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Third Party Qualified Independent Review: Hanford Tank Farm Respirator Cartridge Testing

Report No 1:
Review of:
Nune SK, Liu J, Freeman CJ, Brouns TM. Analysis of Respirator Cartridge Performance Testing on a Hanford AP Tank Farm Primary Exhauster Slipstream. Pacific Northwest National Laboratory, PNNL 25860, September 2016.

WRPS's Prime Contract DE-AC27-08RV14800
Agreement No. 294846

December 11, 2016

Note:

This is a preliminary report. We reserve the right to amend it as more information and test results become available.

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DISCLAIMERS

This "independent third party" review was conducted by a team of subject matter experts assembled by Stoneturn Consultants (STC) and its subcontractor CPWR: The Center for Construction Research and Training. It was conducted as a result of an agreement between Hanford Atomic Metal Trades Council (HAMTC) and Washington River Protection Solutions (WRPS). STC was selected by HAMTC to perform the review.

The review was based on reports supplied by WRPS and Pacific Northwest National Laboratory (PNNL) and interviews with staff from WRPS, PNNL and leaders and representatives of HAMTC. None of these organizations had a say in the way the review was performed or in the findings and recommendations resulting from it.

This work was based on the evidence presented to us. We did not attempt to verify the accuracy of this information. We did observe the testing apparatus but did not physically observe the conduct of actual field testing, and we did not attempt to re-compute the statistical analyses which had been performed. Therefore we do not in any way warrant the validity of the information that we relied on for the assessment. Nor do we warrant, whether express or implied, any health protection stated or implied as a result of the testing performed by WRPS and NPPL.

Any mention of any commercial product in this report does not in any way constitute any endorsement or recommendation by STC, CPWR or the review team.

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ACRONYMS USED IN THIS REPORT

ALARA. As Low as Reasonably Achievable
APR. Tight-fitting Non-powered Air-purifying Respirator
COPC. Chemicals of Potential Concern
CPWR. The Center for Construction Research and Training
DART. Days Away from Work, Restricted Duty, or Transfers, as defined by OSHA
DST. Double shell tank
EPA. US Environmental Protection Agency
HAMTC. Hanford Atomic Metal Trades Council
HEPA. High Efficiency Particulate Air (or Arrestance)
HP. Heath physics
IH. Industrial hygiene
NDEA. N-nitrosodiethylamine (a chemical in the Nitrosamine family)
NIOSH. National Institute for Occupational Safety and Health
OEL. Occupational Exposure Limit
OSHA. Occupational Safety and Health Administration, US Department of Labor
PAPR. Powered Air-Purifying Respirator
PF. Protective Factor
PNNL. Pacific Northwest National Laboratory
RPD. Respiratory Protection Device
SCBA. Self-containing Breathing Apparatus
SST. Single shell tank
STC. Stoneturn Consultants
TVAT. Tank Vapor Assessment Team
WRPS. Washington River Protection Solutions

1. SUMMARY AND WAY FORWARD

Review Finding:

The method used for testing of cartridges and their measured performance is acceptable for the conditions and exposures at the time of testing in the AP Tank Farm Primary Exhauster Slipstream. However, more testing is needed to determine the performance of the cartridges before they can be applied in respiratory protection in the Tank Farms.

This finding is proscribed by the limited evidence available:

- **Only two tests were done (one with each cartridge) at one point in time.**
- **The adsorption qualities of activated or impregnated carbon can be affected by temperature and humidity. Consequently, we have insufficient data to determine if the results are generalizable to times when climatic conditions differ from those at the time of testing.**
- **The testing was performed on a subset of chemicals in the Tank Farm, and we do not know the actual chemical composition of the tank waste. Consequently, we cannot determine if the testing results are generalizable to all potential chemical exposures, and particularly to combinations of chemicals which may act together to increase the risk.**
- **WRPS has not made clear where within the AP Tank Farm use of respiratory protection utilizing the tested cartridges is intended to replace use of self-contained breathing apparatus (SCBA). Consequently, we have no way of assessing whether the proposed chemical cartridge respirators will be sufficiently protective. A precautionary respiratory protection program may require use of SCBA within a defined vicinity near any venting source and during any work activity that may release chemical vapors.**
- **Neither the WRPS Respiratory Protection Program nor the worker chemical exposure data were reviewed as part of this effort. Consequently, we do not know the required level of respiratory protection and whether tight-fitting facepiece air-purifying respirators (APR) with cartridges will provide the expected protection based only on cartridge breakthrough testing data obtained so far.**

Way Forward

We recommend the following steps be taken — some concurrently to expedite the process — and we are prepared to provide continued assessment and consultation to HAMTC and WRPS in establishing effective respiratory protection.

- **Expedite the completion of the analyses of the remaining six tests that have been done to date. Those data should give us a better indication of performance of the cartridges under a broader range of tank or exhauster exposures, work operations, and other conditions during testing that affect cartridge performance.**
- **Immediately increase additional testing of the current cartridges. So far all the tests have been performed in areas where the tanks have been "at rest." Begin re-testing**

in the AP Tank Farm as soon as the disturbing activities there ramp up to see if exposures change cartridge performance.

- **If considered a feasible respiratory protection technology, PAPRs should be tested as soon as possible as a complement to APRs or alternative to SCBA or airline respirators. PAPRs can offer a higher level of protection than APRs and may provide added comfort, although they introduce additional challenges, such as battery duration and maintenance.**
- **Assess the proposed WRPS respiratory protection program to see if it is ready to implement APR. Preventing inward leakage associated with use of APRs may be every bit as challenging as cartridge performance.**
- **Conduct additional assessments of injury data and pulmonary function data.**

These are preliminary findings. We reserve the right to amend them as more information and testing data become available.

For details on our assessment see sections 4 and 5 of this report.

2. BACKGROUND

On August 31, 2016, a Memorandum of Agreement was established between Washington River Protection Solutions (hereafter "WRPS") and Hanford Atomic Metal Trades Council (hereafter "HAMTC") dated August 31, 2016, which called for an independent review of the testing of respirator cartridges conducted by WRPS and PNNL. HAMTC selected CPWR: The Center for Construction Research and Training (hereafter "CPWR"), as its independent reviewer and CPWR in turn asked Stoneturn Consultants (hereafter "STC") to take the lead on the review with support from CPWR. This arrangement was agreed to by HAMTC, and STC assembled a team of leading national subject matter experts to conduct the review. The review was done under a contract between STC and WRPS, in which WRPS had no control over the technical work.

Over the years there have been numerous worker complaints about health effects from being exposed to toxic vapors in the Hanford Tank Farms. In 2014 WRPS commissioned an assessment of whether tank farm vapors pose a hazard to workers. This assessment, known as the "TVAT"[1] concluded there were significant potential risks in WRPS management of worker protection from intermittent, short-term "bolus" releases of tank vapors, and made numerous recommendations for improving health protections. These included giving industrial hygiene parity with health physics, and developing better PPE protection.

In response to the TVAT recommendations, WRPS began developing and implementing an action plan[2] which included establishing an ALARA standard for health protection from chemical vapors, revamping the industrial hygiene program, finding alternative engineering controls, and developing and testing different respiratory PPE.

Meanwhile further complaints from workers about health effects led HAMTC to call for a stop work order in the spring of 2016, and as a result the WRPS implemented a program where all workers in the Tank Farms would work under supplied air using SCBA until a better respirator (RPD) alternative could be found.

The initial alternative selected was tight-fitting non-powered air-purifying respirators (APRs). APRs rely on chemical cartridges or canisters that contain sorbents (e.g. activated or impregnated carbon) to remove gases and vapors from the air. A cartridge or canister can also contain a particulate filter. The cartridge is attached directly to a tight-fitting respiratory protection device (RPD), so that when the worker inhales the air goes through the air-purifying cartridge or canister and into the RPD. This type of APR operates under negative pressure relying on the wearer's inhalation to bring purified air into the RPD. Alternatively, the cartridge or a larger canister can be attached to a battery-powered blower assembly that draws air in through the canister and then delivers the purified air through a hose into a tight-fitting facepiece or loose-fitting hood RPD. This is known as a powered air purifying respirator (PAPR). PAPR can offer higher levels of protection than a tight-fitting negative pressure APR and some comfort

[1]Savannah River National Laboratory. Hanford Tank Vapor Assessment. SRNL-RP-2014-00791, October 31, 2014. http://srnl.doe.gov/documents/Hanford_TVAT_Report_2014-10-30-FINAL.pdf
[2]WRPS. Implementation Plan for Hanford Tank Vapor Assessment Report Recommendations. http://wrpstoc.com/wp-content/uploads/2015/02/WRPS-1500142-Enclosure.pdf

benefits such as cooling. However, these respirators require the use of batteries, and additional maintenance including a battery management program.

In order to determine whether an air purifying RPD approach will work, WRPS selected two cartridges – SCOTT 7422-SC1 and SCOTT 7422-SD1 for initial testing. These were selected because they are compatible with the same full facepiece RPDs that workers are currently wearing with NIOSH-approved SCBA. The SCOTT 7422-SD1 has a P100 high-efficiency particulate filter in front of sorbents including activated and impregnated carbons. The P100 filter prevents particles from going through the cartridge while the sorbents remove gasses and vapors. The SCOTT 7422-SC1 does not include the particulate filter and relies solely on cartridge sorbents. WRPS hired Pacific Northwest National Laboratories (PNNL) to help develop a testing strategy and instrumentation and a protocol for analysis of the data resulting from the testing.[3]

WRPS tested the cartridges in the tank farms, by supplying them with effluents directly from a vent which releases vapors and gases from the tanks, to see if the cartridges prevent vapors and gases known to pose potential health risks (known as Chemical(s) of Potential Concern – COPC) from "breaking through" over the span of a defined period of time.

WRPS conducted field testing in each of the eight double shell tank farms. Chemical analysis was done by either WRPS Organic Studies Group, Wastren Hartford Laboratory, or ALS Environmental Salt Lake City with the results provided to PNNL for data analysis. One of these tests – in the AP Tank Farm – has been completed, and it forms the basis for this report. The remaining seven tests are in various stages of data analysis and report preparation by PNNL. Because this testing has been developed using an "iterative" process in which improvements have been made based on lessons learned, it is necessary to review all of them before a final report can be made. For this reason, **this report should be considered to be preliminary and potentially subject to change as we get more testing information and data**.

3. HOW THIS REVIEW WAS CONDUCTED

3.1 Work Plan

Table 1 outlines the work plan we have generally followed.

Table 1: Tentative Work Plan by Tasks

No	Task	Scope	Schedule
1	Understand Background	a. Review WRPS-HAMTC MoA b. Review Scope of Work c. Review TVAT Report d. Review WRPS TVAT Implementation Plan	Week 1
2	Review	a. Review Sampling and Analysis Plan for Cartridge Testing	Week 1

[3] NPPL. Industrial Hygiene Sampling and Analysis Plan for Respirator Cartridge Testing. TFC-PLN-168, Rev A, June 16, 2016.

	Conceptual Model	b.Summarize findings for preparation of visit to PNNL	
3	Finalize Review Questions	a.Review Volume 1: Technical Proposal b.Finalize list of questions to guide reviews	Week 1
4	Schedule Visit to Richland to meet with HAMTC, WRPS and PNNL	a.Obtain approval and work out arrangements with WRPS Technical Representative for One Day Visit with WRPS and PNNL for sub-committee of 5 members b.Schedule meeting with HAMTC c.Develop visit plan with team and prepare agenda with questions to be submitted to WRPS in advance for distribution to PNNL d. Dates: Nov 30-Dec 2	Week 1
5	Review Test Report No. 1	a.Analysis of Respirator Cartridge Performance on Hanford AP Tank Farm Primary Exhauster Slipstream b.Deliverable: Review Report	Dec 7
6-x	Review Additional Test Reports	a. As produced by WRPS	TBD

3.2 Review Questions

We organized our review around the following questions.

1. Is the conceptual basis for the testing sound?
    a. What is the objective in terms of Protective Factor (PF)?
    b. What is the background information on how the protocol and sampling system for cartridge testing was developed?
    c. What are the supporting data on how the locations on the tanks were chosen to measure the performance of the respirator cartridges?
    d. Was there a peer review of these choices or the background information used to make them? If so by whom and is there a report on their findings?
2. Is the testing protocol acceptable based on the current state of science of testing respirator cartridges for breakthrough and durability in relationship to the PF that is to be achieved?
3. Have the hazards that workers may be exposed to been fully identified and are the toxins that are included in the testing fully representative of the range of hazards?
4. Was the testing performed according to the protocol and was it completed with adequate quality assurance?
5. Was the analysis of the data acceptable?
6. Are the findings, conclusions and recommendations reported based on the testing fully supported by the underlying data?
7. Do the testing results sufficiently replicate the real-life exposures of workers in the Tank Farms so that when workers are wearing the recommended Air-Purifying Respirators (APRs) or Powered Air-Purifying Respirators (PAPRs) they can be assured to be sufficiently protective against the potential hazards that they may be exposed to?

3.3 Primary Evidence

We relied on both written and verbal evidence in this assessment.

The written evidence consisted of the WRPS Sampling and Analysis Plan[4] and PNNL AP Slipstream Exhauster Cartridge Testing Analysis Report.[5]

First hand verbal information was collected during meetings in Richland on November 30 and December 1 with representatives from HAMTC, WRPS and PNNL.

3.4 Secondary Evidence

We relied mainly on the TVAT Report[6] and TVAT Implementation Plan[7] for background. We also used information from a new report from the National Institute for Occupational Safety and Health (NIOSH).[8]

4. FINDINGS

4.1 Conceptual Basis for Testing

The Hanford Tank Farm presents an unusual and highly challenging respiratory protection problem. According to the TVAT report, potential exposures vary and they may be episodic and unpredictable, and are not captured well by relying on time-weighted exposure assessment models. The TVAT report indicates that based on testimony and data provided to them, the chemical concentrations reported as time-weighted averages were not consistent with the health-related symptoms reported.

The TVAT Implementation Plan follows the hierarchy of controls with the aim of increasingly using engineering controls to prevent uncontrolled gas and vapor releases and therefore reducing the need to rely on respirators for personal protection. Just as HEPA particulate filters are already in place in vents and exhausters to prevent particle releases; it should be possible to install chemical scrubbers or adsorbers as well. That will take time, and in the interim worker protection will require reliance on respirators within a comprehensive respiratory protection program.

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[4]WRPS. Industrial Hygiene Sampling and Analysis Plan for Respirator Cartridge Testing. TFC-PLN-168, Rev A, June 16, 2016

[5] Nune SK, Liu J, Freeman CJ, Brouns TM. Analysis of Respirator Cartridge Performance Testing on a Hanford AP Tank Farm Primary Exhauster Slipstream. Pacific Northwest Laboratories. PNNL 25860, September 2016.

[6]Savannah River National Laboratory. Hanford Tank Vapor Assessment. SRNL-RP-2014-00791, October 31, 2014. http://srnl.doe.gov/documents/Hanford_TVAT_Report_2014-10-30-FINAL.pdf

[7] WRPS. Implementation Plan for Hanford Tank Vapor Assessment Report Recommendations. http://wrpstoc.com/wp-content/uploads/2015/02/WRPS-1500142-Enclosure.pdf

[8] National Institute for Occupational Safety and Health. Review of Hanford Tank Farm Worker Safety and Health Programs. November 29, 2016.

In accordance with standard industrial hygiene practice, if unable to determine what potentially hazardous contaminant(s) may be present, the atmosphere shall be considered immediately dangerous to life or health and, the most protective form of respirators must be used.[9] This is also a requirement for the Hanford Tank Farms. According to the Hanford Site Respiratory Protection Program,[10]

> "An APR shall only be used where the hazard has been identified and an exposure assessment has been completed and documented.
>
> "A self-contained breathing apparatus (SCBA) or airline respirator with escape bottle shall be used when the identity of a potential airborne hazard has not been determined by a completed exposure assessment or the known airborne hazard requires this level of protection. If sufficient information on the airborne hazard is determined, a lower level of respiratory protection may be selected."

Based on these requirements, there is substantial support for the reliance on SCBA given the uncertainties that exist about AP Tank Farm chemical vapor compositions and concentrations. However, there are also strong reasons for moving away from SCBAs as soon as possible.

The physical burdens of wearing a SCBA -- including backpack harness, compressed-air tank, hoses, and full facepiece RPD -- has its own risks, including ergonomic injuries and traumatic injuries due to its weight and restrictions on body movements, as well as the increased effort required for exhalation. There is no perfect solution -- or a standard decision-making protocol -- where competing risks and protection tradeoffs may be directly quantified. Defining adequate protection will require protection measures to be tailored based on considerations of industrial hygiene, engineering, and medical experience and available data. However complex, we are confident this can be achieved with the mutual agreement of the parties to manage assessed risks.

When faced with such competing risks, WRPS has instituted a rigorous systematic approach in collaboration with HAMTC to finding alternative respiratory protection options, and we find the overall approach reasonable. It consists of two prongs:

- **Finding alternative ways to deliver air supply**. Air lines configurations whether fixed or from carriages that carry compressed air tanks are being explored.
- **Finding alternatives to supplied air**. This has focused on testing APR cartridges that are compatible with the full face RPDs that are currently being used with SCBA. The testing of these cartridges within the exhauster is consistent with using a high concentration of mixed chemicals to deliver a severe challenge for testing the cartridge. We consider the current engagement of the workforce in the development of alternative approaches to respiratory protection to be an important and positive factor.

However, the complexities of moving from respiratory protection based on supplied air positive pressure SCBAs to negative pressure, air-purifying APRs should not be underestimated.

[9] See OSHA 29CFR1910.134, and ANSI/ASSE Z88.2

[10] DOE. Hanford Site Respiratory Protection Program, p. 20.
http://www.hanford.gov/files.cfm/Hanford_Site_Respiratory_Protection_Program_DOE-0352.pdf

Adding PAPRs as an alternative to SCBA offer advantages that might be a better choice provided the required level of respiratory protection is satisfied, even though, as discussed in section 5.3, use of PAPRs has its own challenges.

4.2 Testing Protocol

The cartridge testing protocol is acceptable. As noted in sections 4.6 and 5.3 below, repeated testing under different conditions is needed to establish applicability and generalization of results.

4.3 Hazard Identification

Of the roughly 1,500 chemicals found in the tank head spaces, 59 "Chemicals of Potential Concern" (COPC) were selected for inclusion in the testing, and each of these was treated as an individual risk. The process of selecting these has been systematic and justified. The cartridges were tested using the combined chemicals from AP Tanks as a challenge for determining breakthrough.

Although carefully designed and executed, there are challenges to this approach. Each chemical is treated for protection purposes as though it is a stand-alone case. We agree with the NIOSH report, which stated: "Upon review of the Technical Basis document,[11] 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."[12]

It is also not clear how current WRPS's hazard identification information is. The NIOSH report also notes, "It appears that no written chemical exposure analyses, as described in the TFC-H_IH-C- 48 document, have been produced since 2012. When questioned regarding the lack of such documented exposure analyses since 2012, NIOSH was informed that a management decision was made at that time to discontinue that activity. This decision may have an unintended consequence of not providing specific guidance for WRPS IH exposure assessment activities in the last four to five years."[13]

4.4 Performance of Testing

We found that the methods and apparatus used to measure cartridge breakthrough were very well conceived and constructed. A substantial effort was made in both training workers to use it and to make sure that data collected would be defensible (e.g. use of primary calibration of flow rates).

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[11] RPP-22491, REV 1 *"Industrial Hygiene Chemical Vapor Technical Basis"* (05/2006).

[12] National Institute for Occupational Safety and Health. Review of Hanford Tank Farm Worker Safety and Health Programs. November 29, 2016, p. 14.

[13] Ibid., p. 15.

4.5 Data Analysis

According to the S&A Plan,

> "The test data collected will serve [two] purposes: First, to provide the objective test data for mixtures of tank vapors from a variety of tanks, and second, to provide the basis for advanced mathematical modeling to generalize the data to be used over a variety of concentrations, temperatures, and humidities." (p. 2)
> "Sequential samples will be taken to characterize the breakthrough characteristics (isotherm curves of adsorption vs. time) necessary to model cartridge performance over a variety of concentrations, temperature, and humidities, not just those conditions specific to the field tests conducted. Analytical laboratory results will be used for determining respirator cartridge capacity and change schedule as the basis for modeling respirator cartridge performance." (p. 3)

To date, insufficient testing has been performed to enable PNNL to conduct needed data modeling. Once all eight of the initial cartridge tests have been completed and we have had a chance to review them it will be possible to get a better understanding of the performance of the cartridges over a wide range of conditions to better understand their variability.

4.6 Validity of Testing Conclusions and Recommendations

We agree with PNNL that cartridge service-life is affected by temperature, humidity, COPC concentration, breathing rate, and cartridge adsorption capacity. We agree with their primary conclusion that cartridge service life performance (breakthrough period) is applicable to the conditions under which the measurements were made. Furthermore, we agree that the PNNL recommendations are consistent with our initial findings.

Our review of the initial data presented and interpreted from the first report issued by PNNL was:

- Substantial variability (approximately 50% difference) occurred in the breakthrough times for ammonia with the two cartridges tested. We do not know if this variability was caused by differences in the challenge concentration of contaminants or that the cartridges were not identical (one had a P-100 filter and one did not).
- At least one of the COPCs – NDEA, a carcinogen -- which might be present, was not detected either in the upstream or downstream measurement. However, the sampling volume used resulted in a limit of detection of approximately 30 percent of its OEL (most other contaminants had detection limits ten percent of their OEL or lower). This could be improved with a longer sampling time and would provide greater confidence that this contaminant was not breaking through the cartridge.
- The concentration of COPCs in the airstream that was used to challenge the respirator cartridge was below historical values in the tank headspace. We concur with the conclusions of PNNL that different results might occur with a higher level of COPCs representative of historical levels.

- The testing of the two different cartridges was not repeated and we have no knowledge as to the uncertainty (confidence limits) in the results reported in the first study.

4.7 Protection under Real Life Working Conditions

We agree that the reliance on SCBA is a solution to be relied on only when a hazard assessment indicates that level of respiratory protection is required. Although very limited in terms of data at this time, the initial cartridge test results suggest it may be possible adopt the use of APRs with the cartridges tested to manage risks in various locations within the AP Tank Farms. However, "suggested findings" is not a sufficient standard on which to base the decision to adopt APR. Before that is done, more testing data are needed to provide WRPS and HAMTC a sufficiently strong evidence base and professional judgement to mutually agree on the assessed risks, protective measures to manage those risks under specified conditions and the type of monitoring that is need to accompany such a transition.

5 WAY FORWARD

We recommend that the following steps should be initiated immediately to expedite decision-making on appropriate respiratory protection including alternatives to supplied air respiratory protection. Most of these steps can be performed concurrently. We are prepared to support HAMTC and WRPS with professional review as this process moves forward.

5.1 Prerequisites for Moving Towards Negative Pressure Respiratory Protection

The following minimum prerequisites should be met before any decision is made to move away from SCBA (or other forms of supplied air respiratory protection). At the present time, there is insufficient testing data to make these determinations.

- A careful delineation of areas where SCBAs are mandatory and areas where APRs are to be used (with the option of still using SCBA being voluntary), much like in RadControl there are "radiation" and "high radiation" areas;
- A thorough testing and evaluation of the proposed APR respirators and the respiratory program that is to accompany them to determine if procedures and equipment are adequate to provide a tight enough seal to protect from inward leakage.
- A conservative cartridge change-out schedule should be adopted. At the time of cartridge testing the AP tanks were "at rest," and measured effluents were below average. When the tanks become disturbed, it is likely that exposures will increase and possible change in composition. A safety factor should be built into the change-out schedule to account for a "worst-case" concentration of contaminants..

5.2 Additional Cartridge Testing

The number of respirator cartridge tests needs to be increased to get sufficient data to estimate the range of variance in exposure levels and breakthrough with statistical validity. This might be accomplished with a reduction in complexity, time and cost of testing as a result of what is learned from previous test results. This expanded testing and results will increase the confidence,

understanding and predictability of the information used for respirator selection e.g., air purifying respirators.

We strongly recommend that the AP Tank Farm Slipstream Exhauster be retested when the tank content is being disturbed using the same cartridges as in the current test. A comparison between the first test (when the tanks were "at rest") to when the tanks are actively disturbed will give a much better perspective on the range of likely tank head space concentrations and potential worker exposures resulting from them.

5.3 Testing of PAPR as Alternative APR Respiratory Protection

PAPR technology should be reviewed to see if it is a viable option. PAPRs have the advantage of offering increased protection over other APR with cartridges and have some benefit of cooling. However, the advantages of protection must be viewed in the context of the additional respirator maintenance and battery management program required to support PAPR use. If the technology is found to be practicable, then testing of cartridges (or canisters) should be started as fast as possible and using the air-flow delivered by the intended PAPR, beginning with testing in the AP Tank Farm during the period when disturbance work takes place there.

5.4 Alternative Approaches to Supplied Air Respiratory Protection

Use of supplied air will be necessary for many work activities carried out by workers for the foreseeable future, both in the vicinity of venting sources in the DST Tank Farms and more widely in the SST Tank Farms, Therefore, it is important to accelerate adoption of approaches which enable workers to be freed from carrying SCBA air tanks on their backs, so that use of SCBAs minimized for those conditions where a hazard assessment indicate they are required. Alternatives should include the installation of fixed airlines wherever possible, and the use of tank carts elsewhere.

5.5 Monitoring

Regardless of type of respiratory protection, monitoring should include comprehensive real-time environmental and personal exposure monitoring. According to the NIOSH report, "…a state-of-the-art pilot scale demonstration project for a continuous chemical monitoring system was being established at this [the AP] tank farm."[14] This should contribute to the kind of exposure surveillance system that should accompany the shift of respiratory protection strategy. An assessment of the adequacy of this monitoring system to assure workers protection from unanticipated vapor exposures should be undertaken.

As noted in Section 4.3, there appears to be a lack of an up-to-date systematic chemical exposure hazard analysis program, and this should be evaluated because of its importance in supporting the respirator selection process.

[14]National Institute for Occupational Safety and Health. Review of Hanford Tank Farm Worker Safety and Health Programs. November 29, 2016, p. 18.

5.6 Examination of Risk Trade-offs

Informed decision-making about SCBA includes assessment of risk trade-offs which include consideration of possible muscular-skeletal and traumatic injuries associated with wearing SCBA. Other than anecdotes, we have not seen any objective evidence to support trade-off considerations. We have not seen any reviews of the medical findings from those workers who have experienced vapor exposures and been evaluated medically thereafter. Nor have we seen any data on injury rates (first aid, recordable, DART) before and after SCBA use was implemented. It would be useful to review such data. We have also not seen any analysis of worker attrition that could reduce the availability of experienced workers.

5.7 Epidemiological Study of Pulmonary Function in Tank Farm Workers

The small airways are a "biological front-line" to airborne toxics. Pulmonary function testing (PFT; also known as "spirometry" or "breathing test"), is a sensitive and specific approach to evaluating airways damage. Tank farm workers undergo periodic occupational medical exams in which PFT is offered. It would be useful to examine the feasibility of evaluating the PFT data on workers with long terms employment in the Tank Farms to examine if their PFT deficiencies differ significantly in prevalence and severity from other Hanford workers or from what is found in the general population. The hypothesis would be that more tank farm work, defined by frequency and duration, is associated with more rapid decline in lung function. If this is not the case then we have a much greater sense of reassurance about how respiratory protection can be used in the absence of complete exposure knowledge. Such a study would not be very hard to conduct if de-identified[15] medical and work history data can be made available.

6 CERTIFICATION

I certify that this is a true description of the process and findings of this Review, and that all members of the Review Team were in unanimous agreements.

_____ Date: December 11, 2016.

Knut Ringen, DrPH, MHA, MPH
Project Director

[15] "De-identified" means removing all personal identification information (PII) such as names, addresses, dates of birth and social security numbers, etc and giving each person's record a random identification number in the place of PII.

REVIEW TEAM

Project Director

Knut Ringen, DrPH, MHA, MPH, Project Director
Dr. Knut Ringen is a principal in Stoneturn Consultants, located in Seattle, WA. He is also the Senior Science Advisor, CPWR: The Center for Construction Research and Training (www.cpwr.com) in Washington, DC, which is a global leader in construction safety and health research, and for which he served as founding director. He has also held senior appointments at the U.S National Academy of Sciences, where he served as study director on major scientific reviews, and the National Institutes of Health.

He chairs the Scientific Committee on Occupational Health in the Construction Industry, International Commission on Occupational Health (ICOH); and is Vice President, Construction Section of the International Social Security Association (ISSA). He was Chairman, Department of Labor's National Advisory Committee on Construction Safety and Health from 1993 to 1997. He is an elected Fellow of the European Academy of Sciences and the Collegium Ramazzini. He received a master degree in health administration from the Medical College of Virginia (now part of VCU) and master degree and a doctorate degree in public health from Johns Hopkins University.

Over the years he has led a number of programs that have made significant changes in safety and health policies in the US and internationally, especially in the construction industry. Since 1996 he has also led an effort to evaluate the health of older construction trades workers in America's nuclear weapons facilities, including over 4,300 former Hanford workers, of whom more than 500 have had experience in the Tank Farms after 1995.

In 2011, the Secretary of Energy's Blue Ribbon Commission on America's Nuclear Future commissioned him to conduct an assessment of the state of safety and health throughout the civilian nuclear fuels cycle, and compare it to other sources of energy, including fossil/hydrocarbon fuels and alternative sources of energy. He has served on a number of National Academies Committees to review respiratory PPE requirements including Committee on Personal Protective Equipment in the Workplace; Committee to Review the NIOSH Personal Protective Technology Program; Committee for the Assessment of the NIOSH Head-and-Face Anthropometric Survey of U.S. Respirator Users.

STC Subject Matter Experts

Howard J. Cohen, PhD, CIH, Subject Matter Expert
Dr. Cohen is located in New Haven, CT. He has worked in industrial hygiene for 40 years, of which the first 17 years for Monsanto and Olin Corporations, and then switching to an academic career at University of New Haven and Yale University. He is widely recognized for his expertise in the administration of respiratory protection programs and in carbon chemistry used

in respirator cartridges and canisters. He has served on many National Academy Committees in the area of personal protective equipment, and was chair of the 2010 Certification Study of Personal Protective Technology. He is a current member of the Committee on Personal Protective Equipment in the Workplace. He has been chair of the ANSI Z88.2 Committee on Respiratory Protection. He has received numerous professional awards for his work. He received his master degree and PhD in industrial health from the University of Michigan.

James S. Johnson, PhD, CIH, QEP, Subject Matter Expert
Dr. Johnson is a nationally recognized respirator subject matter expert who is located in Pleasanton, CA. He has been involved in wide variety of respirator research and program topics such as hazard assessment, proper selection, filter and cartridge performance, fit, fit testing, maintenance, storage and disposal. Before retiring from full-time employment in 2006, he worked in the occupational safety and health program at Lawrence Livermore National Laboratory for 45 years. Since then he has worked as private consultant to government and private sector clients. He also directs, manages and participates on several national consensus standards, e.g. ANSI/ASSE Z 88 on Respiratory Protection and NFPA Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment. He has served on numerous national consensus development and review committees that have driven development of PPE technologies and programs in the US, including the National Academies' Standing Committee on Personal Protective Equipment for Workplace Safety and Health, 2009-2014. He earned a BA in chemistry, a MSH in air pollution and industrial hygiene, and PhD in organic and inorganic chemistry.

William H. Kojola, MS, PhD (ABT), Subject Matter Expert
Bill Kojola retired from full-time employment in 2013. He is an industrial hygienist with more than 40 years of professional experience. He is currently an industrial hygiene consultant to CPWR: The Center for Construction Research and Training, and he is a member of the National Academies' Committee on Personal Protective Equipment in the Workplace. He has served as Industrial Hygienist for the AFL-CIO (1998-2013); Director of Occupational Safety and Health, Laborers Health and Safety Fund of North America (1990-1998); Occupational Safety and Health Specialist, International Brotherhood of Boilermakers (1982-1998); and several other positions. He has served on numerous national expert committees, including the Board of Scientific Councilors of the National Institute for Occupational Safety and Health. He recently served as expert reviewer on the National Academies' *The Use and Effectiveness of Powered Air Purifying Respirators (PAPRs) in Health Care.* He has a BS in biology (cum laude) and MS in genetics from the University of Minnesota, and did doctoral studies in toxicology and industrial hygiene at the University of Illinois.

Ricard W. Metzler, MSIE, Subject Matter Expert
Rich Metzler has 39 years of experience directing, managing, and performing assessment activities in the field of occupational safety and health in conformance with National Institute for Occupational Safety and Health (NIOSH) and Mine Safety and Health Administration (MSHA) respiratory protective device (RPD) and mining equipment Federal regulations, Occupational Safety and Health Administration (OSHA) and National Fire Protection Association (NFPA) personal protective equipment and RPD regulations and standards. Experience includes scientific research and engineering investigations related to product safety standards, laboratory, and field

product evaluations including investigations related to product conformance, injuries, or fatalities. Experience includes more than 35 years directing Federal product approval, certification, and research programs including the supporting laboratories. This experience includes both leadership skills and engineering expertise with national and international respiratory protective device design, performance, quality and reliability standards and associated test procedures

CPWR Subject Matter Experts

Bruce Lippy, PhD, CIH, CSP, FAIHA, Director of Safety Research, CPWR, Subject Matter Expert

Dr. Lippy began his career in industrial hygiene in 1978 working for Maryland OSHA, where he routinely trained workers, union groups and contractors about respiratory protection. He was certified in the comprehensive practice of Industrial Hygiene in 1985 (#3023) and as a Safety Professional in 1992 (#11472). He is a member of the National Response team and served at the cleanup of the World Trade Centers. During his two months at the site, he provided hundreds of respirators to the heavy equipment operators on the pile and taught them proper donning, doffing and cleaning of the respirators. He also worked with NIOSH to determine breakthrough of carbon cartridges on the site. He was a co-director and safety officer of the sampling team that opened the anthrax-contaminated AMI Building in Boca Raton, Florida. His duties there included quantitatively fit testing the team members and workers on the site, all of whom wore full-face powered air purifying respirators. As Director of Special Projects with the Operating Engineers National Hazmat Program, he led several teams evaluating innovative personal protective equipment for the Department of Energy, including a level B ensemble that uses liquid air to supply breathing gas and cooling to a garment for over an hour. Under a grant from the Department of Homeland Security, Dr. Lippy created and delivered training to a broad range of responders who would have to put down an Avian Influenza outbreak among poultry in the midwest. He was responsible for the training on proper respiratory protection in the various scenarios. He has spent hundreds of hours wearing respiratory protection on a wide variety of industrial and disaster worksites. Dr. Lippy was awarded a Distinguished Fellow of the AIHA at the 2015 annual conference.

James W. Platner, PhD, MS, CIH, Subject Matter Expert

Jim Platner is located in Annapolis, MD. He served as CPWR's Associate Director for Science & Technology for 16 years before he retired in 2015, following a long career at Cornell University's Industrial and Labor Relations Program, where he was the director of the Occupational Safety and Health Extension Program. He is the co-chair of CPWR's Institutional Review Board for the Protection of Human Subjects in Research, and in addition to his industrial hygiene qualifications, he adds a concern about the ethics of respiratory protection to the team. He has served on a very large number of National Advisory Committees including the National Academies' Committee on Personal Protective Equipment in the Workplace and Committee on Certification of Personal Protective Technologies and on the Board of Scientific Counselors of the National institute for Occupational Safety and Health. He serves as current Chair of the ASTM/SEI Committee on Certification Programs and prior to their merger with ASTM was Chair of the Safety Equipment Institute (SEI) Board of Directors. SEI, which is now a subsidiary of ASTM International, provides third party certification of personal protective

equipment. He received his undergraduate degree in biophysics from Johns Hopkins University and master degree and doctorate degree in radiation biology and toxicology from the University of Rochester Medical School and qualified for the CIH in 1989.

Liaison with HAMTC

Erich J (Pete) Stafford, BS, Executive Director, CPWR and Principal Interface with HAMTC

Pete Stafford is Executive Director of CPWR – The Center for Construction Research and Training, and also Safety and Health Director for North America's Building Trades Unions. He is responsible for managing $15 million annually in cooperative agreements, grants and contracts with NIOSH, NIEHS, DOE, and DOL on programs dedicated to construction safety and health research, training, and related services. Mr. Stafford has over 30 years of experience in construction safety and health, serves on many construction industry advisory boards and committees, and is the current Chair of OSHA's Advisory Committee on Construction Safety and Health (ACCSH).