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1	1	Cog.Eng. G.R. Tardiff	<i>G.R. Tardiff</i>	10/14/98		13	1	D.W. Crass	<i>D.W. Crass</i>	10/26/98	
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Engineering Study - Alternatives for SHMS high temperature/moisture Gas Sample Conditioners for the Aging Waste Facility

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Abstract: The Standard Hydrogen Monitoring Systems have been experiencing high temperature/moisture problems with gas samples from the Aging Waste Tanks. These moist hot gas samples have stopped the operation of the SHMS units on tanks AZ-101, AZ-102, and AY-102. This study looks at alternatives for gas sample conditioners for the Aging Waste Facility.

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ENGINEERING STUDY
ALTERNATIVES FOR SHMS
HIGH-MOISTURE/TEMPERATURE
GAS SAMPLE CONDITIONERS FOR
THE AGING WASTE FACILITY

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ACRONYMS

AWF	Aging Waste Facility
DOE	U.S. Department of Energy
GSC	Gas Sample Conditioner
HEGSC	High-Efficiency Gas Sample Conditioner
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
SCFM	Standard Cubic Feet Per Minute
SHMS	Standard Hydrogen Monitoring System
TPA	Tri-Party Agreement

1.0 OBJECTIVE

1.1 BACKGROUND

Several Hanford waste tanks have been observed to exhibit periodic releases of significant quantities of flammable gases. Because potential safety issues have been identified with this type of waste behavior, selected tanks have been equipped with standard hydrogen monitoring system(s) (SHMS) offering the capability to continuously monitor gases released from them. The technical basis for gas analysis and monitoring has been established (Estey 1998).

U.S. Department of Energy (DOE) Orders require that Hanford facilities comply with National Fire Protection Association (NFPA) guidelines; flammable gases therefore cannot be present in excess of 25 percent of the lower flammability limit where ignition sources exist. All Flammable Gas Watch List tanks have been fitted with SHMS to determine if hydrogen levels ever exceed 0.625 volume percent. The value is less than 25 percent (1.0%) of the lower flammability limit for hydrogen in air because other gases, like the oxidizer nitrous oxide, may be present and could reduce the lower flammability limit. In the event that a tank is found to have hydrogen levels in excess of 0.625%, other flammable gases will be monitored. Based on this monitoring, the behavior of the tank will be evaluated.

1.2 NATURE OF PROBLEM

SHMS's in the AY and AZ tank farms have experienced some difficulties in desired operation. The following discussion will explain the operational status of the SHMS to date in the Aging Waste Facility (AWF).

AZ-101 and AZ-102

Both AZ SHMS cabinets have experienced an extremely humid sample gas stream. Upon initial installation, the cabinets operated only a matter of hours before the sample stream moisture condensate bowl was filled with water. A peristaltic pump, additional condensate bowl, and condensate stream isolation valves were added to continually return the vapor sample stream condensate to the waste tank. The sample gas stream tubing heat trace temperature was lowered to encourage condensate formation in the sample gas stream tubing. The condensate was then trapped out in the first moisture collection bowl and returned to the tank using the peristaltic pump. A second condensate collection bowl was installed downstream of the system flow control valve and upstream of the sample pump to avoid condensate collection in the sample pump. This allowed the two AZ SHMS cabinets to be operated continuously for several weeks without buildup of moisture in the inlet HEPA filters. On hot summer days, the sun was found to heat the gas sample delivery tubing sufficiently to maintain a high dew point and minimize the condensate

generation in the sample gas stream tubing. This high dew point sample gas did not sufficiently condense in the cabinet tubing prior to the first condensate collection bowl, but condensed in the inlet HEPA filters after a short time of continual operation. An intermittent SHMS operation was established to allow vapor sampling for short durations daily during the back shift hours. The success of the back shift operation has not yet been verified. The solution to the condensate problem is to reduce the sample gas stream dew point prior to the SHMS cabinet. This has been successfully done at other SHMS locations on tanks with lower vapor space dew points. However, the condensate removal systems installed on these tanks are not currently capable of removing adequate moisture from the Aging Waste Tank vapor.

AY-102

The SHMS cabinet on the AY-102 waste tank has been successfully operating for more than a year. The ventilation system has maintained the vapor space dew point low enough to avoid condensate buildup in the SHMS cabinets. This was true until recently, when the air lift circulators were operated during a caustic addition. The recently installed gas sample conditioning cabinet associated with the SHMS was not operating due to installation problems during the caustic addition. During this campaign there was sufficient moisture/particulate in the sample gas stream to plug the inlet HEPA filters enough to terminate the SHMS cabinet operation. Based on engineering estimates it is doubtful that the standard gas sample conditioner would have mitigated inlet HEPA filter plugging during the caustic addition with the air lift circulators in operation. The vapor sample conditions during airlift circulator operations would have exceeded the design limits for temperature and moisture content of the standard gas sample conditioner.

The purpose of this study is to evaluate the alternatives available to allow the SHMS to run continuously during all planned tank farm activities, and to recommend the best alternative.

2.0 RECOMMENDATIONS AND CONCLUSIONS

It is recommended that a High-Efficiency Gas Sample Conditioner (HEGSC) be installed on Aging Waste Tanks AZ-101, AZ-102, and AY-102. It is also recommended that the gas samples for the SHMS be withdrawn from the existing multi-purpose tank probe.

Offsite procurement or onsite development alternatives will both provide an acceptable HEGSC that will meet the system requirements shown in section 3.1. However, the onsite development alternative is recommended over offsite procurement based on the following points.

- Generation of high quality design drawings compatible with Hanford standards and configuration control.

- Generation of high quality design drawings compatible with Hanford standards and configuration control.
- Engineering will have better control of equipment configuration in fabrication shop.
- Equipment design errors/modifications are more easily handled on site.
- Equipment testing/acceptance will be conducted on site.
- Engineering can maintain better system interface control on site.
- Better control of materials.
- Design benefits from onsite operating experience.

3.0 DESCRIPTION OF ALTERNATIVES

3.1 SYSTEM REQUIREMENTS

The gas sample conditioning system will consist of all equipment necessary to reduce the dew point of the defined sample gas stream to 41°F (5°C). The environmental conditions (design parameters) existing in the Aging Waste Tanks are listed in Table 1. Condensed vapor shall be routed back to the tank from which the gas sample was withdrawn. The gas sample hold up time in the GSC shall be shown to be no more than 15 seconds at a flow rate of 0.4 SCFM (11.3 L/m).

The gas sample conditioner/condenser will operate in a vacuum ranging from 0 to -6 inches of water. The gas sample conditioner/condenser shall be an impingement type, designed to minimize gas/liquid contact and the stripping of soluble gases. The equipment shall be housed in a National Electrical Manufacturers Association, (NEMA) 4 rated enclosure that is insulated and cooled to maintain an internal ambient temperature of 77°F (25°C). The gas sample conditioner system shall be equipped with a water backflush system capable of backwashing the complete system of possible contamination. The backwash system shall drain back to the tank from which the sample was drawn.

TABLE 1 - Environmental Conditions

CONDITION	RANGE
Temperature	130°F (54.5°C) to 200°F (93°C)
Dewpoint	130°F (54.5°C) to 176°F (80°C)
Gas Flow Rate	0.4 to 0.5 SCFM ($\approx$ 11L/min to 14L/min)
Gas Content - The following is a list of gases that may be present in the sample stream. The list is not inclusive and other unknown gases may be present.	Air - 100% Hydrogen: typically 50 - 100 ppm, occasionally 1 - 4 percent Ammonia: typically 100 - 1000 ppm Nitrous Oxide: typically 50 - 500 ppm
Radionuclide Particulate (samples taken during air lift circulator operation)	^{137}Cs sample concentrations ranged between 3,106 Bq/m ³ and 11,489 Bq/m ³ in some air samples. ^{134}Cs , $^{106}\text{RuRh}$, and ^{95}Nb have also been detected in some air samples. (See Kimura/Lindsey, 1987)

3.2 ASSUMPTIONS

A condensate removal system will be specified based on conditions expected during mixer pump and air lift circulator operations within the Aging Waste Facility (AWF) and will be bounded by the values shown in Table 1. Should an AWF tank experience a loss of primary ventilation, the dome gas temperature will reach 175°F when the peak sludge temperature reaches 215°F.

TWRS Basis for Interim Operation, HNF-SD-BIO-001, Rev O-L, Chapter 5, Section 5.3.2.22 and TWRS Technical Safety Requirements, HNF-SD-WM-TSR-006, Rev 0-0, LCS/LCO 3.3.2, requires that the peak sludge temperatures below 15 feet shall be limited to $\leq$ 215°F. For current waste conditions with this temperature limit, the dome gas conditions would not exceed 175°F.

However, for Tanks 241-AZ-101 and 102 operating 300 hp mixer pumps for several days, and with the loss of primary ventilation, the dome gas temperature could exceed 176°F. This scenario is based on earlier calculations performed for Tank 241- AZ-101. See WHC-SD-WM-ER-335, Summary Report Thermal Hydraulic Safety Analysis of Aging Waste Tank, AZ-101 Figure 3-4, (Sathyanarayana, 1994).

3.3 ALTERNATIVES

Four alternatives were considered for this study: A brief summary of each alternative is presented here, and a detailed discussion can be found in Section 4.0. Cost estimates are in Appendix A.

Alternative 1: Install two existing Standard GSC's in series.

Use two existing Standard GSC's in series on the same tank. Withdraw sample from the existing multi-purpose tank probe.

Advantages:

1. Utilizes existing sample probe.
2. Minimum impact to other tank farm systems

Disadvantages:

1. Gas sample hold-up time exceeds the requirements of the SHMS analytical equipment
2. Adds double the equipment costs
3. Increased maintenance costs
4. Excessive sample tubing and heat trace additions

Total costs associated with alternative 1: \$300,000

Alternative 2: Use existing GSC procurement specification HNF-S-0553.

Procure and install a high-capacity GSC using existing procurement specification HNF-S-0553 on tanks AZ-101, AZ-102, and AY-102 utilizing existing multi-purpose sample tank probe.

Advantages:

1. Utilizes existing procurement specification
2. Minimum modifications required to tank farm facility
3. Has higher gas sample conditioning capacity than standard GSC
4. Provides increased enclosure ambient temperature control over standard GSCs
5. Does not exceed gas sample holdup time requirements of SHMS analytical equipment
6. Provides adjustable dewpoint gas sample

Disadvantages:

1. Procurement specification requires significant revision by engineering
2. Installation will require additional underground electrical conduit
3. Offsite procured systems in the past have required onsite rework/modifications prior to installation in the field
4. Minimum configuration control of the hardware design
5. Increased cost associated with travel for QA inspection, engineering oversight, and testing

Total costs associated with Alternative 2: \$312,000

Alternative 3: Move SHMS gas sample location utilizing standard GSC.

Relocate the SHMS sample point from the multi-purpose tank probe to a point downstream of the 702-AZ ventilation system K4-5-1 recirculation fan in the Recirculation/Cooling module. Install a standard GSC into the sample system.

Advantages:

1. Utilizes the existing standard GSC design
2. Provides a gas sample that is within the operating limits of the existing standard GSC capabilities

Disadvantages:

1. Requires modification to existing tank farm structures
2. Limits the SHMS ability to sample the gas stream for ammonia or other water soluble gases
3. Requires long runs of sample tubing
4. Requires additional heat tracing of long tubing runs
5. Requires modifying the SHMS cabinets with additional electrical components to accommodate increased electrical loads

Total costs associated with alternative 3: \$287,000

Alternative 4: Design and fabricate new HEGSC onsite.

Design, fabricate, and install new HEGSC on tanks AZ-101, AZ-102, and AY-102 utilizing existing multi-purpose sample tank probe.

Advantages:

1. Minimum modifications required to tank farm facility
2. Higher gas sample conditioning capacity than standard GSC
3. Provides complete set of Hanford Plant Standard design drawings
3. Provides increased enclosure ambient temperature control
4. Minimumizes stripping of water soluble gases from the sample stream
5. Provides adjustable dewpoint gas sample
6. On-site design and fabrication will not require travel to vendor facilities for oversight and testing
7. Can be designed, fabricated, and assembled with off the shelf components
8. Design requires no development

Disadvantages:

1. Requires modification to existing tank farm structures.
2. Installation will require additional underground electrical conduit.

Total cost associated with Alternative 4: \$324,000

4.0 DISCUSSION OF ALTERNATIVES

Estey (1998) states that “Gas monitoring is a key to understanding the nature, and thus the risks, associated with flammable gas tanks.” The major issues driving the operation of the flammable gas monitoring systems are as follows:

- Support of work controls and worker safety
- Obtain data to support unreviewed safety question closure and safety issue resolution
- Monitor the transient behavior of waste tanks
- Monitor the steady state behavior of waste tanks

Johnson (1997) details the major milestones assigned to the Flammable Gas Project By the Tri-Party Agreement (TPA), as well as by other stakeholder agencies or regulatory agreements. Gas monitoring is integral to achievement of the associated requirement of TPA Milestone M-40-00. While Milestone M-40-10 is considered complete, continued flammable gas monitoring is required to meet the intent of obtaining the best possible information upon which to base decisions regarding the closure of the flammable gas safety issue.

Alternative 1

Installing two standard gas sample conditioners in series has the advantage of utilizing the existing sample probe and would have minimum impact on existing tank farm systems. However it is not considered a viable alternative to solve the high temperature/moisture problem being experienced by the aging waste tanks. The major technical disadvantage with this option is that the maximum sample hold-up time allowed in the GSC is 15 seconds. This requirement was established by engineering based on the SHMS analytical equipment requirements. The SHMS analytical instruments require a gas sample every 30 seconds. The 15 second GSC maximum hold-up time was established to ensure that a gas sample could reach the SHMS analytical equipment within 30 seconds. The standard GSCs have a sample hold-up time of approximately 11 to 13 seconds at a flow rate of 0.383 SCFM. This is based on vendor testing of the existing GSC units on site. While this hold-up time meets the specification when using one unit, installing two in series would increase the sample hold-up time to approximately 22 to 26 seconds with a gas flow rate under the specified range of 0.4 to 0.5 SCFM. This excessive holdup time would not allow the gas sample to reach the SHMS within 30 seconds. Based on this disadvantage, no further consideration of this alternative was considered.

Alternative 2

This alternative would procure a high capacity GSC as specified by procurement specification HNF-S-0553, Rev 0. The installation would utilize the existing multi-purpose probe installed in the tanks. The new unit would be installed in the same manner as standard GSC's have been installed in other locations. The advantage of this alternative is that the SHMS would continue to draw their sample directly from the tank via the multi-purpose probes. The HEGSC will have a maximum holdup time of 15 seconds and will be able to deliver the gas sample to the SHMS within the 30 second requirement. This sample location would aid the SHMS in future gas monitoring for other gases such as ammonia and nitrous oxide. The high-capacity GSC design minimizes the stripping of water soluble gases from the sample stream. The major disadvantage to this alternative is that the existing procurement specification would require significant revision to ensure that the procured GSCs would meet the system requirements shown in Section 3.1. A procured system will require additional costs associated with QA/Engineering oversight travel to the vendor's site. There will be additional underground electrical conduit along with new electrical service equipment required to install this alternative.

Alternative 3

This alternative would change the SHMS gas sample point from the multi-purpose gas sample probe to a point downstream of the 702-AZ ventilation system K4-5-1 recirculation fan in the Recirculation/Cooling Module. A standard GSC would be installed adjacent to this location. The advantage of this sample point is the gas stream environmental conditions are more favorable than those taken from the multi-purpose tank probe. The gas temperature and moisture content at this sample location are more in line with the capabilities of the standard GSC. A disadvantage of this alternative is that long runs of sample tubing and support stanchions will be required along with additional heat tracing. This will add clutter to the equipment already installed on top of the tanks. This alternative will also necessitate modifications to the SHMS cabinets. New electrical breakers and wiring may be needed to accommodate the additional amperage required by the heat trace addition. SHMS cabinet temperature controllers for the heat tracing have a 25 amp maximum capacity which will accommodate approximately 240 feet of heat traced tubing. Depending on the additional length of heat trace, new circuit breakers may be required. Another disadvantage is the procurement specification for the standard GSC will need to be revised to correct marginal performance encountered in the early systems. The 702-AZ ventilation system Recirculation/Cooling Module sample location will degrade the SHMS capacity for future sampling of other gases such as ammonia and nitrous oxide. Additional trenching will also be required to accommodate new electrical conduit runs. A third disadvantage is that SHMS performance will be subject to the operating mode of the 702-AZ ventilation system, (i.e. Recirculation vs By-pass). When the 702-AZ ventilation system is in by-pass mode there are no advantages to this gas sample location.

The gas samples that will be available to the SHMS will exceed the capability of the standard GSC.

Alternative 4

This alternative will design, and fabricate a HEGSC onsite. The design capacities of the HEGSC will meet all of the system requirements shown in section 3.1. The HEGSC would be designed to utilize existing off-the-shelf components. The HEGSC will be installed close to the existing multi-purpose tank probe. The advantage of this alternative is that the SHMS would continue to draw their sample directly from the tank via the multi-purpose probes. This sample location would aid the SHMS in future gas monitoring for other gases, such as ammonia and nitrous oxide. The high-capacity GSC design would minimize stripping of water soluble gases from the sample stream. This alternative will also provide a full set of design drawings for the GSC. Having a full set of documentation for the system greatly improves operability and maintainability of the system. A disadvantage of this alternative is that new electrical circuit breakers and wiring will be required for the HEGSC installation. New underground electrical conduit runs will be required. This may necessitate digging long trenches in the tank farm.

5.0 NO ACTION ALTERNATIVE

Estey (1998) Section 6.1 details the minimum monitoring duration before a permanent SHMS installation can be removed from a tank. Continuous SHMS monitoring is required until all monitoring criteria conditions have been met. Taking no action to improve the gas samples currently available to the permanent SHMS installed on Tanks 241-AZ-101, 241-AZ-102, and 241-AY-102 in the AWF will prohibit continuous flammable gas monitoring. Some form of gas sample stream conditioning must be integrated into the flammable gas monitoring systems to allow the SHMS to function on a full-time bases. Therefore, taking no action to mitigate the gas sample problems encountered by the SHMS in the AWF tanks is unacceptable until monitoring criteria are met.

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7.0 APPENDIX A

COST ESTIMATES

NOTE: The costs reflected on the following estimates are based on prior experience and actual costs incurred during procurement and installation of GSCs in other tank farms. The costs shown for work package preparation and procurement are also based on prior GSC work.

ALTERNATIVE #1

Install two standard GSCs in series

INTRODUCTION

The cost reflected here is a rough order of magnitude cost estimate. The estimate is to procure five new standard GSCs and install two conditioners in series on three tanks (AZ-101, AZ-102, and AY-102) in the AWF. This estimate is based on using the existing GSC installed on AY-102. This estimate assumes that the units will be procured off-site utilizing Procurement Specification WHC-S-0480, Rev 2.

Procurement and Inspection Costs

AZ-101 (2 new GSCs)	\$40,000
AZ-102 (2 new GSCs)	\$40,000
AY-1-2 (1 new GSC)	\$20,000

Engineering (ECN preparation)	\$5,000
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Work Package Preparation and Approvals	\$10,000
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Installation Costs

AZ-101 (install 2)	\$60,000
AZ-102 (install 2)	\$60,000
AY-102 (install 1)	\$35,000

TOTAL COSTS EACH TANK

AZ-101	\$115,000
AZ-102	\$115,000
AY-102	\$70,000

<u>TOTAL COSTS FOR THREE TANKS</u>	\$300,000
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ALTERNATIVE #2

Use existing GSC procurement specification HNF-S-0553

INTRODUCTION

The cost reflected here is a rough order of magnitude cost estimate. The estimate is to procure three HEGSCs to be used on the high heat tanks in the AWF, (AY & AZ Tank Farms). This estimate assumes that the units will be procured off-site utilizing Procurement Specification HNF-S-0553.

Procurement and Inspection Costs

AZ-101	\$24,000
AZ-102	\$24,000
AY-1-2	\$24,000

Engineering (ECN preparation)	\$5,000
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Work Package Preparation and Approvals	\$10,000
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Installation Costs

AZ-101	\$60,000
AZ-102	\$60,000
AY-102	\$60,000

TOTAL COSTS EACH TANK

AZ-101	\$99,000
AZ-102	\$99,000
AY-102	\$99,000

<u>HEGSC COSTS FOR THREE TANKS</u>	\$307,000
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<u>PROCUREMENT SPECIFICATION REVISION</u>	\$10,000
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<u>QA/ENGINEERING VENDOR OFFSITE TRAVEL</u>	\$5,000
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<u>TOTAL COSTS FOR THREE TANKS</u>	\$312,000
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ALTERNATIVE #3

Move SHMS gas sample location utilizing a standard GSC

INTRODUCTION

The cost reflected here is a rough order of magnitude cost estimate. The estimate is to relocate the SHMS sample point from the multi-purpose tank probe to a point downstream of the 702-AZ ventilation system K4-5-1 recirculation fan in the Recirculation/Cooling module. Install a standard GSC into the sample system. This alternative will utilize one existing standard GSC, and procure two new standard GSCs using Procurement Specification WHC-S-0480, Rev 2.

Procurement and Inspection Costs

AZ-101 (1 new GSC)	\$20,000
AZ-102 (1 new GSC)	\$20,000
AY-102 (use existing GSC)	\$ 0.000

Engineering (ECN preparation)	\$20,000
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Work Package Preparation and Approvals	\$10,000
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Installation Costs

AZ-101	\$60,000
AZ-102	\$60,000
AY-1-2	\$37,000

TOTAL COSTS EACH TANK

AZ-101 (new installation)	\$110,000
AZ-102 (new installation)	\$110,000
AY-102 (relocate existing GSC)	\$67,000

TOTAL COSTS FOR THREE TANKS

	\$287,000
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ALTERNATIVE #4

Design, fabricate, and install new HEGSCs

INTRODUCTION

The cost reflected here is a rough order of magnitude cost estimate. The estimate is to produce three HEGSCs to be used on the high-heat tanks in the AWF, (AY & AZ Tank Farms). This estimate assumes that all procurement, design media, fabrication, and testing will be done onsite.

Total hardware cost	\$10,900
Fabrication Costs	\$13,000
Engineering (ECN preparation)	\$5,000
Work package preparation and approvals	\$10,000
Installation Costs	
AZ-101	\$60,000
AZ-102	\$60,000
AY-102	\$60,000
TOTAL COSTS EACH TANK	
AZ-101	\$98,900
AZ-102	\$98,900
AY-102	\$98,900
GSC COSTS FOR THREE TANKS	\$296,700
DESIGN MEDIA COSTS	\$28,000
TOTAL COSTS FOR THREE TANKS	\$324,700