S

OCT 16 2000

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 629379

2. To: (Receiving Organization) Plant Supp Engr-Engr & Desgn Ser	3. From: (Originating Organization) Engineering & Design Services	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Plant Supp Engr-Engr & Desgn Ser	6. Design Authority/Design Agent/Cog. Engr.: GP Janicek/RG Brown	7. Purchase Order No.: N/A
8. Originator Remarks: Release.		9. Equip./Component No.: N/A 10. System/Bldg./Facility: 200G 12. Major Assm. Dwg. No.: N/A
11. Receiver Remarks:	11A. Design Baseline Document? ☐ Yes ☒ No	13. Permit/Permit Application No.: N/A 14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	RPP-7170	N/A	0	Evaluation of Validity of Three Criteria for Sampling and Analyzing DST Wastes in Support of Waste Feed Delivery	N/A	2		

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
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18.	19.	20.	21. DOE APPROVAL (if required)
F.R. Reich 10/3/00 Signature of EDT Originator / Date	R.M. Boger 10/5/00 Authorized Representative for Receiving Organization / Date	G.P. Janicek 10/5/2000 Design Authority/ Cognizant Manager / Date	Ctrl No. ____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

BD-7400-172-2 (10/97)

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EVALUATION OF THE VALIDITY OF THREE CRITERIA FOR SAMPLING AND ANALYZING DST WASTES IN SUPPORT OF WASTE FEED DELIVERY

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U.S. Department of Energy Contract DE-AC06-99RL14047

EDT/ECN: 629379 UC: 2000
Org Code: 7M100 Charge Code: 112356
B&R Code: EW02J2010 Total Pages: 28

Key Words: sampling system criteria, LAW, HLW, DST, mixer pump, waste feed delivery

Abstract: This document summarizes the analysis of 3 basic criteria for the sampling systems that will provide waste validation samples of tank waste feeds prior to delivery to the waste treatment and immobilization plant where the wastes will be converted to glass forms. The assessed criteria includes sampling through a 4-inch riser, sampling while a mixer pump is operating, and the deployment of an at-tank analysis system. The assessment, based on the Phase 1, 3S6 waste feed scenario, indicated that for high level waste, sampling through a 4-inch riser is not required but sampling while mixer pumps are operating will be required. For low activity waste, sampling through a 4-inch riser will be required but sampling while mixer pumps are operating is not required. The assessment indicated that an at-tank analysis system to provide tank mixing/settling (homogeneity) status is not needed since the number of tanks providing LAW feed was expanded and the payment basis in the original privatization contract has been modified.

Release Approval Date 10/16/00 Release Stamp

DATE: HANFORD RELEASE
STA: 4 ID: 2
OCT 16 2000

Approved for Public Release

EVALUATION OF THE VALIDITY OF THREE CRITERIA FOR SAMPLING AND ANALYZING DOUBLE-SHELL TANK WASTES IN SUPPORT OF WASTE FEED DELIVERY

September 28, 2000

Prepared for the Tanks Focus Area
By
Dade Moeller & Associates, Inc.

1.0 INTRODUCTION

Advanced double-shell tank (DST) sampling and at-tank analysis systems are being developed at Hanford to support staging of high-level waste (HLW) and low-activity waste (LAW) feeds for delivery to the Waste Treatment and Immobilization Plant (WTP) where the wastes will be converted to glass forms. The sampling system may be capable of obtaining more-representative samples and/or achieving higher sampling accuracies than the conventional grab-sampling method currently used at Hanford. The at-tank analysis system may be capable of performing certain waste analyses at the tank faster than if the samples were transferred to the 222-S Laboratory and analyzed.

Specifications and criteria for these systems have been developed, and have evolved over time in response to changing DST waste feed requirements (Rasmussen 2000, and Reich 2000-DRAFT). Three of the criteria may be unwarranted or overly constraining, and affect the potential feasibility of and need for the systems. The first criterion is the requirement that the sampling system be deployable through a 4-inch tank riser. The second criterion is the requirement that the sampling system be capable of sampling while a tank mixer pump(s) is operating in the tank being sampled. The third criterion is the requirement that at-tank analytical capability be installed to provide screening data for assessing the homogeneity of the waste feed. The purpose of this report is to document an independent assessment of the validity of these criteria to support sampling of waste feeds for delivery to the WTP.

The authors of this report were Mr. Russell Treat and Mr. Ross Potter from Dade Moeller and Associates, Inc. Mr. Mike Boger, from Numatec Hanford Corporation, and Mr. Fred Reich, from COGEMA Engineering Corporation, both responsible for implementing the DST sampling and at-tank analysis systems at Hanford, provided relevant documents and information on the availability of and access to risers in DSTs 241-AW-103 and -104, 241-AY-101 and -102, and 241-AZ-101 and -102. Mr. Pete Gibbons and Mr. Tom Thomas, both Technical Integration Managers from the Tanks Focus Area, and Mr. Bill McEvoy, from the Savannah River Site (SRS), provided information on the development and application of the sampling systems at Hanford and SRS. Information provided by these sources served as bases for this report.

Section 2.0 of this report provides a summary of changes in the mission that have impacted the sampling and at-tank analysis systems requirements. Section 3.0 lists key assumptions for the assessment. Section 4.0 assesses criterion one, that samplers must be deployable through 4-inch risers. Section 5.0 assesses criterion two, that sampling must occur while tank waste is being mixed. Section 6.0 assesses criterion three, that an at-tank analysis system is required. Section 7.0 provides a summary of the assessment and Section 8.0 lists references.

2.0 BACKGROUND AND BASES FOR WASTE FEED SAMPLING AND ANALYSIS CRITERIA

In 1996, the U. S. Department of Energy (DOE), Richland Operations Office (DOE-RL) awarded two privatization contracts to develop preliminary designs and supporting information for constructing and operating two WTPs at Hanford. Two DSTs (tanks 241-AP-106 and -108) were to be turned over to the private contractors as feed receipt tanks, and two DSTs (tanks 241-AP-102 and -104) were designated to serve as waste feed staging tanks. Both DSTs 241-AP-102 and -104 contain spare 12-inch risers (Hanford Drawings H-14-010503, sheets 2 and 4). Initial fluidic sampler development plans at SRS and Hanford included a sampler mast that could be inserted through 6- to 12-inch risers (DOE 1999).

In 1998, DOE-RL selected only one of the two private contractors (BNFL Inc.) to develop a detailed design of a single WTP. DOE-RL also instructed BNFL Inc. to construct additional feed receipt tanks and eliminated the requirement for the Tank Farm Contractor (TFC) to turn over DST 241-AP-106 to BNFL Inc. The increased number of DSTs under the control of the TFC allowed the TFC to revise its waste feed staging strategy. The new strategy reduced the risk of late feed delivery by the addition of about a dozen new staging tanks, which greatly increased the time available to complete all staging activities (Kirkbride 2000). These activities include receipt of waste in the staging tank, mixing the contents, sampling, analysis, documentation and certification, and pumping feed to the WTP. Each of the added staging tanks contain spare 4-inch risers that satisfy the minimum requirements for work area around the risers and distance from the mixing pumps (Boger 2000). Only a few of the tanks contain 6-inch or larger risers that also meet the work area and distance requirements.

During the past two years, BNFL Inc. developed Interface Control Documents (ICDs) (BNFL 2000a and BNFL 2000b) for representatively sampling the LAW and HLW feeds (ICDs 19 and 20, respectively). The ICDs stipulate that eight grab samples are to be taken in a staging tank immediately after ceasing mixer pump operation. ICD 19 also requires the application of the Analysis of Variance (ANOVA) statistical technique to assess the homogeneity of LAW feeds based on three, generally soluble waste species (sodium, aluminum, and cesium-137). Neither the ANOVA procedure nor other requirements of ICD 19 include statistical limits that necessitate high sampling and analytical accuracy. ICD 20 does not require the application of ANOVA or other statistical technique to establish the homogeneity of HLW feeds.

In May 2000, the Office of River Protection (ORP, the successor to DOE-RL for Hanford tank waste management) decided to terminate the BNFL Inc. contract (DOE 1996). On August 31, 2000, the ORP issued a Request for Proposals (RFP) for a new contractor to assume responsibility for the greater part of the BNFL Inc. scope of work under a cost-plus-incentive-fee contract (DOE 2000). The RFP contains no new waste feed sampling and analysis requirements relative to the three criteria in question (deployability in a 4-inch riser; capability of sampling during mixing; and need for at-tank analysis).

3.0 KEY ASSUMPTIONS FOR CRITERIA EVALUATION

The following assumptions were made in evaluating the three criteria:

1. The sampling system will be deployed over a tank riser to access the waste in the tank.

2. The sampling system will require approximately a 10-foot diameter circle of clear working space around the riser.

3. In-tank components of the system will be subject to forces from mixer pump effluent. The sampling masts must be positioned a sufficient distance from the mixer pumps to avoid damage to the masts.

4. The feed tanks in which the advanced sampling system is currently being considered for deployment are based on the waste batch feed staging sequences shown in Figures 1 and 2 of the *Tank Farm Contractor Operation and Utilization Plan* (Kirkbride 2000), with the addition of DST 241-AW-103, a new backup HLW feed tank.

5. The 10,000-gpm mixer pumps to be installed in the staging tanks represent the state-of-the-art for mixing wastes in Hanford DSTs; there is no other feasible technology that can appreciably improve mixing in these tanks.

6. LAW feeds will be homogenized and then allowed time for suspended solids to settle. This will minimize the potential for exceeding the <2-weight% solids specification for LAW feed (DOE 2000) and the rate of solids buildup in the WTP's 250,000-gal LAW feed receipt tanks, which are not designed for routine resuspension of settled solids.

7. Dissolved wastes, when homogenized, will remain so except for some precipitation of species that reach their solubility limits as the mixed waste cools in the tanks. The temperature rise in LAW feed tanks caused by the mechanical heat of mixing will be small, probably less than 10° F, thus limiting precipitation. The temperature of LAW feed will be controlled in LAW source tanks containing settled salts by controlling the temperature of water added during the dissolution process.

8. Large (>1 millimeter), dense particles, if present in the tanks, will not be homogeneously distributed in a mixed tank, even when the mixer pump(s) is operating, due to the fast settling rates of such particles relative to the variable upward flow velocities created at different points in a tank by an operating mixer pump(s).

9. The particle size distribution and chemical composition of the particles in a mixed tank will change somewhat as the level of waste in a tank is lowered by pumping.

This is due to the changes in the velocity and shape of the induced waste currents that will occur when the tank level is lowered, causing mixing efficiency to change.

10. The WTP contractor will normally receive the entire contents of a tank of staged LAW feed into four 250,000-gallon tanks, and about one-eighth fractions of a tank of staged HLW feed into two 300,000-liter tanks. Several months may elapse before the next one-eighth fraction of HLW feed is transferred from the HLW feed staging tank. A period of operating the mixer pumps in the HLW staging tank prior to transferring each one-eighth fraction will be required to resuspend solids that settle.

11. The HLW feed in a staging tank will heat up somewhat as a consequence of the mechanical heat added during remixing the feed before the next transfer is made to the WTP, and then cool down in the intervening months before the next transfer. The rate of heat up and the highest temperature reached in the HLW feed will increase as the depth of waste in the tank decreases due to the lower mass of waste available to absorb the relatively constant rate of mechanical heat produced by the mixer pumps. The increase in temperature may also result in additional dissolution of the waste solids.

12. The mixer pumps seals are protected against frictional heat and abrasion with slightly pressurized water added on the clean side of the seals. The rate of leakage of water past the seals will increase over time until it reaches the maximum rate allowed by a flow-restricting orifice. Water leakage will cause further dissolution of waste salts that are at their solubility limits; this may somewhat alter the chemistry of the waste feed.

13. The LAW and HLW feed receiving tanks are likely to contain about 5 volume% heels of waste from the previous feeds transferred to the tanks. The WTP tanks will be mixed using pulse jet mixers. The mixed waste will then be fed to various separations processes, before or after being combined with other waste streams, and then vitrified. The WTP contractor will sample and analyze these streams at various points as necessary to comply with environmental permitting, nuclear safety licensing, and process efficiency requirements for the WTP.

14. Further evolution of waste feed sampling and analysis requirements will occur as a consequence of future flowsheet development, flowsheet variability analysis, and analysis of the impacts of sampling and analysis error on compliance with process efficiency requirements, which also are evolving.

In addition to the technical assumptions outlined above, two other assumptions were made about regulatory drivers for sampling and analysis to comply with environmental and nuclear safety requirements:

1. Applicable regulations address the need to have adequate information about a waste (including data gathered through testing of the waste, if necessary) to manage it in accordance with various health, environmental, and nuclear safety requirements. However, the regulations generally are not prescriptive, and instead establish performance-based objectives that must be met. With respect to the three criteria evaluated in this report, the regulatory drivers do not specify access points or dimensions for sampling tanks (i.e., 4-inch riser), nor do they specify methods for collecting samples of heterogeneous wastes in tanks (i.e., mixing while samples are collected). The location of analyses (i.e., at-tank or at a laboratory some distance away) also is not prescribed. Thus, this report assumes that no explicit regulatory drivers mandate the three criteria.

2. The regulatory agencies will review the adequacy of ORP's efforts to comply with health, environmental, and nuclear safety requirements. The agencies have the authority to impose more prescriptive requirements (through permits, compliance letters, and other administrative vehicles) if necessary to achieve the performance-based objectives specified in the regulations. Although this could include specifying sample access locations and/or dimensions, or when and how samples must be collected, such a degree of specificity would normally not be exercised unless the agencies found deficiencies with the existing information used to manage the waste. It is not possible at this time to predict what stance the regulatory agencies may take on the adequacy of waste feed knowledge, but ORP must provide a technical basis and rationale for the available data that is fully defensible for regulatory agency purposes. Thus, this report assumes that the technical requirements developed by ORP and its contractors, relative to riser dimensions, sampling during mixing, and location of sample analysis, will be the requirements the agencies adopt in administering the regulatory objectives.

Based on these two assumptions, this report can remain focused on the technical requirements for sampling and analysis, and makes no further attempt to interpret health, environmental, or safety regulations, nor to anticipate unpredictable regulatory agency requirements.

4.0 ASSESSMENT OF CRITERION 1: SAMPLER MUST BE DEPLOYABLE THROUGH A 4-INCH RISER

Applicable requirements documents were reviewed to identify drivers for this criterion that largely are outside the TFC's control. Documents reviewed included the RFP (DOE 2000), the BNFL Inc. contract (DOE 1996), the ICDs (BNFL 2000a and BNFL 2000b), and applicable health, environmental and nuclear safety regulations. No requirements were found that directly specify the criterion, nor were related requirements found from which one might reasonably infer the criterion. As noted in Section 3.0, there are no explicit regulatory drivers, and it is unlikely that the 4-inch riser criterion would be stipulated by a regulatory agency or in the ICDs by the WTP contractor since the criterion has little relevance to protecting workers, the public, and the environment, or to assuring that a suitable waste feed sample is provided to the WTP contractor.

The criterion is based on the TFC's practical objective of using available risers whenever possible, thereby avoiding the need for and cost of modifying the DSTs, and the interferences that would occur with other Phase 1 construction activities. While this objective has merit, it could be outweighed by a future need for an improved sampling method that requires access through a larger riser.

The case for an improved sampling method (e.g., one that is capable of collecting more-representative samples and reducing sampling error) has not been made yet, at least not for LAW feeds. The LAW feed ICD 19 (BNFL 2000a) requires mixing the staging tanks to create a "homogeneous" mixture. No mixture is perfectly homogeneous, thus the standards for homogeneity will be based on the WTP's needs, which are still evolving. However, several factors strongly support the current LAW feed staging and grab-sampling methods as "good enough":

1. A single mixer pump planned for a LAW feed staging tank will turn over the one-million-gallon contents of the tank more than 14 times in a 24-hour period. One who has witnessed the roiling action created by this pump in a similarly large tank might reasonably conclude that the dissolved tank contents will be highly mixed in this period. Additional mixing will have little effect on homogenizing dissolved species. Once mixed, dissolved species will remain mixed. Thus, grab sampling will produce a sample that is representative of the mixed condition of the dissolved solids, even though the mixer pump is not operating.

2. The baseline strategy includes adequate time for the solids to settle after mixing, and then sampling without the mixer pump operating. Samples of waste taken after precipitation and settling will best represent the LAW feeds to be sent to the WTP. Transfers of LAW feed to the WTP also will occur after the solids have settled and without operating the mixer pump. There is no apparent advantage of using an advanced sampling method over grab sampling when the objective is to sample well-mixed, dissolved wastes in a static tank.

3. The LAW feed will contain a small fraction of entrained solids, even after a long settling time. These solids may not be homogeneously distributed in the staging tank at the time of sampling. BNFL Inc. expressed a need to know the quantity and composition of the entrained solids in the LAW, no matter how small a fraction of the LAW feed they represent. BNFL Inc. was concerned about how to prove that the fissile fraction of the entrained solids is low enough or that it is diluted in the solid phase sufficiently to preclude a nuclear criticality in the receiving tanks and in downstream processes in which the solids may be chemically altered by treatment with acids. It is likely the several-liter samples of the settled LAW that are to be taken for certifying the waste will, in many cases, contain an insufficient mass of entrained solids to adequately determine the fissile material content and the level of solid phase dilution in the entrained solids, regardless of the sampling method used.

   The ORP has recently closed all nuclear criticality safety issues associated with waste in the DSTs. By extension of this action, the potential for a criticality in the feed receipt tanks would appear to be extremely remote since no chemical alteration of the waste will occur in those tanks. However, the prospect of concentrating the fissile material through chemical alterations in downstream processes that employ acids will probably remain an issue for some time. One method of obtaining a sufficient amount (probably a few grams) of entrained solids for criticality-control testing may be by using a modified grab sampler to obtain a sample at the surface of the settled solids layer in the tank. Surface solids are likely to be most representative of the entrained solids since they were the last solids to settle. Moreover, the feed transfer pump will likely disturb and resuspend a small fraction of the settled solids in the vicinity of the pump's intake, and feed them with the LAW supernatant to the WTP. Another method is to employ grab sampling immediately after mixing to assure a sufficient mass of solids is collected. This method would also collect larger particles that are unlikely to be present in the entrained solids pumped to the WTP, however. If either of these two grab sampling methods can obtain a suitable sample for criticality-control testing, there would appear to be no need to develop an advanced sampling system to meet this objective.

4. The need to establish a defensible basis for paying the privatization contractor to process the waste was a former driver for achieving homogeneous conditions in the LAW feed tanks and minimizing sampling error. Uncertainty in the sodium loading in the LAW feed could have led to overpayment or underpayment for the processing services. This driver has been eliminated since the WTP contractor will now be paid on a cost-plus-incentive-fee basis that provides for penalties and incentives depending on the level of cost and schedule performance (DOE 2000). There appears to be no advantage of using an advanced sampler to reduce the sodium-sampling error since the grab-sampling error is likely small and because the WTP contactor will mix other sodium-bearing wastes with the LAW feeds, thus requiring re-characterization for sodium and other species before the waste can be vitrified.

5. The very low solids content of LAW feed (<2 weight %) and the small particle size of entrained solids alleviates most concerns about plugging pipelines. The feed pump suction will be positioned above the settled solids layer to assure complying with the solids limit. The LAW feed transfer pump also will probably be run in the tank-recycle mode for a short period of time prior to beginning delivery to the WTP. This will ensure that a slug of solids that might momentarily be drawn from the settled solids layer into the pump and potentially plug the pipelines will be distributed back to the tank where it will be diluted. If sampling during waste transfer and delivery is required to verify compliance with the <2-weight % limit, only an in-line method will suffice because of the uncertainty of how much of the settled solids are drawn into the pump. The need for such sampling seems doubtful because similar low-solids wastes are routinely pumped in the tank farms without plugging problems.

6. The impacts of not complying with the <2-weight% requirement are inconsequential below a 4-weight% solids loading. The WTP will be designed with extra capacity to pretreat (and filter) LAW at two times the nominal vitrification plant capacity (DOE 2000). Thus the WTP will have the capacity to filter LAW feeds in the unlikely event the <2-weight% limit is exceeded.

These factors support retention of grab sampling for LAW feeds, the current baseline technology, which is deployable through a 4-inch riser. A fluidic sampler (DOE 1999) or other advanced sampler appears to offer no advantage in obtaining a more representative LAW feed sample or in reducing sampling error in LAW feeds. Thus, for purposes of the LAW feed tanks, the criterion for using a 4-inch riser appears to be valid and should not impose unacceptable limitations on the types of sampling methods that can be used.

However, this same conclusion is not similarly supported for the HLW feed tanks. As discussed in Section 5.0, the fluidic sampler or other advanced sampler may offer advantages for HLW feeds, which are potentially more sensitive to waste homogeneity issues. The structural requirements for the fluidic sampler mast appear more likely to be met where 6-inch risers are available to accept a more robust mast. Each of the Phase 1 HLW feed staging tanks contains available 6-inch risers, with the exception of DSTs 241-AW-103 and -104. Thus, only two 6-inch risers may have to be added if decisions are made to use fluidic sampling or another advanced sampling method that requires a robust mast in HLW feed staging tanks.

5.0 ASSESSMENT OF CRITERION 2: SAMPLING MUST OCCUR WHILE THE TANK IS BEING MIXED

Applicable requirements documents were reviewed in an attempt to identify drivers for this criterion that are largely outside the TFC's control. Documents reviewed included the RFP (DOE 2000), the BNFL Inc. contract (DOE 1996), the ICDs (BNFL 2000a and BNFL 2000b), and applicable health, environmental and nuclear safety regulations. No requirements were found that directly specify the criterion, nor were related requirements found from which one might reasonably infer the criterion. As noted in Section 3.0, there are no explicit regulatory drivers to sample during mixing. Instead, this criterion is based on the TFC's interest in collecting as representative a sample of the waste feed as possible, so validity of the criterion has been assessed against this basis.

The LAW feed tanks will usually be mixed (but not always, as in the case of DST 241-AP-101), and then allowed to settle before sampling. Samples of the settled tank feed will then be collected and analyzed to ensure the feed meets the specifications for waste feed delivery (DOE 2000). One of the more problematic specifications is the need to deliver LAW feeds containing less than 2 weight % solids. The planned method of meeting this specification is to pump LAW feed from a level above the settled solids layer. Operating the mixer pumps just prior to or during pumping of feeds to the WTP would defeat the purpose of settling. Thus, LAW feed sampling for certification will be conducted without the mixer pumps operating and after settling has occurred to ensure the samples collected are representative of the LAW feeds to be delivered to the WTP. Thus, this criterion is not valid for LAW feeds.

HLW feeds will be pumped to the WTP while the mixer pumps are operating, however. The current baseline for sampling the HLW feed tanks is grab sampling immediately after completing mixing of the tank contents (BNFL 2000b). The operation of mixer pumps must be stopped because grab samples cannot be collected during mixer pump operation due to practical limitations associated with deploying a sample bottle attached to a cable in a tank of moving waste. Thus the samples collected may not be representative of the feeds delivered to the WTP if fast-settling particles are present in the waste that settle before grab sampling.

A mixing-settling test recently conducted in DST 241-AZ-101, the first tank of HLW feed that is scheduled for delivery to the WTP, indicated that particle-settling rates were higher than expected (Tucker and Wood 2000). The preliminary test results showed that few solids in the upper 30% of the tank waste remained in suspension after 1.5 hours of settling, and that few solids remained in suspension in the upper 80% of the tank waste after 7 hours of settling.

Although the sampling crews demonstrated the ability to obtain a sample from near the bottom of the tank within 15 minutes of stopping operation of the mixer pumps, the fast settling rates observed raise doubts that the bottom sample contained a representative fraction of the larger, denser particles suspended by the mixer pumps. The size, density, and mass of such unsampled particles are of high importance to waste feed delivery process control planners. The information is needed to establish an upper limit on solids loading in the slurry to ensure that it will be pumped under turbulent flow conditions without exceeding pipeline pressure limits.

The sampling crews also demonstrated the ability to obtain the eight, incrementally spaced samples required in ICD 20 (BNFL 2000b) in as little as one hour. However, the substantial settling that was observed in that time frame almost certainly rendered the samples non-representative of the waste slurry that existed at the sample locations while the mixer pumps were operating. It is likely that the average of the solids contents of the 8 samples will underpredict the true solids loading in the mixed slurry due to the solids that settled before the first sample could be collected.

Gamma energy profiles of the waste slurry as it settled were also recorded (CHG 2000). These profiles showed distinctive layers of energy levels as settling occurred. These layers may indicate the presence of two or more different predominant particle sizes in the slurry. Such particles may indicate that the waste originated from different sources and, if so, the particles probably are chemically and radiochemically dissimilar. The average chemical and radiochemical compositions of the HLW feed predicted through analysis of the sample results may be skewed if the unsampled, fast-settling solids have a different composition than the bulk solids actually sampled.

The results of the DST 241-AZ-101 mixing-settling test indicate that samples obtained by grab sampling are not representative of the tank contents during mixing. An evaluation of the sampling error realized in the test is needed, as is a preliminary definition of the acceptable level of error, to determine if grab sampling in HLW tanks is the appropriate baseline method. Further evaluation and extrapolation of the results of the individual sample analyses may enable prediction of the contribution of the unsampled, fast-settling solids to the overall solids mass, chemical, and radiochemical compositions of the HLW feed as it is undergoing mixing. One can only speculate about the value of such a prediction until individual sample data are made available. Analysis of core-samples of DST 241-AZ-101 waste is another option that also may provide important data on the solids that were not sampled by grab sampling.

Grab-sampling error can be estimated if the mass and composition of the unsampled solids can be extrapolated or otherwise inferred from the test and core data. The acceptable level of sampling error for some waste species might be estimated by comparing HLW feed Envelope D limits (DOE 2000) and potential WTP operating limits to current HLW compositional data.

Regardless of whether the results of an analysis of sampling error and preliminary definition of the level of acceptable sampling error support continued grab sampling, it may be prudent to ensure an alternate sampling method is available that can be deployed while the mixer pumps are operating. It is unlikely that sufficient information is available on HLW in other tanks to be able to relate the results of the DST 241-AZ-101 test to other tank wastes. Settling rates may be even faster in other tanks, and the ability to predict the impact of the unsampled, fast-settling wastes may be lower.

Moreover, the predicted level of acceptable sampling error will likely be highly uncertain until the WTP's environmental regulatory, nuclear licensing, and technical limits are set. These limits will serve to define acceptable quantities and concentrations of HLW feeds delivered to the WTP, and the allowable error in determining waste feed compositions. Further, the conditions in the HLW feed staging tanks are expected to vary by location in the tanks, with mixing time, and with residual waste depth as described in Section 3.0 (see Assumptions 8 through 12). The factors described in these assumptions may further complicate the ability to obtain adequately representative samples.

6.0 ASSESSMENT OF CRITERION 3: AT-TANK ANALYSIS IS REQUIRED

Applicable requirements documents were reviewed in an attempt to identify drivers for this criterion that are largely outside the TFC's control. Documents reviewed included the RFP (DOE 2000), the BNFL Inc. contract (DOE 1996), the ICDs (BNFL 2000a and BNFL 2000b), and applicable health, environmental and nuclear safety regulations. No requirements were found that directly specify the criterion, nor were related requirements found from which one might reasonably infer the criterion. As noted in Section 3.0, there are no explicit regulatory drivers to analyze waste at the tank. Instead, this criterion is based on the TFC's interest in assuring waste homogeneity requirements are met in as little time as possible.

Reich 2000-DRAFT specifies an at-tank sampling system that includes a sensor loop equipped with various sensors for measuring chemical, radiochemical, and physical properties to indicate compliance with feed specifications and process control limits. Reich 2000-DRAFT states, "The measurement data will be used in assessing the homogeneity (mixing) or settling status of the tank waste. The homogeneity or settling data will be used as screening data to assist in determining when a waste batch is ready for formal sampling as required by waste feed delivery. The at-tank sensor data shall not be used to provide data for the validation or qualification of the chemical and solids content of the waste batch as required by the privatization contract".

When all HLW and LAW feed staging was to have been conducted in two tanks, one for each of two contractors, the cycle time for staging was so short that there was essentially no flexibility for remixing and reanalyzing feeds if the initial analysis at the laboratory showed that the homogeneity requirements were not met. This was a compelling driver for at-tank analysis. The addition of thirteen staging tanks eliminated the time constraint and need to avoid reanalysis at the laboratory. The potential for reanalysis has also been reduced as a consequence of the greater amount of time allowed for mixing due to the addition of staging tanks, and the demonstrated effectiveness of the thermocouples in the mixing-settling test (CHG 2000) for indicating that an adequately mixed state of HLW solids has been achieved.

As discussed in Section 4.0, the mixer pumps are expected to be highly effective in achieving a homogeneous mixture of dissolved waste species in a about a day's time. Thus an at-tank analysis system for monitoring the status of the dissolved-chemical-homogenizing process appears to have little merit. The mixing-settling test also showed the effectiveness of existing thermocouples to indicate where solids had been mobilized and where solids were resettling during mixing of a HLW feed staging tank. The test also showed the potential utility of other devices, e.g., the gamma energy profiler, that are probably much more robust and maintenance-free than waste-loop sensors, yet indicative of the level of homogeneity of solids achieved in the tank. Thus the use of the loop sensors for monitoring the mixing status of HLW solids also appears to have little merit.

7.0 SUMMARY OF ASSESSMENT AND RECOMMENDATIONS

The criterion that the sampler be deployable through a 4-inch riser is valid for LAW staging tanks; it is highly likely that representative samples can be obtained by grab sampling from a 4-inch riser.

The criterion that the sampler be deployable through a 4-inch riser is not valid for HLW feed staging tanks unless it can be shown that the error associated with grab sampling is acceptable, or that an acceptably strong sampling mast that will fit in a 4-inch riser can be constructed. The likelihood of unacceptable sampling error and mast strength is moderately high, and several years of analysis are probably required to establish the acceptable level of sampling error. Thus, development of a robust sampling method that can obtain a more representative sample (i.e., while the mixer pumps are running) is a prudent action to take. This may include contingency plans to use and/or install 6-inch (or larger) risers that will support more representative sampling methods.

The criterion that the sampling system be capable of sampling while the mixer pump is operating is not valid for LAW feed staging tanks. This criterion, if enforced, would yield a sample that is not representative of the settled LAW feeds to be delivered to the WTP.

The criterion that the sampling system be capable of sampling while the mixer pumps are operating is likely valid for HLW feed staging tanks, pending analyses of grab samples collected in the DST 241-AZ-101 mixing-settling test. Continued development of a robust sampling method that can obtain samples while the mixer pumps are operating is a prudent action to take while the adequacy of grab sampling is being assessed.

The criterion that an at-tank analytical capability be installed to provide screening data on waste feed homogeneity is not valid. Changes have occurred and knowledge has been gained that invalidate the former drivers for the at-tank analysis system.

8.0 REFERENCES

BNFL, 2000a. *Interface Control Document for Low-Activity Waste Feed,* BNFL-5193-ID-19, Rev. 4e, February 24, 2000, BNFL Inc., Richland, WA.

BNFL, 2000b. *Interface Control Document for High-Level Waste Feed,* BNFL-5193-ID-20, Rev. 4f, February 24, 2000, BNFL Inc., Richland, WA.

Boger, R. M., 2000. *Mobile, Variable Depth Sampling System Design Study,* RPP-6735, Rev. 0, August 25, 2000, CH2MHILL Hanford Group, Inc., Richland, WA.

DOE, 1996. *Tank Waste Remediation System Privatization Contract,* DE-AC06-96RL13308, Mod. 10, December 21,1999, U.S. Department of Energy, Richland, WA.

DOE, 1999. *Fluidic Sampler,* DOE/EM-0485, September 1999, U.S. Department of Energy, Washington D.C.

DOE, 2000. *Request for Proposals – Waste Treatment and Immobilization Plant,* DE-RP27-00RV14136, August 31, 2000, U.S. Department of Energy, Richland, WA.

Kirkbride, R. A., 2000, *Tank Farm Contractor Operation and Utilization Plan,* HNF-SD-WM-012, Rev. 2, April 19, 2000, CH2MHILL Hanford Group, Inc., Richland, WA.

Rasmussen, J. H., 2000. *Double-Shell Tank Process Waste Sampling Subsystem Definition Report,* RPP-5786, Rev. 0, April 25, 2000, CH2MHILL Hanford Group, Inc., Richland, WA.

Reich, F. R., 2000-DRAFT. *Level 2 Specification – Sampling and At-Tank Analysis Systems for DST Waste Processing and Immobilization,* HNF-3483, REV. 1, June, 2000, COGEMA-Engineering Corporation, Richland, WA.

Tucker, R. P. and R. F. Wood, 2000. (transmittal letter for) *AZ-101 Process Test,* CHG-0002514, May 9, 2000, CH2MHILL Hanford Group, Inc., Richland, WA.

EVALUATION OF THE VALIDITY OF THREE CRITERIA FOR SAMPLING AND ANALYZING DOUBLE-SHELL TANK WASTES IN SUPPORT OF WASTE FEED DELIVERY

September 27, 2000

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INTRODUCTION

- Advanced sampling and at-tank analytical systems are under development to increase speed and accuracy
- Specifications are evolving
- Three criteria may not be germane
  - Sampler deployable through 4-in. riser
  - Sampling while mixer pumps on
  - Need for at-tank analysis

BACKGROUND/BASIS FOR EVALUATION

- Originally 2 contractors and 2 staging tanks, each with 12-in. risers (1996)
- Reduced to 1 contractor and required additional WTP tank storage capacity (1998)
- Staging tanks added to reduce risk of late feed delivery (1998-1999)
- "Representative" sampling required in ICDs (1998-2000)
- BNFL contract terminated and RFP for cost-plus services issued (2000)

KEY ASSUMPTIONS

- Sample through risers with 10-ft. work space
- Sampler located safe distance from mixer pumps to avoid damage by mixer pump currents
- ~15 staging tanks in Phase 1, plus AW-103
- Mixer pumps are state-of-the-art for creating as homogeneous mixture as possible in Hanford tanks
- Current LAW feed strategy: mix, settle, sample/analyze, pump without mixing

KEY ASSUMPTIONS (continued)

- HLW feed strategy: mix, sample ASAP, analyze, pump while mixing
- Mixed LAW feed solutions will not stratify
- Large particles will not be homogeneously distributed in the tanks even with mixer pumps operating
- Solids and possibly chemical concentrations may change as tank levels are lowered
- HLW solids require resuspension before each transfer

KEY ASSUMPTIONS (continued)

- HLW staging tanks may get hotter over time, resulting in changed chemistry
- Pump seal leakage may change feed composition
- WTP will add waste streams and chemicals at various points, requiring reanalysis of feeds
- Evolution of requirements will continue
- Prediction of related regulatory requirements not possible, but prescription of the 3 criteria not likely

ASSESSMENT OF 4-IN. RISER CRITERION

- Valid for LAW feeds because grab sampling is good enough and compatible with 4-in. risers. Supporting arguments include:
  - Use of mixer pumps and multiple staging tanks eliminates the time constraint issue
  - Homogeneous solutions stay homogeneous, so no need to run mixer pumps while sampling
  - Sampling for suspended solids made viable by allowing fast-settling solids time to settle
  - Sampling (and analytical) accuracy not as important under cost-plus contract

ASSESSMENT OF 4-IN. RISER CRITERION (continued)

- Criticality-control samples can probably be obtained using grab sampling or modified grab sampling
- No need for pumpability process control sample
- Solids filtration capacity of WTP can handle twice the solids specification limit

- Not valid for HLW feeds because 6-in. risers available in 4 of 6 staging tanks; 2 risers can be added with relatively small impact, if needed

ASSESSMENT OF SAMPLING WHILE MIXING CRITERION

- Not valid for LAW feeds because sampling while mixing would stir up solids and create nonrepresentative feeds
- May be valid for HLW feeds because;
    - AZ-101 tests indicate nonrepresentative samples were collected, even samples collected within 15 minutes
    - Samples with fast-settling particles also likely needed for process control planning and to support pipe-upgrade decision making
    - Uncertainty in how fast solids settle in other tanks; may not be able to predict characteristics of large solids

ASSESSMENT OF SAMPLING WHILE MIXING CRITERION (continued)

- Uncertainty in allowable level of sampling error; new requirements may dictate low level of sampling and analytical error for some waste species

- Solids mobilization efficiency will likely change with waste level; frequent high-quality resampling and reanalysis may be necessary to avoid adverse impacts on pumpability and treatment processes

RECOMMENDATIONS

- Continue development of capability to sample HLW staging tanks from 6-in. risers while mixing
- Analyze for unsampled solids in AZ-101 by data extrapolation/ core sample analysis, make preliminary analysis of the level of acceptable HLW feed sampling error, and decide if continued development of the advanced HLW feed sampler is warranted
- Cease work on the advanced LAW sampler and the at-tank analytical system

ASSESSMENT OF NEED FOR AT-TANK ANALYSIS

Not valid for LAW and HLW feeds because:

- Additional staging tanks provide ample time in the unlikely event remixing and reanalysis are needed
- Use of existing thermocouples and/or other robust instruments are likely to indicate when mixing of HLW feeds are completed