Hanford Tank Farms Independent Qualified Third Party Review

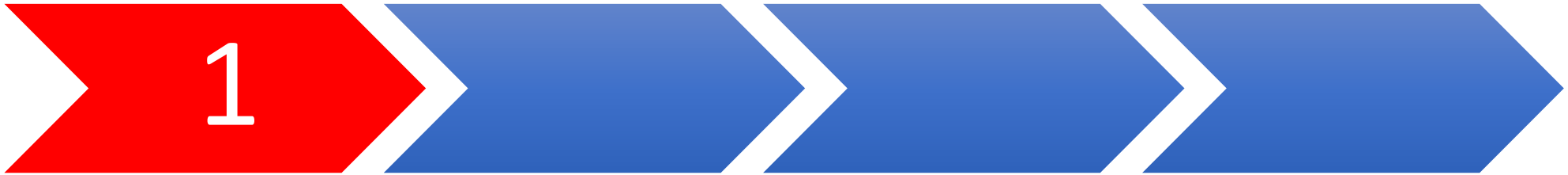
August 9, 2017

Presentation outline

1. Background and overview
2. Review of cartridge testing
3. Review of APR implementation
   - Documentation
   - IH and respiratory protection programs
4. Way forward: recommendations

Background and overview

Knut Ringen



The team has faced major challenges

- Separating **cartridge performance** from **respiratory protection**
- Drawing conclusions from a single test
- Understanding variability in main factors affecting cartridge performance:
  - Chemical concentrations
  - Relative humidity
  - Temperature
- Getting a common understanding of key terms
  - Breakthrough
  - Service life
  - Change-out (or change) schedule
- Getting a clear understanding of how the IH and RP programs operate

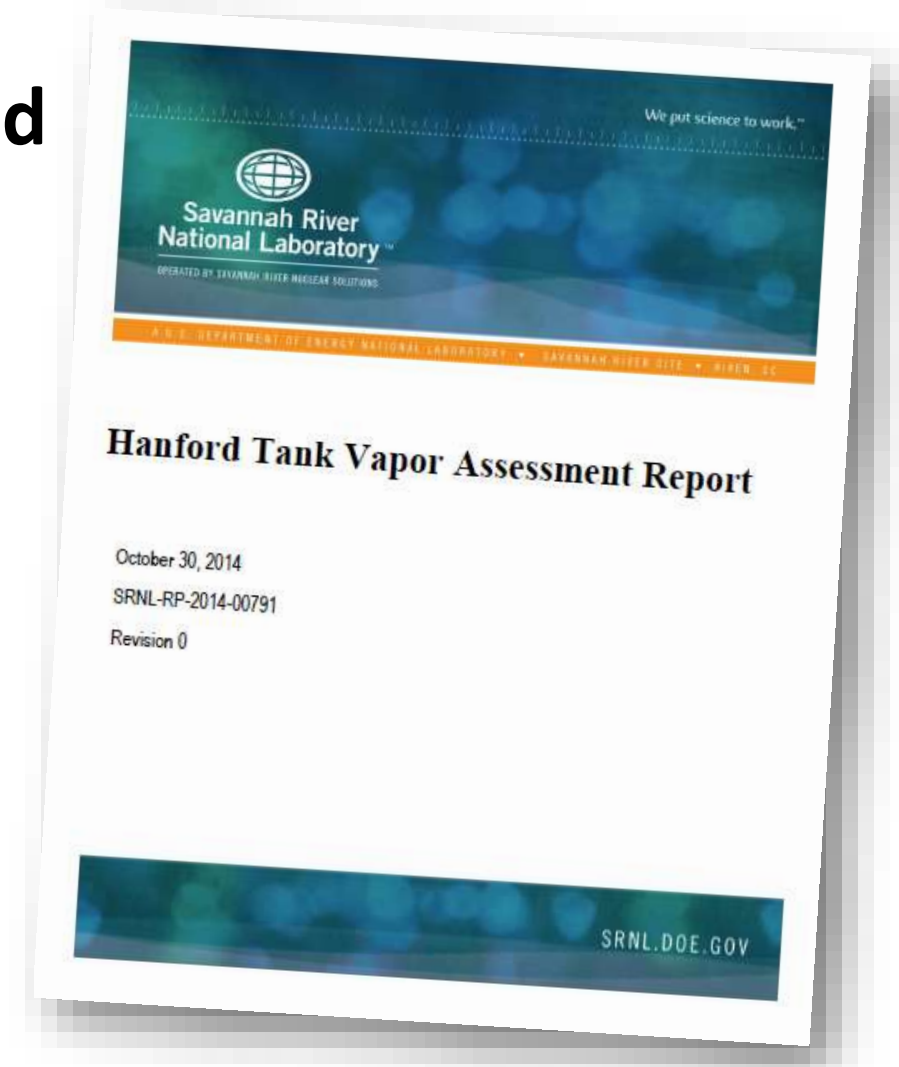
Worker complaints about hazards go way back

- More than a dozen technical reviews of tank farm hazards over past 30 years, including 2 from NIOSH
- Currently two law suits and ongoing DOE and congressional investigations about worker protection

HANFORD CHALLENGE

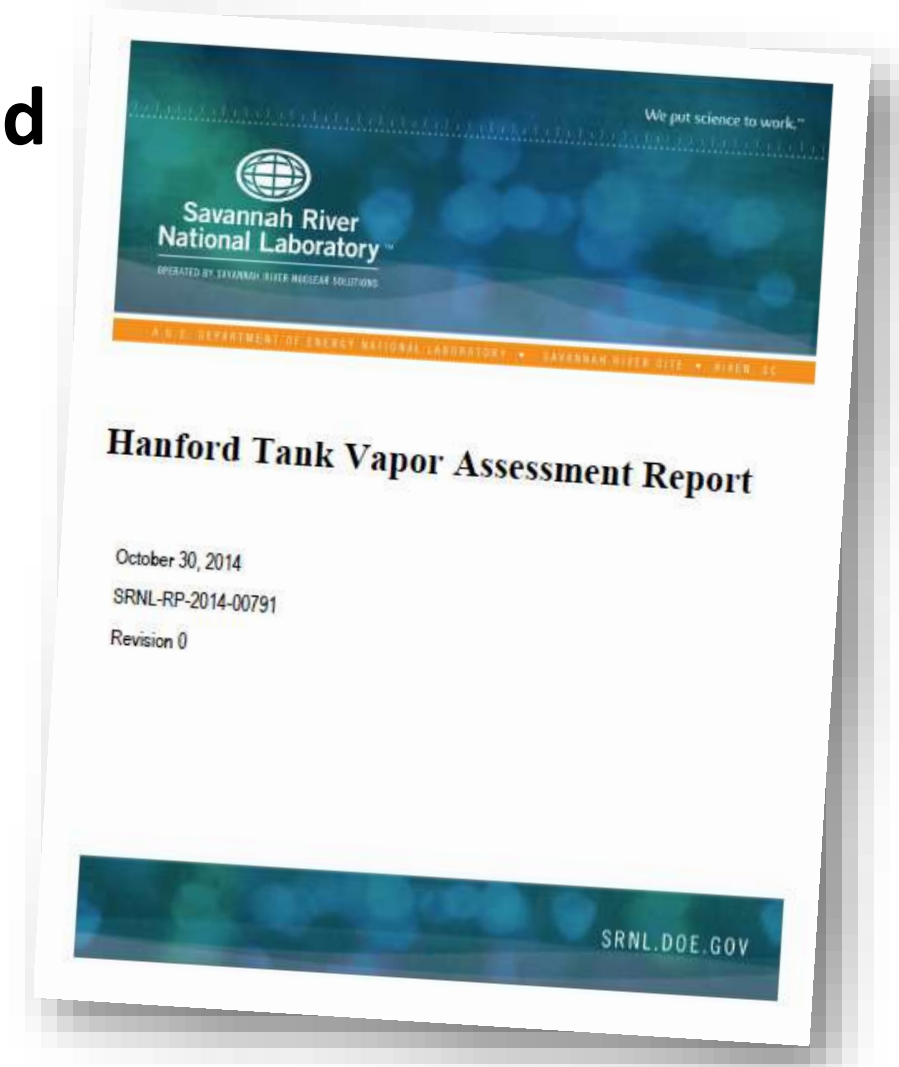
Major 2014 Tank Vapor Assessment Team from Savannah River reported:

- Worker complaints about sicknesses valid
- Sicknesses caused by tank vapors
- Most likely from “bolus” exposures (unpredictable plumes “burping” from tanks)

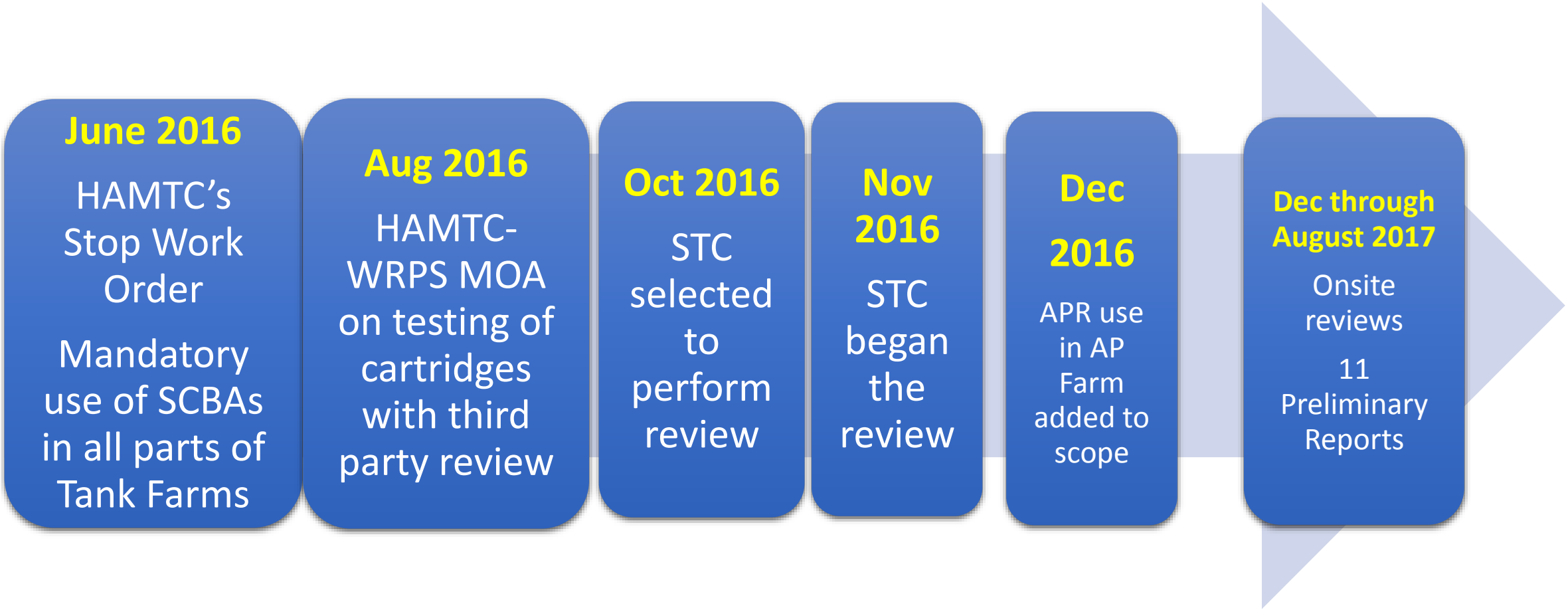


Major 2014 Tank Vapor Assessment Team from Savannah River reported:

- Worker complaints about sicknesses valid
- Sicknesses caused by tank vapors
- Most likely from “bolus” exposures (unpredictable plumes “burping” from tanks)
- Nevertheless, respiratory protection generally ***not*** needed



There has been positive movement towards a solution



We've issued 8 reports on cartridge testing and 4 on respiratory protection

Cartridge testing reports:

- Report No. 1: AP Tank Farm, December 11, 2016
- Report No. 1, *Addendum 1*: SY-102 Tank, February 8, 2017
- Report No. 1, *Addendum 2 (corrected)*: A-101 Tank, February 16, 2017
- Report No. 1, *Addendum 3*: BY-108 Tank, February 16, 2017
- Report No. 1, *Addendum 4*: 702-AZ Primary Exhauster, March 10, 2017
- Report No. 1, *Addendum 5:* AX-101 Tank, March 10, 2017
- Report No. 1, *Addendum 6:* AW Tank Farm, April 13, 2017
- Report No. 1, *Addendum 7:* AN Tank Farm, April 13, 2017

Respiratory protection reports:

- Report No 2: Review of: Use of Full Face Air Purifying Respirators in AP Tank Farms for Low-Hazard Tasks. January 31, 2017
- Report No 2, *Addendum 1:* Review of Final Plan Implementation of APR in AP Tank Farm (Email Report), March 1, 2017
- Report No 2, *Addendum 2:* Early Implementation of APR in AP Tank Farm. April 11, 2017
- Report No 2, *Addendum 3:* Review of Hazard Assessment and Radiological Work Permit for SY Farm (Email Report), July 31, 2017

STC and CPWR assembled a team of seasoned respirator experts

Knut Ringen, DrPH, MHA, MPH, STC Project Director

Subject Matter Experts

- Howard Cohen, PhD, CIH, Yale U. (ret)
- James S. Johnson, PhD, CIH, Lawrence Livermore National Lab (ret)
- Bill Kojola, PhD (ABT), MS, AFL-CIO (ret)
- Bruce Lippy, PhD, CIH, CSP, CPWR
- Richard Metzler, MSIE, NIOSH (ret)
- James Platner, PhD, MS, CIH, CPWR (ret)

Pete Stafford, BS, CPWR (ret) Liaison to HAMTC

More than 250 years of professional expertise

Team Onsite visit 3-30-17, photo courtesy Bruce Lippy.

The team agreed on a review protocol that would be:

Evidence based: WRPS must provide adequate information

Systematic: We follow a list of review questions

Consensus: All our review findings are agreed upon by *all* team members

Certified: all our reports are signed

Independent: Our team's review is completely independent of WRPS and HAMTC (neither party sees our draft reports - only the final product).

The MOA says all work inside tank parameters to be performed with SCBA ***until***

- Cartridge testing is completed ***and***
- Results are demonstrated to provide worker protection from tank farm vapors

To be confirmed by independent 3rd party

To be done on farm-by- farm basis

Anticipated completion: Nov 2016

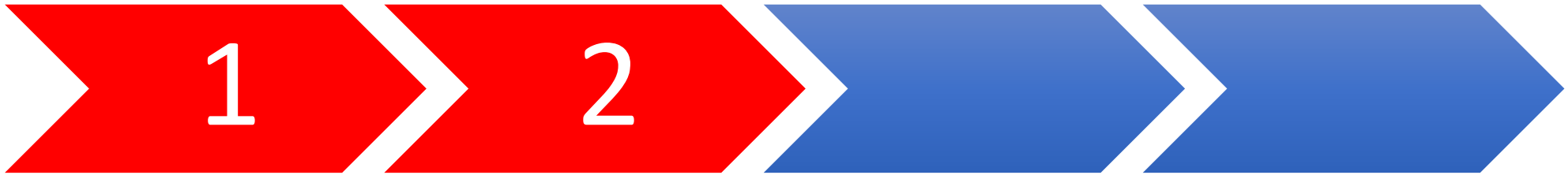
Cartridge performance has been confused with respiratory protection

- Cartridge performance is the ability of a respirator cartridge to adsorb chemicals. Cartridge testing measure how long it takes for a chemical to break through the cartridge under specific conditions.
- Respiratory protection is the written program that takes a cartridge and fits it to a respirator, and includes hazard assessments, medical determination of fitness, selection of respirator, training, fit testing, maintenance of equipment, monitoring of workplace exposures, routine evaluations of the program's effectiveness, etc.

It is the quality of the program that confers protection!

STC's Review of the WRPS Respirator Cartridge Test Program

Howard Cohen



Background

1. STC was asked to provide an independent review of 16 respirator cartridge tests conducted by WRPS from the headspace and exhauster of eight different tanks and tank farms.
2. Our involvement began after the protocol and all testing had been completed by WRPS personnel.
3. Our analyses of the results and our conclusions were based on the eight PNNL issued reports.

Two Scott cartridges were tested

Photos courtesy of Grainger

SCOTT 7422 SC-1

OV, AM, CL, CD, FM, HC, HF, MA, SD, HS

SCOTT 7422 SD-1

OV, AM, CL, CD, FM, HC, HF, MA, SD, HS, P100

Our team approached the review with these questions

1. Is the **conceptual basis** for the testing sound?
2. Is the **testing protocol** acceptable?
3. Have the **hazards been fully identified** and 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** fully supported by the underlying data?
7. Do the testing **results sufficiently replicate the real-life exposures** of workers who will be wearing APRs?

In general we agree with the approach taken by WRPS:

1. Modeling and lab testing **could not** have provided an understanding of the use of APRs including the adsorption capacity of the Scott cartridges for the 59 COPCs (due to the complexity of the mixture).
2. Examining the service life, by modeling or laboratory testing, of only one or two target COPCs (e.g. ammonia) **would be insufficient.**

WRPS Testing Protocol Parameters

- Flow rate: 30 L/min (60 L/min for worker with two cartridges)
- Upstream measurements of 59 COPCs every two hours (some tests only at the first and last two hours) as well as temperature and humidity
- Downstream measurements of 59 COPCs every two hours as well as temperature and humidity
- Temperature: 32 to 115°F
- Relative Humidity: 5% to 100%

We agree with the WRPS protocol:

1. Cartridge service-life is affected by temperature, humidity, COPC concentration, breathing rate, and cartridge adsorption capacity.
2. Cartridge service life performance (breakthrough period) is applicable to the conditions under which the measurements were made.
3. The flow rate of 30 liters per minute through each cartridge in each test was an appropriate and conservative value to have used to estimate the breathing rate of respirator wearers.

We identified some problems, however:

Some of the furans and nitrosamines monitored had limits of detection above 10% of their OEL.

- For **furans**, 10% of OEL (100 **ppt**) is at or below the **LOQ**
- For some **nitrosamines**, the OEL was at or below the LOQ

Monitoring only the first and last two hours of inlet concentrations made it impossible to evaluate the impact of COPC concentrations that were changing during the 16-hour test. This was eventually corrected after four of the eight studies had been completed

Several of us have experience in building and testing cartridge service life equipment

This equipment is **quite exceptional** and we commend all those involved in the design, construction and operation of this apparatus.

WRPS's *Sampling and Analysis Plan for Respirator Cartridge Testing* identifies the following important features of the study:

- Field calibration of all flow rates used in the study traceable to **NIST primary standards.**
- Industrial hygiene **field blank** samples taken **for all of the sorbent tubes** in the study.
- **Chain of custody** forms used for each set of media tubes.
- **Established analytical methods** published by EPA, NIOSH and OSHA used for COPC collection and analyses
- All laboratories performing the analyses required to comply with **DOE quality assurance plans** and contracting laboratories were also required to be **AIHA-Accredited** and participate in their **PAT program** (proficiency testing).

All of our evaluations relied on our review of the PNNL reports. Problems:

- **Report Organization**: Appendices D, E and F had useful information. Appendix D had all of the cartridge test data and failed to easily identify the specific Scott cartridge tested and whether the samples were from the inlet or outlet.
- **Historical data**: we had to assume relevancy
- **Use of limit of detection**: we preferred limit of quantification to describe results
- **Cartridge service life**: we agreed with some PNNL recommendations

Some of our definitions differed from those of PNNL and affected our recommendations:

- **Breakthrough** is the detection of contaminants downstream of a respirator cartridge during specific test conditions.
- **Service life** is how long a cartridge provides adequate protection from harmful chemicals in the air. It is based on many factors, including environmental conditions, breathing rate, cartridge adsorption capacity, and the amount of contaminants in the air during working conditions.
- **Change (or change-out) schedule** is a refinement of service life that adds a safety factor to the service life, typically reducing the duration of use of a cartridge.

Comparison of PNNL and STC Cartridge Breakthrough/Service Life Findings

Cartridge Test	PNNL Service Life	STC Review Finding	Comments
AP Tank Farm Exhauster	4 hours for SC1 6hours for SD1	4 hours	SC1 and SD1 equally protective. Lowest breakthrough time should be applied.
SY-102 Tank	16 hours	16 hours	
A-101 Tank	2 hours for SD1 6 hours for SC1	70 minutes	PNNL used 10% of OEL. STC used earliest recorded breakthrough (ERB)
BY-108 Tank	APR not appropriate	APR not appropriate	SST
702-AZ Primary Exhauster	12 hours	4 hours 35 minutes based on max historical data	PNNL used 10% of OEL. STC used ERB. Conc. much lower than historical values. Variability in RH and temp. considered.

Comparison of PNNL and STC Cartridge Breakthrough/Service Life Findings (2)

Cartridge Test	PNNL Service Life	STC Review Finding	Comments
AX-101 Tank	2 hours	APR not appropriate	PNNL used 10% of OEL STC used ERB, <2 hours.
AW Tank Farm	12 hours	4 hours 110 minutes based on max historical data	PNNL used 10% of OEL. STC used ERB. Conc. much lower than historical values. Variability in RH and temp. considered.
AN Tank Farm	10 hours	3 hours 110 minutes based on max historical data	PNNL used 10% of OEL. STC used ERB. Conc. much lower than historical values. Variability in RH and temp. considered

Comments on Our Findings

- Respiratory protection decisions should be made on a tank farm by tank farm basis
- Cartridge change schedules should **not** be based on cartridge testing results alone
- The use of FFAPRs appears appropriate for SEG-1 non-disturbing activities at six of the eight tanks and tank farms where the studies were conducted, **provided they are supported by:**
  - **A comprehensive hazard assessment**
  - **A comprehensive respiratory protection program**

FFAPRs are not appropriate for BY-108 and AX-101 because of high levels of ammonia

Also we would **not recommend** the use of FFAPRs when:

- Headspace and exhauster concentrations of any COPC is > IDLH level or 50 times its OEL
- Cartridge breakthrough times are less than 2 hours

Other Notable Findings

- **Ammonia:** The first (and often only) COPC that broke through cartridges in almost all of the studies.
- **Nitrosamines:** Carcinogens found at high concentrations in the inlet in a few studies. Well adsorbed onto the cartridges.
- **Furans:** Carcinogens that were detected downstream of the cartridges at very low concentrations.
- **Elemental mercury**: Detected at the inlet >10% of OEL at some sites. Although the cartridges showed good adsorbtion, Scott cartridges tested are not NIOSH-approved for protection against mercury as they lack an end-of-service-life indicator.
- **Very low concentrations of many COPCs** were detected downstream of cartridges. None poses a health threat by itself at these concentrations.

Cartridge Change Schedules

- Current union-management agreement limits the use of APRs to **3 continuous hours**. Fresh cartridges are used if respirators are worn again. **We think this is a practical rule to follow in general**
- Cartridges should not be reused due to concerns of COPCs migrating through the carbon beds during non-use times.
- Attention should be taken when high temperatures and low humidity exist (mid-summer times) as ammonia will be poorly adsorbed.
- Always change cartridges whenever any odor is detected which is current WRPS procedure.

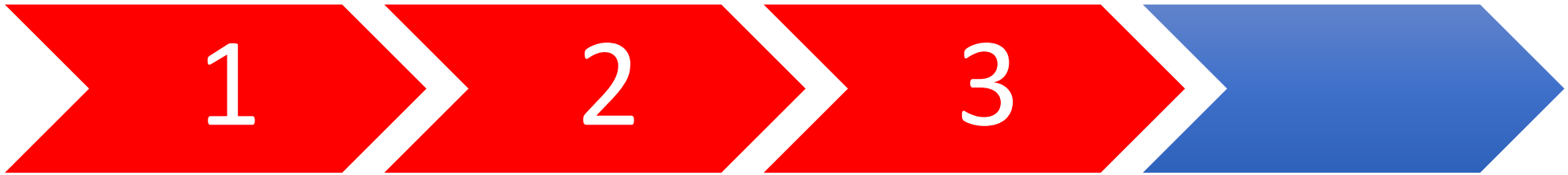
Conclusions

- **Cartridge test program is a positive effort** to assure workers that they will be protected when wearing a FFAPR should a gas-release event occur.
- **Future testing** is likely to reinforce the safety and value of wearing these air-purifying respirators.
- **Monitoring of the headspace** of tanks and the exhausters remains an important step in identifying COPCs and their concentrations that could be emitted during a gas-release event.
- The **current IH program** that monitors long-term or full-shift worker exposures remains an important exposure assessment task. However, it **may not adequately detect brief short-term exposures** that may occur with gas-release events.

Review of APR implementation

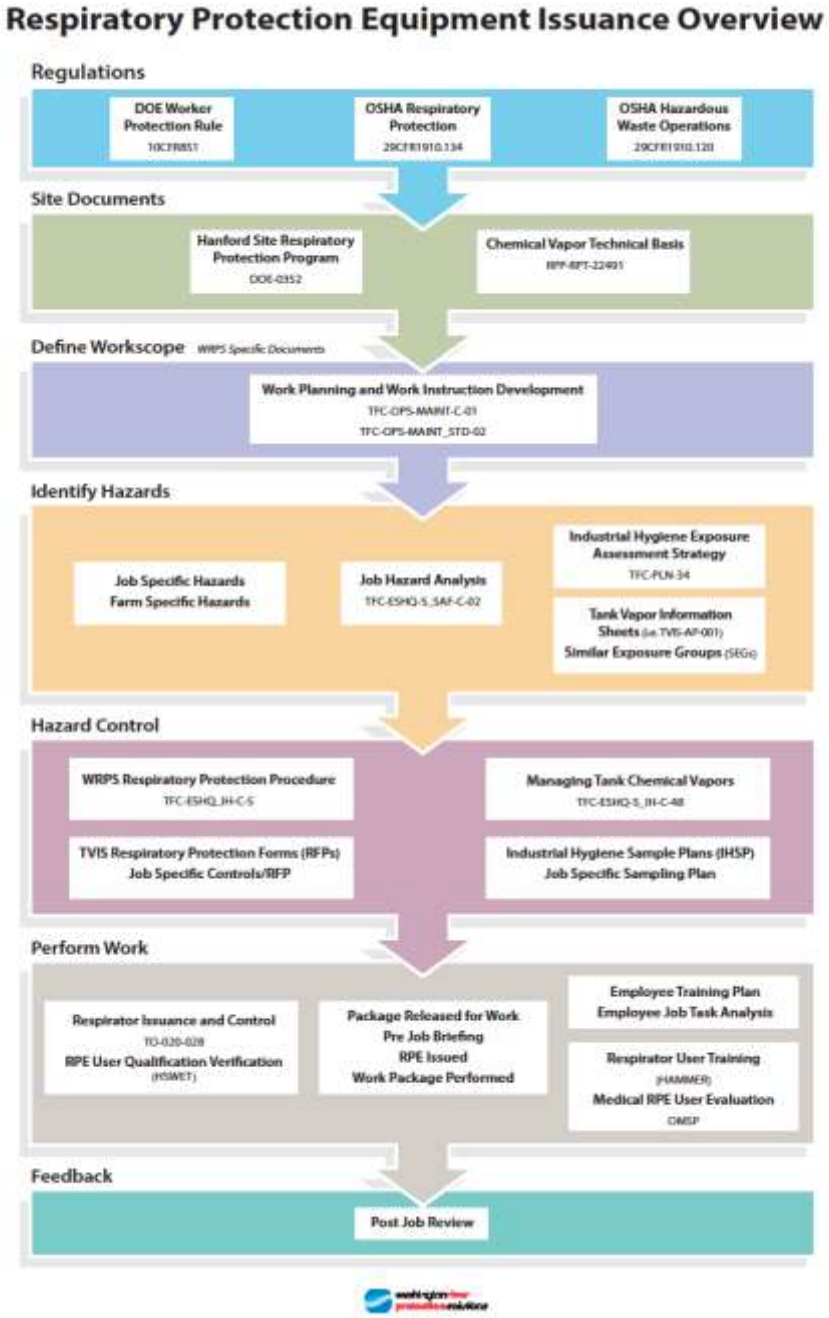
Program Documentation

Rich Metzler



Documentation System

- Blueprint defining RPP permissible practice (e.g. policies and procedures) established, implemented and evaluated to assure workers are protected
- Seven WRPS-related categories
  1. Federal Regulations
  2. Site Documents
  3. Work Scope
  4. Identify Hazards
  5. Hazard Control
  6. Perform Work
  7. Feedback (Program Evaluation)



Our objectives are to:

1. Assure the respiratory protection program (RPP) is coherent, well documented, current, internally consistent and easy to follow, both in terms of flow and content.
2. Confirm documentation accurately represents permissible practice – the policies and procedures of the RPP.
3. Observe practice conforms with RPP documentation, is consistently implemented, and evaluated for effectiveness.
4. Effective labor/management relationships and trust can grow with a coherent IH/RPP program, easily understood, and consistently administered.

Initial Findings

- ☺ Documentation is extensive, comprehensive, robust, and shows a sincere and dedicated interest in protecting tank farm workers.
- ☺ Encouraged by STC, WRPS adopted a systematic approach (template) for respiratory protection based on hazard assessment **augmented with** cartridge test results.
- ☺ Respirator issuance and control documents, practices, facility, and staff were observed on-site and found conforming.

Initial findings continued

- ☹ Document structure was difficult to understand, lacked clarity of purpose, and did not highlight respirator selection based on a systematic approach and hazard assessment.
- ☹ Documents were being updated to define permissible practice for FFAPR use in the AP Farm and were provided piecemeal making them difficult to understand, relate, and assess.
- ☹ A complete set of documents associated with the RPP was not available for review during this period.

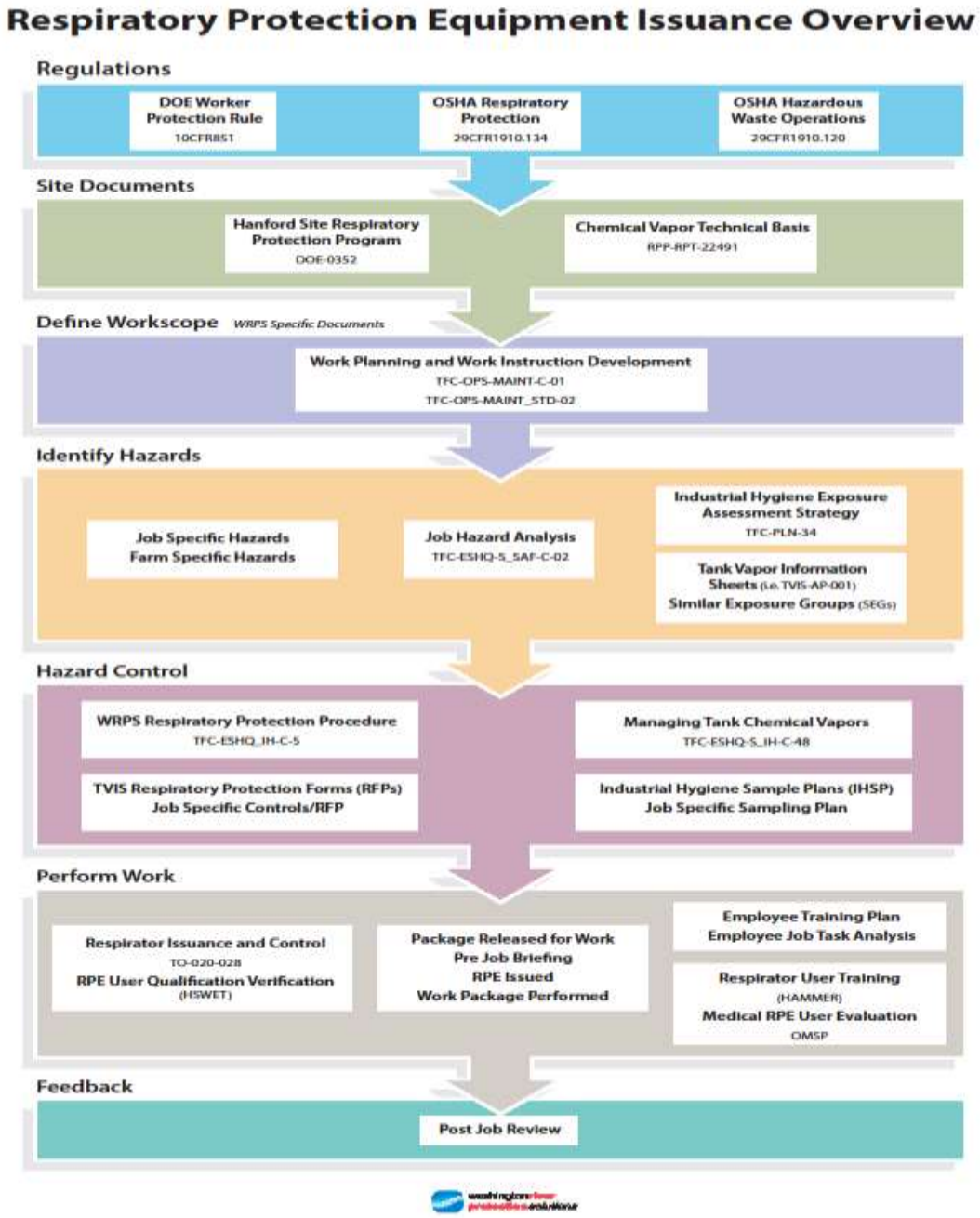
On-going efforts

- ☺ WRPS updated its FFAPR AP Farm proposal using its systematic approach and template.
- ☺ WRPS established and updated a diagram showing document associations with regulations, work site, work scope, hazard identification, hazard control, work performance, and program evaluation (feedback).
- ☹ Work continued to relate documents with WRPS system categories, and identify missing documents or those needing update.
- ☹ Complete set of associated documents with the RPP was not available and some RPP documents were pending final updates.

On-going Progress.

WRPS Documentation System Diagram

Effectively guides permissible practice, improves clarity of purpose, and is easy to follow.



Example of On-going Progress:
Associating documents for hazard ID

Document Category	Title	Type/Pages	Date	Notes
TVIS-AP-001 A-6004-063 (REV 10)	**TANK VAPOR INFORMATION SHEET (TVIS)**	**PAGES 1**	**11/17/2016**	**Defines WRPS summary of hazards specific to each tank farm. Specifies COPCs in AP Farm at perimeter of concrete pad of primary exhauster.**
STD-03, REV D-5 USQ#RPP-27195 USQ# GCX-2	MONITORING, REPORTING, AND RECORDS MANAGEMENT	ESHQ PAGES 3		reporting, and record management.
TFC-PLN-34 REV E-6 USQ# GCX-2	INDUSTRIAL HYGIENE EXPOSURE ASSESSMENT STRATEGY	PAGES 21	2/22/2013	Presents the WRPS IH exposure strategy, links JSA exposure assessment, and medical surveillance.
CEHA 0916-572	CHEMICAL EXPOSURE HAZARD ANALYSIS	PAGES 4	9/8/2016	Provides a hazard analysis for a specific operation, tasks, etc. Attachment 10 in WRPS FFARP Use Proposal, TOC-IH-58345 REV 0, USQ# RPP-27195, SPF-001 (REV.D1)
TFC-ESHQ-S_SAF-C-02, REV G-6 RPP-27195	JOB HAZARD ANALYSIS	PAGES 15	4-May-17	Provides direction for the performance and administration of the Hazard Analysis process implemented by WRPS.

Findings

- ☺ Systemic approach and template was developed, implemented and being updated. It bases respirator selection on hazard assessment augmented with cartridge test results.
- ☺ RPP Permissible practice documents for the AP Tank Farm represent policy and practices.
- ☺ Documentation system diagram links WRPS associated documents with RPP permissible practice documents, provides clarity of purpose, and is easy to flow.
- ☺ WRPS complete set of documents is coherent, documented well, current, internally consistent and easier to follow, both in terms of flow and content for the use of FFAPR in the AP Tank Farm.

Recommendations

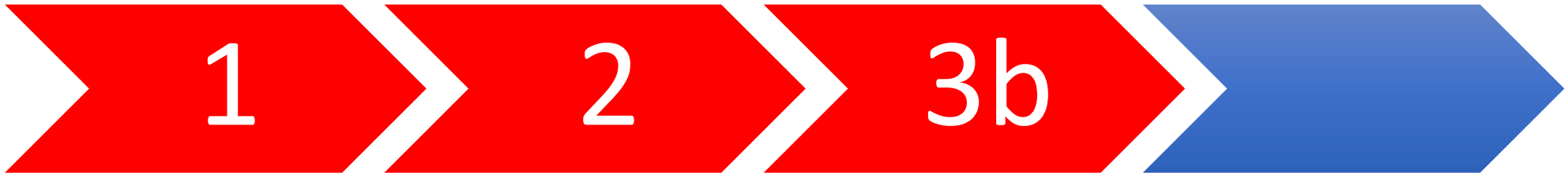
Achieve Effective Labor/Management Relationships and **Trust**
with a transparent, coherent IH/RPP program, administered consistently.

1. The documentation system diagram or similar tool should be used for training purposes, adding transparency, building trust through clarity of the purpose of permissible practices and RPP documentation. *This highlights and underscores the dedication and commitments of all parties at Hanford.*
2. The RPP documentation must be sustained, updated as necessary, with effective evaluations of the program. These evaluations should be accomplished jointly with Labor input and participation. *This builds effective labor/management relationships and trust among the parties.*

Review of APR implementation

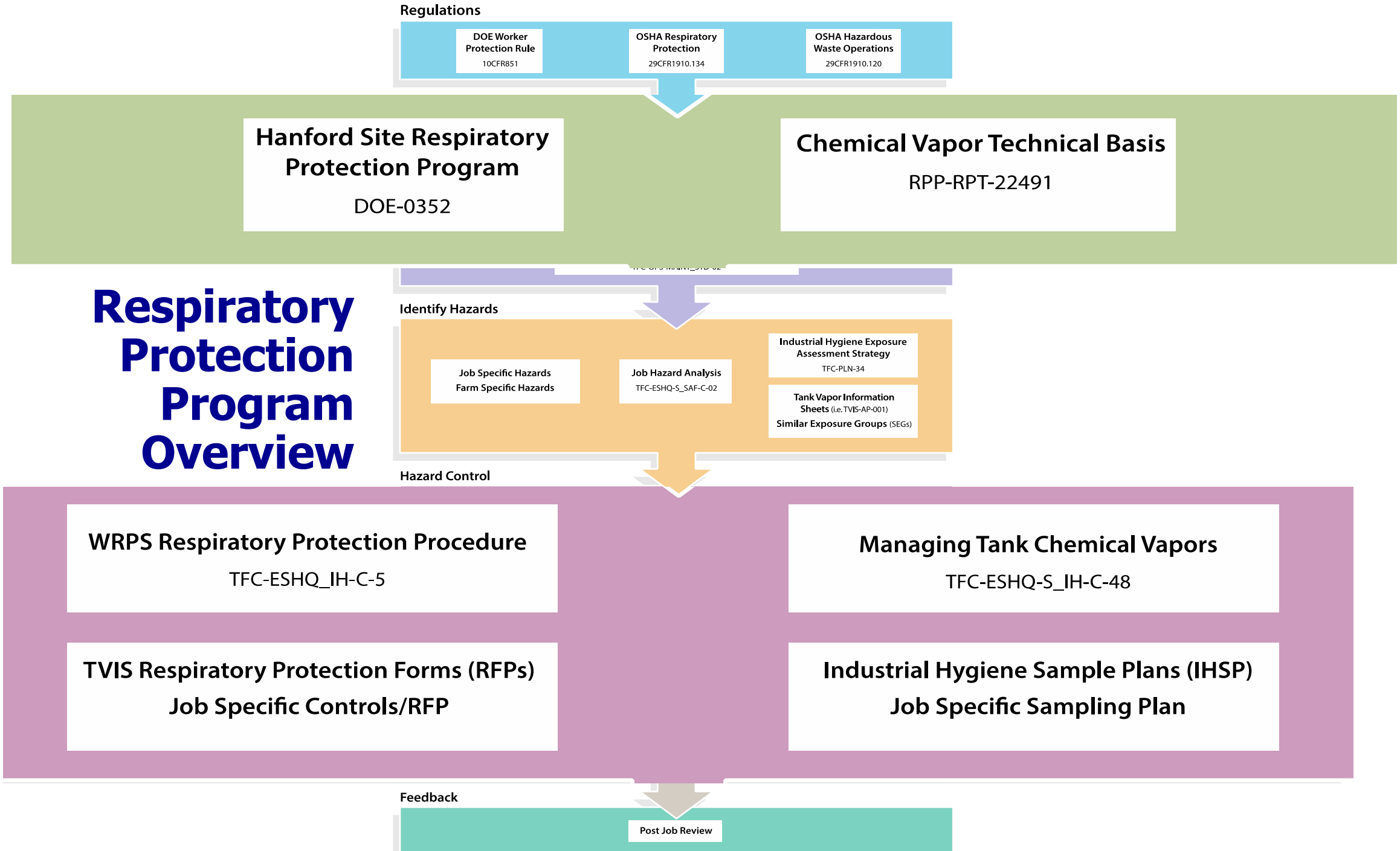
Program Implementation

Jim Johnson and Bruce Lippy



We have seen that the program is implemented as documented

Respiratory Protection Program Overview



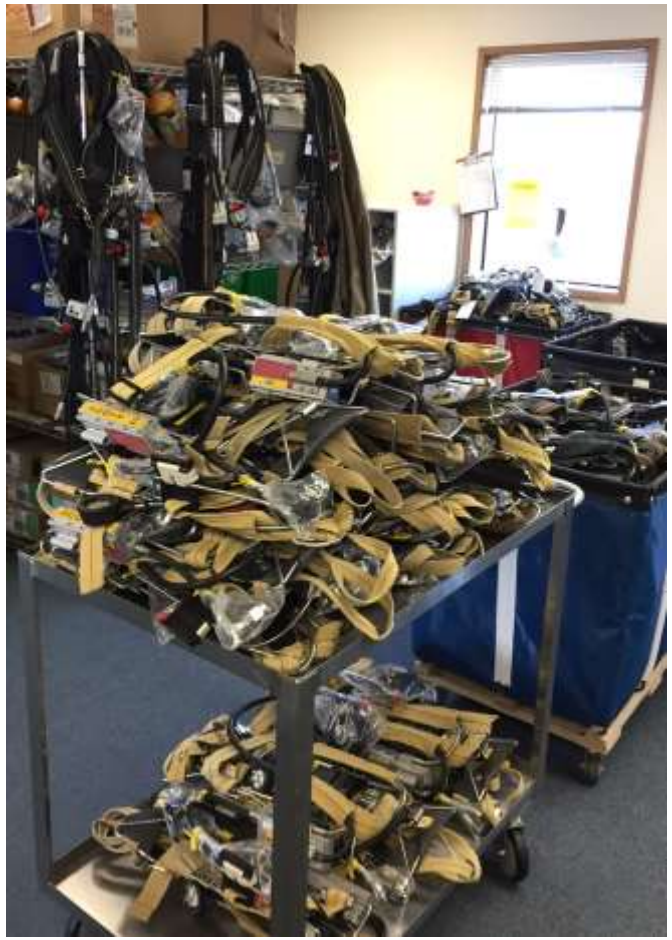
Hanford Site Respiratory Protection Requirements (DOE-0352) are addressed and appear to be implemented in WRPS Respiratory Protection Procedure (TFC-ESHQ_IH-C-5)

Team found key respiratory protection program (RPP) elements had been addressed

- Responsible Program Individuals
  - Industrial Program Manager
  - Respirator Protection Program Administrator
  - Industrial Hygienists and Radiological Planner
  - Respiratory Protection Core Team
- Purchase, Control, and Storage of Respiratory Protective Equipment
- Cleaning and Maintenance of Respiratory Protection Equipment

Key RPP elements that we identified

- Exposure Assessment and selection of Respirators
- Issuance, Use, and Return of Respiratory Protection Equipment
- Review Respiratory Equipment Sign Out/Sign In Log
- Work plan implementation
- Medical Evaluation
- Training
- Fit Testing



Additional elements that are addressed, but we have not evaluated

- Emergency/Immediately Dangerous to Life and health Conditions (Excluding Fire Fighting)
- Breathing-Air Distribution systems
- Breathing-Air Cart issuance and Control
- Self-Contained Breathing Apparatus (SCBA)
- Monthly Inspections of Self-Contained Breathing Apparatus

Final set of important elements addressed by WRPS:

- Cold Weather Considerations and Controls
- Voluntary Use
- Management Directed Use
- Alternative Respiratory Protection Authorization
- Evaluation of Respiratory Protection Program
- Records

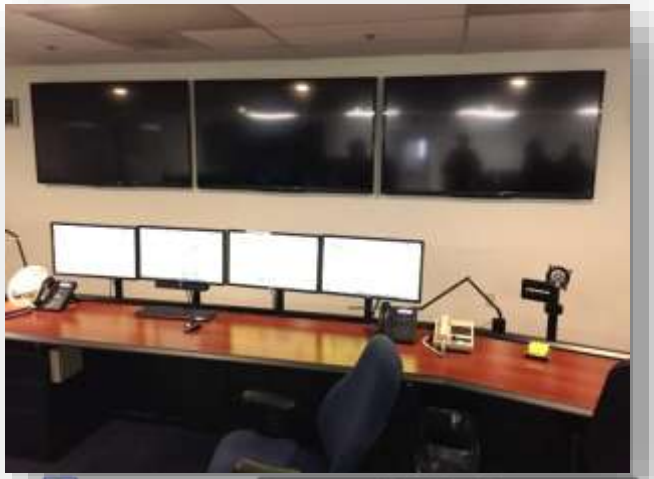
Hanford workers being sent home 2/8/17. Photo courtesy DOE.

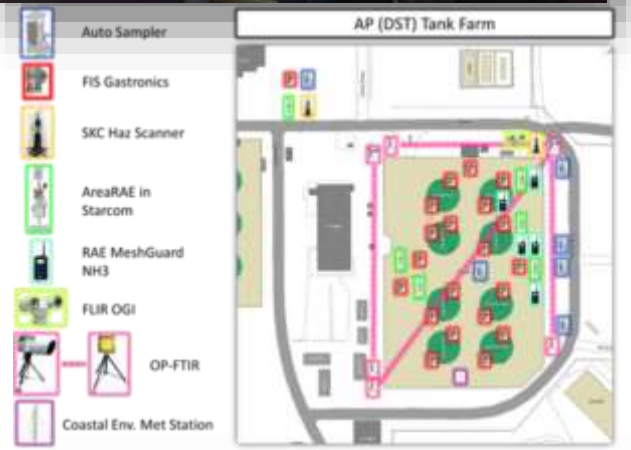
Our site visit revealed a conforming RPP

- We found the documents identified in the RPP Overview comprehensive and well done
- The respirator maintenance and issuance facility at AP Tank Farm we found it to be well organized, equipped, stocked, and staffed with knowledgeable individuals
- We observed a typical issue of a respirator to a worker and noted the computer data system that allowed confirmation of up-to-date qualifications before the respirator was issued

What considerations influenced our deliberations about use of APRs in AP Farm?

1. **Engineering controls** have reduced risks since testing
   - Exhauster height increased from about 20 to 40 ft
   - Ventilation rate increased from 850 cfm to 1500 cfm
2. **Administrative controls** have been strengthened
   - Only SEG 1 activities
   - Only during non-disturbing times
   - Outside the exhauster VCZ
3. **Monitoring** has been strengthened
   - Robust and representative
   - Source, area and personal
4. **Communications** have improved through Vapors website



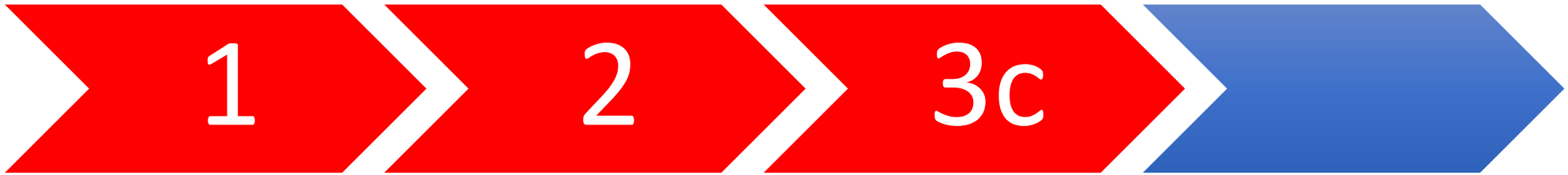


https://hanfordvapors.com

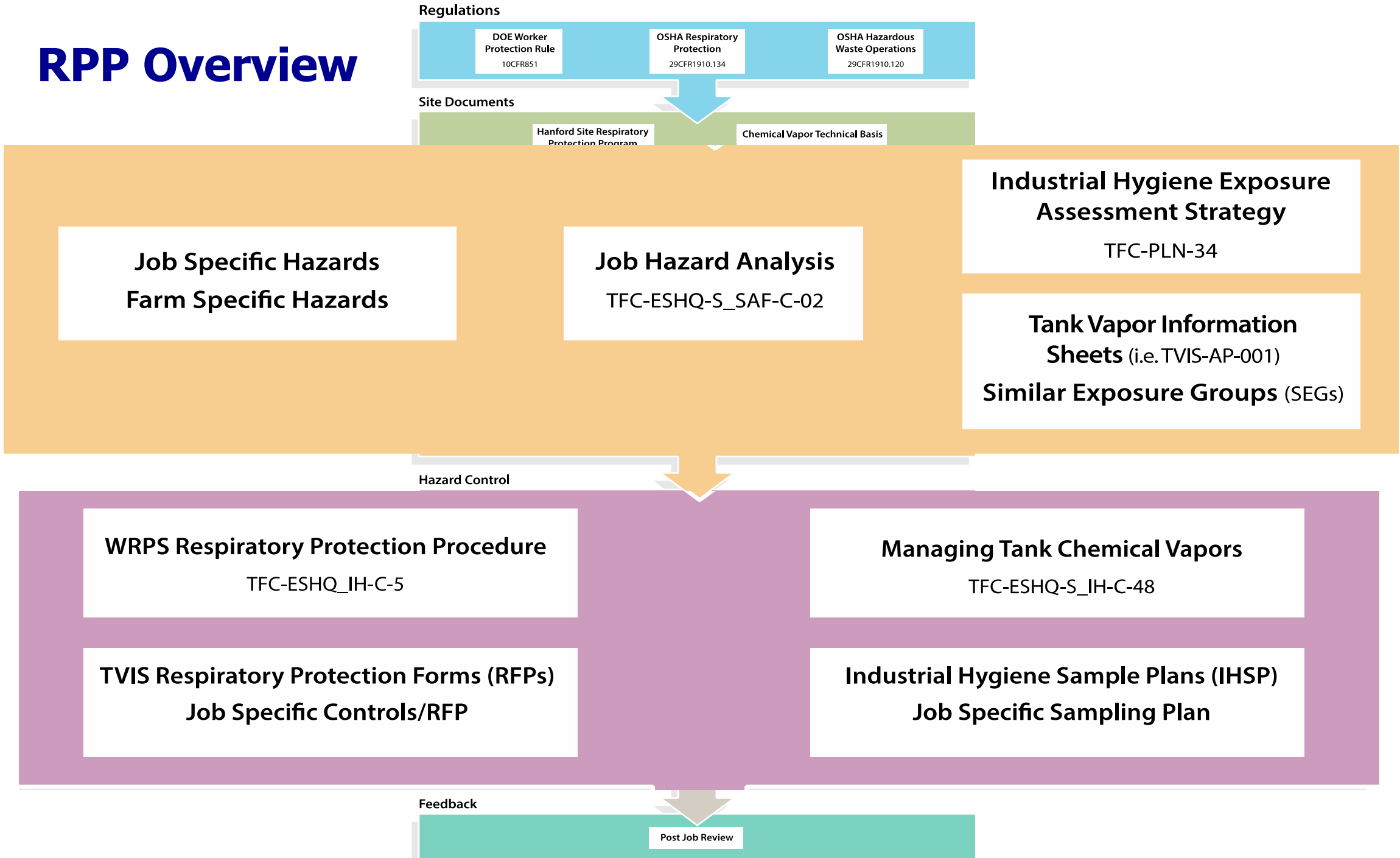
Review of APR implementation

Exposure Monitoring

Jim Johnson and Bruce Lippy



RPP Overview

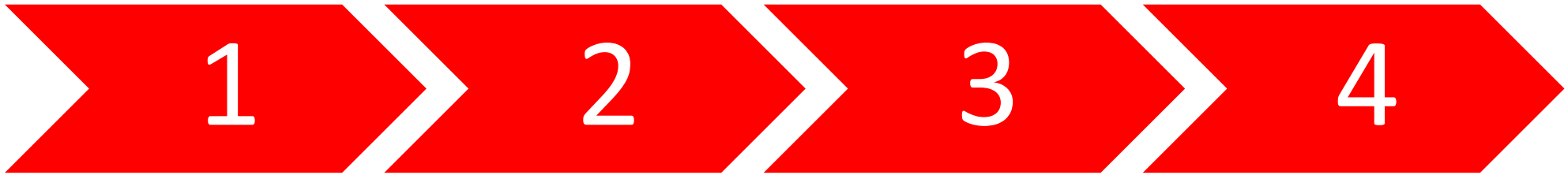


Hanford monitoring data will be evaluated

- **Source Monitoring:** the collection of airborne chemical samples at or close to the source
  - Tank headspace sampling
  - Stack sampling
- **Area Monitoring:** the collection of airborne chemical samples at a fixed position in the work area
  - Industrial Hygiene Tech direct read out instrument measurements
  - Fixed location instrument measurements
- **Personal Monitoring:** the collection of airborne chemical samples in the worker's breathing zone done by having the worker wear the sampling equipment throughout a representative period of the day
  - Worker breathing zone sampling

Way Forward

Knut Ringen

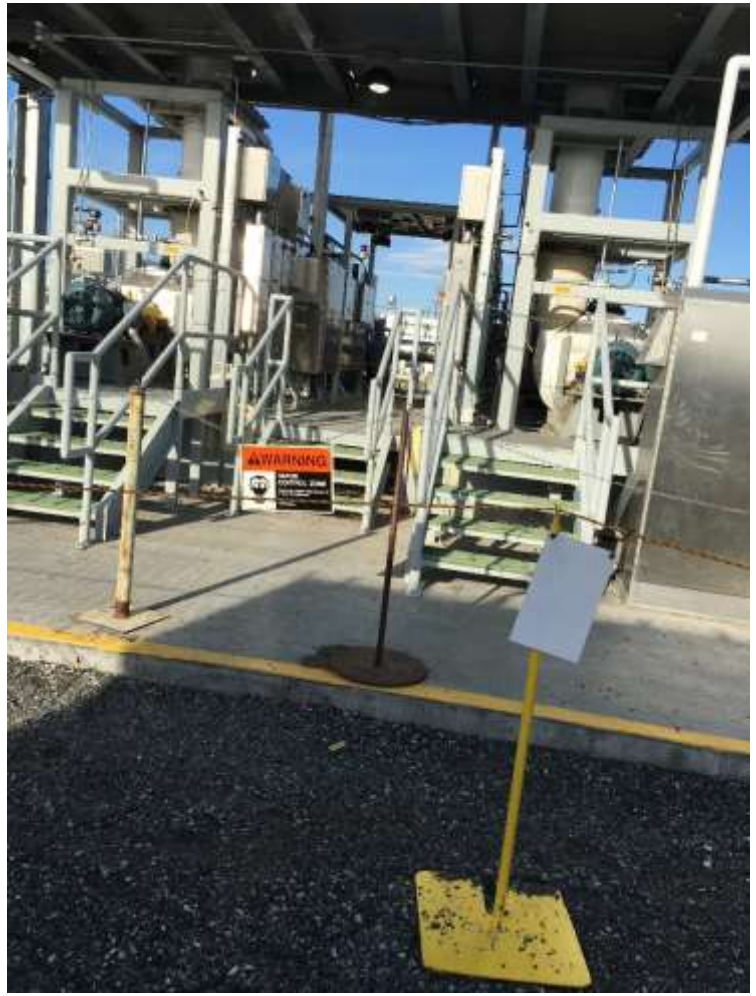


Summary

- Understanding when and where SAR is necessary and when and where APR may be an alternative
- Enhancing engineering and administrative controls
- Expansion of APR use
- Additional APR cartridge tests, including during waste disturbing work
- Testing of powered air purified respirators (PAPR) and their use in respiratory protection
- Additional testing for furans
- Understanding short-term episodic releases (so-called "Bolus" or "GRE" events) and finding controls against them
- Communications program needs to be improved

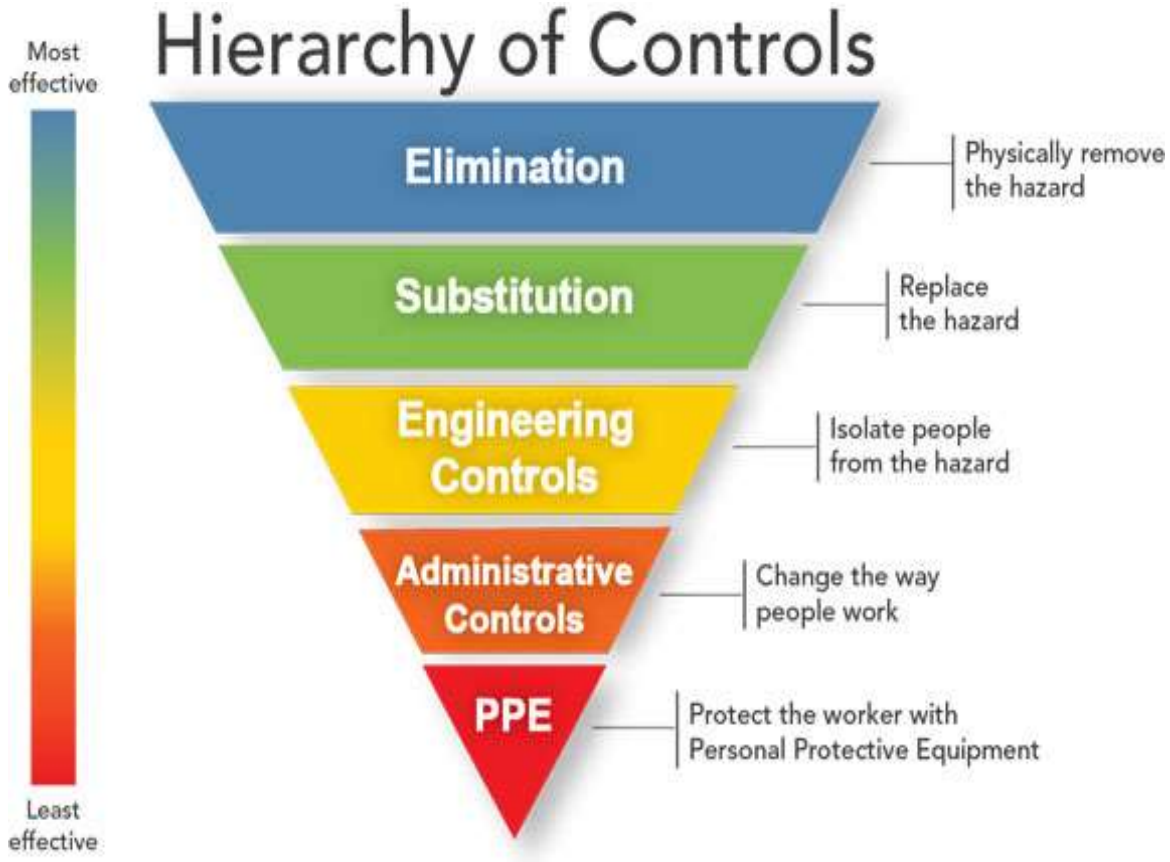
Understanding when and where SAR is necessary and when and where APR may be an alternative

- TVAT Implementation Plan (OR 6): SAR to be worn in SSTs and when hazard is present in DSTs
- WRPS-HAMTC MOA: SAR to be worn inside all perimeter fences until effective alternatives have been found
- Recommendation:
  - PPE Requirements should be based on IH hazard assessment
  - There should be clearly demarcated SAR Zones (currently known as VCZ) and APR Zones
  - These Zones should be based on dispersement modeling of head space chemical concentrations, ventilation and stack height, and atmospheric conditions
  - Where SAR is needed, air lines should be established as alternative SCBA where possible



Enhancing engineering and administrative controls

- The more that can be done in terms of enhancing engineering and administrative controls, the less need there will be for PPE.
- Doubling ventilation rate and stack height in AP Farm reduced exhausted vapor concentrations of ammonia by ~ 50%
- Recommendation:
  - Aggressive adoption of increased ventilation and stack heights and redundant systems
  - Adoption of chemical alarms on all vents (ammonia probably best choice)



Expansion of APR Use

Prerequisites for considering APR (or PAPR):

Following the template that has been developed (TOC-IH-58345)

Recommendation on expansion of APR use should be on a farm-by-farm basis:

- SEG 1 Work in DSTs other than in AP Tank Farm
- SEG 2 activities, beginning in AP Farm
- During some waste disturbing activities
- SSTs (very low likelihood if there is any liquid waste)

Recommendations for PAPR Cartridge/Canister Testing

- PAPRs are a useful respirator approach
- Testing of the PAPR cartridges is underway, but we have not seen the protocol

Cartridges should be tested for furans above their OELs

- Furans were detected in many of the cartridge tests, but the concentrations were below the limit of quantification.
- We cannot determine if the APR cartridges are protective because the concentrations were too low to produce a reliable test.

Understanding Short-term Episodic Releases (so-called "Bolus" or "GRE" events) and Finding Controls Against Them

- TVAT postulated “boluses”
- A “bolus” of the content of a tank must be the same as a gas release event (GRE)
- Episodic events attributed to the stacks in active ventilation (as in AP farm) should prevent GREs
- APRs are almost certainly protective against GREs as long as chemical concentrations in head space are below IDLH or 50 times OEL
- It should be possible to anticipate GREs or monitor for their occurrence
- Current monitoring system is inadequate to address this issue.

Recommendations for "Bolus" or "GRE" events

- Examination of GRE history in tank farms
- Examination of monitoring data in the AP Farm, historically and since new engineering
- Pressure monitoring of head spaces (especially in passive tanks containing liquid waste)
- Chemical alarming of all vents

Communications need improvement

- We have noted this in several of our reports
- We have not received evidence of a systematic or robust communication
- We observed a good pre-brief out on the site
- We found many workers accessing Hanfordvapors.com

Recommendation:

- Systematize communications and messages at all levels
- Build in a strong communications component in IH-T training

Thanks for your time.