizing exposures to all possible chemicals and combinations, establishing validated sampling methods where necessary, and developing evidence-based OELs, is problematic and likely not possible.

Despite significant investments, communication recommendations from previous investigations, utilization of risk communication consultants, and the availability of a risk communicator as a full-time contractor (HPMC), labor-management issues continue and are a core obstacle to resolving worker health and safety issues associated with exposure to tank farm gases and vapors. Recent events involving approximately 50 workers seeking medical assistance and high profile attention from the Washington State Attorney General, Congressional representatives, the media, advocacy groups, and DOE Inspector General, have exacerbated this situation.

This distrust and adversarial relationship are compounded by a perceived lack of transparency, inconsistencies, issues associated with the workers' compensation system determination of work-relatedness, miscommunication between labor and management, and management skepticism. As such, an effective, comprehensive, and transparent program is not in place for effectively communicating across organizational and employee boundaries regarding tank farm vapor issues. Despite significant efforts by DOE and WRPS to address tank farm issues (e.g., multiple internal and external evaluations, extensive investment in monitoring capacity and technology, lack of sampling results indicating exposures may exceed OELs, employee concerns continue.

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This indicates that efforts to establish a strong safety climate and comprehensive approach for providing timely, open, and clear information have not been successful.

Recommendations

Exposure Assessment

All levels of management should recognize and emphasize the importance of initial and recurring training for IHTs. A detailed policy document that delineates specific IHT training requirements, qualification, and requalification should be developed. Identify those skills of most importance for IHTs field work and maintain an active schedule of regular and recurring continuing education opportunities to ensure those skills are retained by trained employees.

- Ensure that a minimum of one years' job-related experience be accumulated before IHTs receive their OJT/OJE qualifications.
- When OJT and OJE qualifications are awarded, ensure that one-on-one training has been emphasized to provide individual learning and that a thorough evaluation of training and skills on-the-job by the IHT has been conducted.
- Ensure initial chemical hazards training is conducted in a period of time sufficient to adequately cover and convey the needed information.
- Establish a program of professional mentoring for inexperienced industrial hygiene technicians to improve and enhance in-the-field training. Such a program could be designed in the apprenticeship model and would allow inexperienced technicians to learn valuable skills and knowledge from more experienced personnel.
- Provide appropriate office/works space for industrial hygiene technicians at a level commensurate with other technician-level employees.
- Improve the management of the IH program through the creation of a centralized manual or website that pulls together the disparate IH procedures, documents, etc. into a structure that management, IH staff, and the workforce can understand, including how they are inter-relatable and better explaining what, how, and why specific IH activities and procedures occur.
- Reinstigate and/or develop a more formal and documented chemical exposure hazard analysis process to provide a consistent basis for documenting and performing occupational exposure assessments for SEGs at specific locations and for specific activities.
- IH managers should ensure the IH Chemical Vapor Technical Basis document is updated on a recurring basis to include new scientific findings and enhanced understandings of potential exposures gained since the document was originally developed. These developments include efforts undertaken as part of the TVAT response to further characterize chemicals in the headspace of the tanks will help inform future assessment and protective actions.
- WRPS has invested significant resources into the pilot monitoring program and other efforts to improve exposure characterization. NIOSH views this as a very positive step and recommends continued efforts to implement leading edge technology and strengthen the IH program. It is important that all collected data be interpreted accurately, including

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the determination of risk; limitations; acknowledgement of associated uncertainty, such as the toxicological significance of very low concentrations; relevance of odor thresholds; and analytical bias. Additionally, it should be recognized that full characterization of potential exposures in all scenarios may not be possible. Regular communication of the information collected and actions taken or not taken in response to the collected data must be reported and made available in a timely manner that is understandable and relevant to the worker population. Such information should include any limitations or uncertainty associated with the data, and an evidence based rationale for collecting samples at specific times and locations, and how results are pertinent to workers in the area. The WRPS Hanford Vapors web site provides one good mechanism for sharing this data. However it is also important to meet directly with workers to convey this information and answer questions.

- Continue working with outside contracting companies and experts to provide unbiased and independent scientific assessments of programs in place and to help guide improvements in hazard identification and control, and risk. This includes s CTEH and scientific experts such as the VMEP that are currently evaluating and monitoring tank farm IH and safety programs. Communicate the results of the CTEH IH program evaluation and other consultant findings to workers in a timely, consistent, and comprehensive manner. This should entail more than providing the report; it should include a discussion of how WRPS and DOE interpret the findings and actions they will take in response.
- It was evident that the services and expertise provided by the VMEP have provided helpful scientific guidance and is a very positive action; such oversight should continue through the completion of Phase 1 implementation and extended into Phase 2 activities.
- Ensure all personnel working in or at the periphery of the tank farms maintain possession of their phones, radios, or other communication devices to ensure messages are received. Investigate the use of localized reader boards or other warning systems that can provide near real-time information to personnel in the area.

Exposure Controls

DOE and WRPS are pursuing a comprehensive exposure and emissions monitoring program with a focus on investigating hypothesized short-term episodic chemical releases. This is a critical component of the tank farm safety and health program and should continue. However, in the absence of a documented hazard, the development and implementation of appropriate engineering and administrative controls is recommended as a prudent precautionary course of action. Due to the complexity and changing nature of the chemical constituents, it does not appear feasible in the near term to comprehensively characterize exposures to all possible chemicals and combinations, develop appropriate sampling methods as necessary, and establish scientifically based OELs. Additionally, the potential episodic nature of emissions are such that exposure monitoring may not capture these events and the results may be misleading. This should be acknowledged and is further rationale for focusing on engineering controls. An emphasis on controls is consistent with the ALARA approach that has been adopted by DOE and WRPS for the tank farms. A primary focus of Phase 1 of the WRPS IP is determining the validity of hypothesized short-term episodic chemical releases through monitoring and modeling

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and should be revised to emphasize engineering and administrative controls as a first priority. This can include control technologies that have already been considered (e.g., improved ventilation, exhaust controls, automation, redundant control systems to prevent a single point failure from resulting in a release to atmosphere).

Additional actions to consider:

- Minimize the need for, and number of, workers who must enter the tank farms;
- Use a precautionary and conservative approach to establish, as much as possible, an evidence-based rationale for the tank farm perimeter and adjust accordingly. This may entail relocating ancillary personnel, including offices, away from the vicinity/perimeter of the tank farms,
- Relocate personnel and offices away from the tank farms whose immediate presence at these locations is unnecessary
- Evaluate the utility and feasibility of establishing control rooms or “safe havens” inside the tank farms; and
- Utilize continuous closed circuit TV for monitoring the tank farms, possibly in conjunction with fixed FLIR camera, which provides a visual indication of a release, as an early warning mechanism.

In the previously referenced 2004 NIOSH Health Hazard Evaluation Report, NIOSH recommended that an approved air purifying respirator be provided to any worker entering a tank farm to protect against exposure to nuisance vapors. This recommendation is still applicable for those situations where objective data indicate that exposures are below OELs and workers wish to voluntarily use a respirator. However, if exposures are known to be above OELs, are uncharacterized, or for specific job activities where there is the potential for a hazardous exposure to occur, respiratory protection may be required as an interim control. The need for respiratory protection should be determined by a qualified IH professional and based on objective data where possible. Reliance on respiratory protection (either SCBA or with cartridges should the respirator cartridge study prove fruitful) for routine work should be considered a temporary control only and not an acceptable permanent solution. Where supplied air is determined to be necessary, utilize airline systems where possible.

Safety and Health Program Management

Emphasis should be placed on establishing a strong, positive, safety climate where everyone, from line worker to upper management, believe in and support the DOE and WRPS commitment to the safety, health, and well-being of the workforce. This must be an explicit effort and have an inclusive, collaborative approach where labor and management participate in evaluating, planning, and making decisions about occupational safety and health issues.

Efforts to improve labor-management interaction, communication, transparency, and employee involvement in safety and health decisions should include:

- DOE and WRPS leadership periodically meeting and interacting directly with

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- workers at the tank farm and unions to provide updates and answer questions,
- Frequent interaction and coordination between contractors, workers, IH staff, and technicians at the work site, and with supervisory/middle-management personnel,
- Establishing and fostering consistency on safety and health issues and trust building between unions.

DOE and WRPS leadership should acknowledge health and exposure concerns as legitimate and directly interact with workers and union leadership on these issues. Frequent presence in the field by professional IH staff and DOE and WRPS leadership is needed to ensure availability and demonstrate commitment. Clear procedures for recording and responding to concerns should be established to ensure adequate and timely response to exposure and health concerns and to prevent small issues from becoming major problems.

Previous risk communication recommendations from the TVAT report and consultants are still valid and should be implemented. The HPMC Risk Communicator should be more directly involved in tank farm worker-management issues.

Utilize mediation/arbitration

Significant labor-management issues remain despite the number of recommendations regarding communication, and the use of professional RC experts for training and consultation. As such, the use of a professional mediation/arbitration service to reconcile differences, resolve specific issues, and establish agreements for future actions is recommended. Objectives should include restoring trust and establishing a positive safety climate.

Medical Program

Consult with an occupational medical professional who can comprehensively review medical data that are available for tank farm workers (e.g., the medical surveillance data collected by HPMC) and who can provide expert advice on collection, analysis, and interpretation of these data and their potential to help assess any relationship between medical findings, reported health effects and/or exposures. For example, if sufficient relevant and scientifically valid information to allow for meaningful conclusions is available, medical lab results for all workers who have reported exposures could be compared to medical lab results for tank farm Hazardous Waste Workers in the HPMC database who have not reported an exposure. It may also be useful to work with the DOE Former Worker Medical Screening Program Manager (<http://energy.gov/ehss/outreach-former-worker-medical-screening-program-fwp>) to identify medical conditions that are being diagnosed in former Hanford tank farm workers and assess whether these conditions are unusual in type or frequency.

- The above reviews might best be accomplished by a professional with expertise in both occupational medicine and occupational epidemiology. Such professionals may be associated with a NIOSH Education and Research Center (<http://niosh-erc.org/courses/locator.shtml>) or with a clinic in the Association of Occupational and Environmental Clinics (<http://www.aoec.org/directory.htm>).

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- Share any results from the above reviews with workers; utilize the HPMC Contract Risk Communicator or other qualified professional to describe findings to workers in non-technical terms. Provide ample time for questions and discussion.
- The focused medical data reviews discussed above would be the types of studies NIOSH recommends, but they are distinct from an etiologic epidemiology study. These reviews are intended primarily to help HPMC OMS maximize the usefulness of current medical surveillance and screening activities to allow the DOE to provide the most appropriate occupational medical care for tank farm workers. From the information made available to NIOSH, an etiologic epidemiologic research study among Hanford tank farm workers would be limited by a number of factors (e.g., lack of relevant exposure data) and would likely not provide timely or useful information to tank farm workers related to their health concerns. Given these limitations and that the issues with the tank farms are immediate and urgent, there should not be an over-reliance on the outcome of such a study to determine what actions should be taken to address the current issues. Therefore, we are not recommending an etiologic epidemiologic study at this time.

Review the medical protocols for workers who report a possible exposure to tank farm vapors and ensure there is an evidence-based rationale for the medical tests that are conducted.

Ensure that all workers (former and current) are provided information about the DOE Former Worker Medical Screening Program (FWP) and their potential eligibility to participate in one of the FWP screening projects; either the National Supplemental Screening Program (NSSP), which provides medical screening exams to former in-house/production workers (<http://www.ornl.gov/nssp/>), or the Building Trades National Medical Screening Program (BTMed), which provides exams to former construction/building trades workers (<https://www.btmed.org/index.cfm>).

Medical management and workers' compensation

Provide to all workers a more thorough explanation of the policy concerning return-to-work following a reported exposure and before the results of all medical tests are available. Provide this information not only to workers who report to HPMC for evaluation, but to all tank farm workers during general meetings.

- a. Work with the L&I Workers' Compensation ombudsman listed on the L&I website (<http://www.lni.wa.gov/ClaimsIns/Insurance/SelfInsure/ContactUs/Default.asp>) to organize meetings with workers to discuss questions, concerns, and issues related to the Workers' Compensation program.

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Appendix A: NIOSH Program Review: Hanford Tank farms Site Visit Agenda

Monday July 25

- 7:15 AM: Visitor Orientation
NIOSH members: *all*
Location: *Federal Building*
- 8:00 AM: Arrange Logistics
NIOSH members: *all*
Location: *office space in DOE ORP Building 2440*
- 8:30 AM: Opening Meeting with DOE and Union representatives
NIOSH members: *all*
Location: *DOE ORP Bldg. 2440 Stevens/Conference Room 1305A*
- 9:30 AM: Tank Farm tour: SST and DST farms, review process, tasks conducted by workers, perimeter establishments, observe area where PPE/SCBA is donned and doffed, observe current and planned monitoring equipment
NIOSH members: *all, DOE, WRPS, Worker Representative*
- 1:00 PM: Lunch
(approx.)
- 2-3:00 PM: Meet with Union Safety Representatives
NIOSH members: *all*
Location: *WRPS building 2704, room C-207*
- 3-5:00 PM: Open time to meet with workers
NIOSH members: *all*
Location: *WRPS building 2704, room E-213*
- 5-6:00 PM: NIOSH Team Meeting

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Tuesday July 26

- 7-9:00 AM: Medical interface oversight interview with ORP
NIOSH members: *Max, Yvonne*
Location: *DOE ORP 2440/1305C*
- 9-11:00 AM Tour 200 West Medical Clinic with Ashley
NIOSH members: *Max, Yvonne*
- 8-10:00 AM: Open time to meet with workers (WRPS building)
NIOSH members: *Sam*
Location: *WRPS building 2704, Room E-213*
- 9-11:30 AM: Meet with WRPS IH and ESH&Q related to chemical vapor management (Ken Way and Rob Cantwell), WRPS IP Progress (Jeff Peterson), WPRS Pilot Scale Technology Demonstration (Jason Vitali), WRPS Engineering Controls for Vapors (Dan Baide)
NIOSH members: *Bradley, Barb (+ Sam when available)*
Location: *DOE ORP 2440/1305B*
- 11 AM- 1 PM: TF Interview on Medical Interface
NIOSH members: *Max, Yvonne*
Location: *DOE ORP 2440/1305C*
- 11-1:30 PM: Lunch
(approx.)
- 12-1:30 PM: Meet with IP leads
12-12:30 Abatement (George Weeks)
12:30-1:00 Cartridge Filter Testing (Mark Bleauz)
1-1:30 Headspace Sampling (Jim Ilar)
NIOSH member: *Bradley, Barb, Sam, Max Yvonne*
Location: *DOE ORP 2440, Room 1600*
- 2-3:00 PM: NIOSH Team Meeting
- 3-7:30 PM: Meet off-site with HAMTC union officials/members
NIOSH members: *all*

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Wednesday July 27

- 7-8:00 AM: NIOSH Team Meeting
- 8-10:00 AM: Open time to meet with workers
NIOSH Team members: *Yvonne, Sam*
Location: *WRPS building 2704, Room E-213*
- 8-9:00 AM Meet with Rob Cantwell, WRPS EH&S Manager
NIOSH members: *Max, Bradley, Barbara*
Location: *WRPS building 2704, office 2750E/C201*
- 9-11:30 AM: Tour of 2704-HV IH lab, respirator check out, respirator cleaning station
NIOSH members: *Max, Bradley, Barb*
Location: *2704 IH lab*
- 10:30-1 PM: Tour of Main Medical Clinic and Meeting with Dr. Sandy Rock, Dr. Karen Phillips, Ms. Ashley Morris
NIOSH members: *Max, Yvonne*
Location: *Main Medical Clinic, 1979 Snyder Street, CR 136*
- 11:30-12:30: Lunch
(approx.) (Working lunch for Bradley and others interested in reviewing the IH database in Rich's office in 2704; Joyce Caldwell, manager of the database, can be present to answer questions)
- 12:30-2 PM: VMEP interview and conference call
NIOSH members: *Sam, Bradley (Max, Yvonne if available)*
Location: *DOE ORP Building 2440, Room 1200 or conference call in from 2704 HVF112 (many of the VMEP members will be calling into this rather than actually physically present)*
- 1-2:00 PM Attend New Technology subcommittee meeting
NIOSH member: *Barb*
Location: *2704-HV G229*
- 2-4:00 PM: WRPS Chemical Vapor Solutions Team Meeting
NIOSH members: *all*
Location: *2704-HV Conference room G-206*
- 4:30-7:00 PM Meet off site with UA Local Union 598
NIOSH members: *all*
- 6:00 PM: NIOSH Team Meeting

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Thursday, July 28

- 7-8:00 AM: NIOSH Team Meeting
Location: *WRPS building*
- 8-10:00 AM: Open time to meet with workers
NIOSH members: *all*
Location: *WRPS building 2704, Room E-213*
- 10-11 AM: Meet with 3 IH Tech for interview
NIOSH members: *Bradley, Max and Barb*
Location: *WRPS building 2704, Room F112*
- 11-12:00 PM: Meet with New Technology CVST chair (Ron Calmus) to discuss Pilot Scale Technology and RJ Lee Van
NIOSH members: *Bradley, Barb, Sam, Max*
Location: *WRPS building 2704, Room F-112 (or out in the field to view equipment)*
- 12-12:30 PM: Meet with Engineering Chair (Dan Baide)
NIOSH member: *Barb*
Location: *WRPS building, 2704, Room F-112 (or out in the field to view controls)*
- 1-2:00 PM: Meet with Event Investigation Process with WRPS (Steve Killoy) and ORP (Ron Frink)
NIOSH member: *Barb*
Location: *WRPS building 2704, Room F-112*
- 1-2:00 PM: Meet with IH Tech Training/Chemical Training group(s)
NIOSH members: *Bradley*
Location: *WRPS building 2704-HV, Room E-213*
- 2-4:00 PM: NIOSH Team Meeting
Location: NIOSH assigned space in 2440
- 4:00 PM: Closing Meeting with DOE and Union Representatives
NIOSH members: *all*
Location: *2440/2200*

Appendix B: DOE letter requesting NIOSH assistance



**U.S. Department of Energy
Hanford Site**

16-SHD-0031

JUN 20 2016

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Washington, D.C. 20201

Dr. Howard:

We very much appreciate the National Institute for Occupational Safety and Health (NIOSH) contacting the U.S. Department of Energy (DOE), Office of River Protection (ORP) on June 3, 2016, to discuss opportunities for NIOSH to provide assistance regarding Hanford Tank Farm worker safety and health programs. As you know, ORP staff have been communicating with NIOSH on a variety of topics including potential Health Hazard Evaluations, assistance with a recommendation pertaining to possible epidemiological studies, personal protective equipment, and exposure monitoring. ORP is very interested in working with NIOSH and appreciates your proposed plan to conduct a short-term, focused, evaluation in four programmatic areas. ORP has evaluated our ongoing Tank Farm worker safety and health program improvement actions to identify activities consistent with the proposed areas of interest identified by NIOSH and feel the plan (attached) addresses important DOE safety and health priorities. We also understand that during the conduct of the evaluation there may need to be modifications to the proposed course of action and we will work with you as necessary. The dates listed in the plan are the dates activities are scheduled that NIOSH may wish to observe. The dates are not completion dates for NIOSH activities.

The scope of the evaluation is not limited and includes all workers and organizations that work within, or in the proximity of, the Hanford Tank Farms. We understand that for NIOSH to conduct this evaluation, access to personnel (workers, managers, safety, health, and medical staff), records, and data is necessary, and DOE will ensure this information and personnel access is made available.

We understand and agree that all activities and communication will include labor and management representation to ensure transparency in conformance with the NIOSH regulations and policies. Prior to any site visit, a teleconference will be held with DOE, Union, and other appropriate representatives to ensure all involved understand and agree on NIOSH's role and objectives.

*Office of River Protection
P.O. Box 450
Richland, Washington 99352*

*Richland Operations Office
P.O. Box 550
Richland, Washington 99352*


Review of Hanford Tank Farm Worker Safety and Health Programs

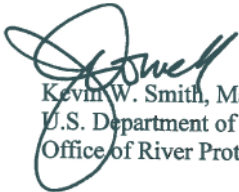
Dr. John Howard
16-SHD-0031

-2-

JUN 20 2016

Your primary point-of-contact within ORP will be Mr. Brian Harkins, Deputy Assistant Manager, Technical and Regulatory Support, (509) 376-3567. Brian will be happy to resolve any questions and facilitate completion of these activities. We look forward to working with NIOSH on this evaluation.


Stacy Charboneau, Manager
U.S. Department of Energy
Richland Operations Office


Kevin W. Smith, Manager
U.S. Department of Energy
Office of River Protection

Attachment

cc w/attach:
L.D. Romine, North Wind Solutions LLC

Review of Hanford Tank Farm Worker Safety and Health Programs

Attachment
16-SHD-0031
(2 Pages Excluding Cover Sheet)

Proposed NIOSH Action Plan for Technical Assistance

**Hanford Tank Farms:
Proposed NIOSH Action Plan for Technical Assistance**

In response to recent concerns associated with potential for exposures to chemical vapors on the U.S. Department of Energy's (DOE) Hanford Site in southeast Washington State, DOE Office of River Protection and the National Institute of Occupational Safety and Health (NIOSH) proposes conducting a short-term, focused, programmatic evaluation in the following areas:

1. **Medical:** NIOSH proposes to review current policies and operational procedures for evaluating worker health concerns for all employees associated with the Hanford Tank Farms. This review would include details concerning routine or targeted medical monitoring, clinical assessments performed in the event of health concerns associated with occupational exposures, recording of potential occupational health effects, management and analyses of the health data which are collected, and how individual and group information is communicated. NIOSH will review previous assessments of the occupational medicine program that have been conducted. NIOSH occupational medicine and epidemiological personnel will provide recommendations to DOE regarding the development of a statement of work for these activities as appropriate. During the evaluation, NIOSH will:
 - Review DOE's health effects clinical study design and management plan that was initiated in response to the April 25, 2016, NIOSH recommendation. (July)
 - Review of past occupational medicine assessments for comment or follow up. (June)
 - Meet with the Office of River Protection Vapor Management Expert Panel to review past Hanford Epidemiological studies relevant to tank farm workers.

2. **Exposure Assessment:** NIOSH proposes to review programs in place for monitoring worker exposure to chemical contaminants, including the development of sampling strategies, biological monitoring, real time and integrated sampling, identification of unknowns, data interpretation, reporting of results, responding to concerns regarding possible exposure, and managing the data for trend analysis. NIOSH is aware of the following current Office of River Protection projects and may observe/review these activities as a component of NIOSH's review:
 - Contractor headspace characterization methodology and results. (August/Sept.)
 - Tank farm trial Instrumentation data and operational value/viability. (June – Sept.)
 - Deployment strategy and application of summa canisters to better characterize emissions and exposures. (June – Sept.)
 - Tank farm air dispersion models and applications and integrations with the air monitoring strategy. (June)
 - DOE evaluation of the Savannah River Report bolus theory. (October)
 - DOE plans and progress to benchmark or modify personal sampling techniques to account for short, transient exposures. (June - October)

3. **Safety and Health Program Management:** NIOSH proposes to review policies and operational procedures regarding risk communication and labor-management interaction on health and safety issues, how issues regarding exposure monitoring are communicated and resolved, and mechanisms for worker reporting of safety concerns. NIOSH is aware the following items are currently ongoing and may review:

- The Pacific Northwest National Laboratory proposed Tank Farm Toxicity Review Board for Occupational Exposure Limits and Chemicals of Potential Concern development. (Fiscal Year 2017)
 - Industrial Hygiene and Industrial Hygiene Technician procedures, policies, and training needs. (July)
4. **Exposure Control:** NIOSH proposes to review the overall Hanford tank farm Site Control and Vapor Control Strategy, including the development, implementation, and assessment of engineering controls, personal protective equipment use, including respiratory protection, determination of the scope of restricted areas, and other, e.g., administrative, controls. NIOSH is aware the following items are currently ongoing and may review:
- Tank vapor and gas respirator cartridge test results and utilization plans (August/Sept./Oct.)

NIOSH Evaluation Team

The NIOSH Western States Division in Spokane, Washington, would lead a NIOSH multi-disciplinary team to conduct the evaluation.

NIOSH Team Members:

Max Kiefer—Interim Director, Western States Division

Sam Glover—Supervisory Research Health Scientist, Chief, Biomonitoring and Health Assessment, Division of Applied Research and Technology

Barbara Alexander—Research Mechanical Engineer, Division of Applied Research and Technology

Bradley King—Industrial Hygienist, Western States Division

Yvonne Boudreau—Occupational Physician, Western States Division

Evaluation Report

It is anticipated that one or more site visits will be necessary to fully evaluate the focus areas. Upon conclusion of the NIOSH evaluation, a letter report of findings and recommendations will be prepared and sent to DOE and worker representatives.

Review of Hanford Tank Farm Worker Safety and Health Programs

Appendix C: Selected documents reviewed by NIOSH staff (not all inclusive)

Hanford Tank Vapor Assessment Report, Savannah River National Laboratory: SRNL-RP-2014-00791 (DOI 10/30/2014)

WRPS Implementation Plan for Hanford Tank Vapor Assessment Report Recommendations

Federal Occupational Health Independent Assessment Team assessment of the HPMC Occupational Health Services relative to Tank Farm vapor issues (DOI 5/14/2014)

Hanford Atomic Metals Trades Council Letter to DOE and WRPS: Tank Farm Vapors and Worker Safety (DOI 6/20/2016)

Washington River Protection Solutions Letter to HAMTC President: Response to HAMTC Tank Farm Vapors and Worker Safety Letter (DOI 6/21/2016)

Hanford Atomic Metals Trades Council Letter to WRPS President: Tank Farm Vapors and Worker Safety (DOI 7/11/2016)

Independent Review Panel Report on Chemical Vapors Industrial Hygiene Strategy: Breysse P, Stenzel M (DOI 9/2010)

TF-AOP-O15 Response to Reported Odors or Unexpected Changes to Vapor Conditions procedure and selected AOP-015 reports

Selected WRPS Industrial Hygiene Sampling Plans for the Tank farms.

Documentation on technology, sampling strategy, and instrumentation for the Hanford Pilot Monitoring program, including the PTR-MS Mobile Laboratory

DOE Memorandum 16-SHD-0034: Safety and Health Exposure Assessment: Tank Farm Worker Exposure to Elemental and Dimethyl Mercury, June 2016 (DOI 7/16/2016)

Inhalation Technology Journal: Development of occupational exposure limits for the Hanford Tank farms (2010)

U.S. DOE Hanford Site Stop Work Procedure: DOE -0343, Rev.3. (DOI 11/21/2013)

US DOE Occupational Health Data Review: Incidence and Risk of Central Nervous System Disorders. (DOI 8/11/2011)

US DOE ORP S-15-SHD-TANKFARM-001: Health Surveillance of Vapor Exposure Concerns November 9-20, 2015. (DOI – unknown)

CH2M Hill Industrial Hygiene Chemical Vapor Technical Basis RRP 22491, Revision 1
http://hanfordvapors.com/wp-content/uploads/2016/08/ESH_IHTechBasis_RPP-22491Rev1.pdf
(DOI- unknown)

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Benchmarking Survey of Industry Programs and Academic Experts' Recommended "Best Practices for Medical Surveillance of the Hanford Site Tank Farm Workers: Lee Newman and Michael Kosnett: (DOI 8/31/2010)

"Health Effects Panel Evaluation of Pulmonary Function and Liver Enzyme Levels Among Hanford Tank Farm Workers" – panel of national exposure assessment and medical experts – purpose 'to determine if conclusions could be drawn about health effects from past exposure (2006).

Occupational Medicine Review" by Dr. Hutchins – contract occupational medicine physician (2009)

"Consultation to AMH regarding Hanford Tank farms and Workers" by Dr. Brady- independent Medical Review (2009)

DOE/ORP assessment of industrial hygiene and occupational medicine activities (2015)

HPMC report "Population Health Analysis Trending Report, Tank Farm Hazardous Waste Worker" (2015)

Review of Hanford Tank Farm Worker Safety and Health Programs

Appendix D: Chemicals of Potential Concern

As of June 3, 2016

Agent List (CAS Number)	Occupational Exposure Limit (OEL) **	Action Level (50% OEL)
Ammonia 7664-41-7	25 ppm	12.5 ppm
Nitrous Oxide 10024-97-2	50 ppm	25 ppm
Mercury 7439-97-6	25 ug/m3	12.5 ug/m3
1,3-Butadiene 106-99-0	1 ppm	0.5 ppm
Benzene 71-43-2	0.5 ppm	0.25 ppm
Biphenyl 92-52-4	0.2 ppm	0.1 ppm
1-Butanol 71-36-3	20 ppm	10 ppm
Methanol 67-56-1	200 ppm	100 ppm
2-Hexanone 591-78-6	5 ppm	2.5 ppm
3-Methyl-3-butene-2-one 814-78-8	0.02 ppm	0.01 ppm
4-Methyl-2-hexanone 105-42-0	0.5 ppm	0.25 ppm
6-Methyl-2-heptanone 928-68-7	8 ppm	4 ppm
3-Buten-2-one 78-94-4	0.2 ppm	0.1 ppm
Formaldehyde 50-00-0	0.3 ppm	0.15 ppm
Acetaldehyde 75-07-0	25 ppm	12.5 ppm
Butanal 123-72-8	25 ppm	12.5 ppm
2-Methyl-2-butenal 1115-11-3	0.03 ppm	0.015 ppm
2-Ethyl-hex-2-enal 645-62-5	0.10 ppm	0.05 ppm
Furan 110-00-9	1 ppb	0.5 ppb
2,3-Dihydrofuran 1191-99-7	1 ppb	0.5 ppb
2,5-Dihydrofuran 1708-29-8	1 ppb	0.5 ppb
2-Methylfuran 534-22-5	1 ppb	0.5 ppb
2,5-Dimethylfuran 625-86-5	1 ppb	0.5 ppb
2-Ethyl-5-methylfuran 1703-52-2	1 ppb	0.5 ppb
4-(1-Methylpropyl)-2,3-dihydrofuran 34379-54-9	1 ppb	0.5 ppb
3-(1,1-Dimethylethyl)-2,3-dihydrofuran 34314-82-4	1 ppb	0.5 ppb
2-Pentylfuran 3777-69-3	1 ppb	0.5 ppb
2-Heptylfuran 3777-71-7	1 ppb	0.5 ppb
2-Propylfuran 4229-91-8	1 ppb	0.5 ppb
2-Octylfuran 4179-38-8	1 ppb	0.5 ppb
2-(3-Oxo-3-phenylprop-1-enyl)furan 717-21-5	1 ppb	0.5 ppb

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2-(2-Methyl-6-oxoheptyl)furan 51595-87-0	1 ppb	0.5 ppb
Diethyl Phthalate 84-66-2	5 mg/m3	2.5 mg/m3
Acetonitrile 75-05-8	20 ppm	10 ppm
Propanenitrile 107-12-0	6 ppm	3 ppm
Butanenitrile 109-74-0	8 ppm	4 ppm
Pentanenitrile 110-59-8	6 ppm	3 ppm
Hexanenitrile 628-73-9	6 ppm	3 ppm
Heptanenitrile 629-08-3	6 ppm	3 ppm
2-Methylene butanenitrile 1647-11-6	0.3 ppm	0.15 ppm

**OEL: Most protective limit selected from the OSHA Permissible Exposure Limit, American Conference of Governmental Industrial Hygienists Threshold Limit Value, or Hanford Acceptable OEL; the upper limit on the acceptable concentration of a hazardous substance in workplace air for an 8-hour day and a 40-hour work week

Appendix E: Occupational Exposure Limits and Health Effects

NIOSH investigators utilize mandatory (legally enforceable) and recommended occupational exposure limits (OELs) for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a time-weighted average (TWA) exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limit or ceiling values. Unless otherwise noted, the short term exposure is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations. The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.

NIOSH Recommended Exposure Limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2010].

Other OELs commonly used and cited in the United States include Threshold Limit Values (TLVs), which are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), a professional organization, and the workplace environmental exposure limits (WEELs), which are recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. These OELs are not consensus standards. TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline “to assist in the control of health hazards” [ACGIH 2016]. WEELs have been established for some chemicals “when no other legal or authoritative limits exist” [AIHA 2016].

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution

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ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) PPE (e.g., respiratory protection, gloves, eye protection, hearing protection).

References

ACGIH [2016]. 2016 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

AIHA [2016]. AIHA 2016 emergency response planning guidelines (ERPG) & workplace environmental exposure levels (WEEL) handbook. Fairfax, VA: American Industrial Hygiene Association.

NIOSH [2010]. NIOSH pocket guide to chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2010-168c, <http://www.cdc.gov/niosh/npg/>.

Appendix F: Case Series Review of Hanford Tank Farm Workers' Comp Claims: Draft Proposal

By Debbie Cherry, MD
Associate Professor, University of Washington
7/29/2016

Background

Hazardous waste, comprised of complex mixture of chemicals and radioactive materials, has been stored for decades in underground storage tanks at Hanford. A recent uptick in worker complaints of odors & irritant type symptoms has occurred. The onsite clinic, HPMC, has performed internal epidemiological analysis of all the information they have on these workers, including comprehensive annual screening, onsite evaluation for acute events, and return to work clearance exams. They do not store or access medical information related to worker's comp claims. It is estimated that about 10% of workers who file an internal report of vapor exposure go on to file a worker's comp claim.

Case Series Review – Objectives

The purpose of this descriptive study is to review the medical provider notes on worker's comp case files related to Tank Farm exposure. The review will summarize exposure of concern, presenting symptoms, objective findings (physical exam and diagnostic tests), and diagnoses.

The study team will interpret any trends in diagnoses and/or exposures of concern related to diagnoses in the set of data as a whole. The team will not comment on any individual cases in terms of etiology. The team will NOT view or consider whether the case was "accepted" under L&I.

The study team will make recommendations regarding any additional steps that ORP may consider for further study or to protect worker health based on the findings.

The data available to the employer currently regarding these claims includes the final diagnosis, whether or not the claim was accepted as being work related, and the amount of time loss, if any.

The final product will be a report describing the worker's comp claims in aggregate that will add a systematic review of objective findings, description of the specialist seen, any causality trends, and extent of diagnostic work up performed.

Methods

Population: Hanford employees who filed an AOP15 and also a worker's comp claim with Penser between Jan 1, 2012 and current date (apx. December 2016) related to Tank Farm vapors (n=apx. 100). There is no comparison group for this case series approach.

Note:

Alternative method A, which would be more comprehensive and time consuming, would involve population = all Tank Farm workers, claims = all worker's comp claims filed, regardless of vapor exposure concerns. Comparison group = same group that HPMC uses for health trending report on annual

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surveillance data for comparison to Tank Farm workers, all worker's comp claims over the reference time period.

Alternative method B would involve same populations as above (all Tank Farm workers + comparison group), but would include not only worker's comp claims but also all personal health records for the reference time period (2012-2016).

Exposure data: If not available from the medical provider notes, obtain additional data from Hanford including IH data from AOP15; job title; geographic location of exposure; job title at time of exposure; and employment history

Variables to be abstracted from medical provider files of worker's comp claims:

Demographic – age, gender, race, job title

Presenting symptoms – such as headache, nosebleed, nausea, sore throat, etc.

Exposure of concern – see “exposure data” above*

Pre-existing conditions (if mentioned)

Current medication (if listed)

Smoking history (if available)

Physical exam findings – vital signs; height and weight; any abnormal findings such as wheeze, rash, tremor, etc.

Diagnostic findings – tests offered/recommended, tests performed, and results of blood work, lung function, x-rays, etc.

Type of specialist seen (could be many, including referrals and consultations)

Number of visits to each specialist (will review IMEs but **not** consider any administrative decisions related to individual claims)

Final diagnosis

*IH data and employment history may or may not be relevant to the exposure of concern

Data Collection

Hanford has indicated that the HPMC provider could legally collect detailed data as described above from worker's comp files without individual permission. They could not, however, make the data public not even the aggregate data based upon initial discussions with DOE legal counsel. Another advantage – HPMC could link the worker's comp files to the epi data they have already compiled re AOP15 filers or the Tank Farm workforce. The disadvantage of this approach would be the loss of independence and deviation from guidance previously received by NIOSH. This is the only approach that supports the initial method and would have limited UW participation.

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For a UW investigator to gather this data, individual consent is required. DOE will require record release from individuals, at a minimum. The UW IRB may additionally require individual consent to protect human subjects, with an explanation to each individual as to the benefits and risks of participation, with assurance that no one is coerced to participate. This option would be better suited to Alternative A or B since it is anticipated that less than 100% participation will be achieved through voluntary release of records and to maximize the population to be evaluated.

Recruitment – to be determined

Data storage – to be determined (simplest = Excel spreadsheet on a secure server, each row has a unique subject ID)

Chart review will occur in Richland, Penser office

Will probably take 50 hours for a provider to complete 100 charts

Appendix G: NIOSH Hanford Program Review: Informal Worker Interview Checklist

Date/Time: _____

NIOSH Representative(s): _____

Introduce yourself and provide overview of NIOSH and our program review.

Number of workers present at interview _____ (this will often be only 1 person, but if there is a group of workers participating, be sure to note the number in that group).

Use the topics below as a guide for your interview

Job Description/Tasks:

Work location (Tank Farm identifier):

Tenure at Hanford Tank farms (overall and at current job title):

Priority health and safety concern(s):

Vapor incidents experienced personally: frequency, duration, locations, use of PPE at the time; were they smelling odor only or did they experience a health effect.

Communication: reporting of incidents to management; responsiveness to requests/issues/odors; information provided, explanations, interaction with IH technicians, training, provision of IH personal sampling results, etc.

Medical support if symptoms are experienced; treatment/follow-up; communication of results; specific tests if known

Description of PPE used inside the Tank farms (training, how accessed):

Suggestions for resolving issues associated with exposure to vapors at the Tank farms:

Questions for NIOSH:

Thank the worker(s) and let them know a report will be forthcoming and we will ask that it be provided to all employees associated with the Tank farms.