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| 1 | 1 | Cog. Mgr. D. Price | [signature] | 4/9/92 | R2-18 | SE Kelly | [signature] | | | 3 | 1 |
| 1 | 1 | QA JJ Verderber | [signature] | 4/9/92 | S1-57 | WF Zuroff | [signature] | | | 3 | 3 |
| | | Safety | | | | | | | | | |
| 1 | 1 | RJ Blanchard | [signature] | 4/8/92 | R1-17 | | | | | | |
| 1 | 1 | GN Boechler | [signature] | 4/8/92 | | | | | | | |
| 1 | 1 | RJ VanVleet | [signature] | 04/13/1992 | H5-32 | | | | | | |

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**6. Author**

Name: M. J. Minette

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**7. Abstract**

This Engineering Evaluation of Alternatives Study reviewed Alternative Sampling Systems for use in waste tanks. The criteria and options for recovering tank samples were identified with the options being evaluated for use in the sampling of the salt cake in the tanks. Bit Temperature Monitoring Systems, Alternative Sample Recovering Systems, and Alternative Hydrostatic Head fluids were also evaluated.


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# ENGINEERING EVALUATION OF ALTERNATIVES STUDY - WASTE TANK SAMPLING SYSTEMS

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AUTHOR

M. J. MINETTE

J. ELLIS (SAIC)

FOR

WESTINGHOUSE HANFORD COMPANY

April, 1992

# ENGINEERING EVALUATION OF ALTERNATIVES STUDY - WASTE TANK SAMPLING SYSTEMS


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# ENGINEERING ALTERNATIVES STUDY - WASTE TANK SAMPLING SYSTEMS

## 1.0 Objectives

Sampling of the waste forms in the Hanford single shell tanks (SSTs) and double shell tanks (DSTs) is required to support characterization of the wastes under the Resource Conservation and Recovery Act (RCRA). Resolution of tank safety issues, and development of tank waste retrieval techniques are also requirements of the Hanford Federal Facility and Consent Order, an agreement between Washington State, the U.S. Department of Energy and the U.S. Environmental Protection Agency.

The Hanford Federal Facility Agreement and Consent Order (also called the Tri-Party Agreement or TPA) was originally signed in May of 1989 and established a Hanford site restoration plan with interim and final milestones for each major program. Included among these milestones is M-10-00, Characterization of Single-Shell Tank (SST) Wastes. M-10-00 has 13 interim milestones for core sampling and analysis of SST wastes to be completed by September 1998. Developing a Hard Salt Cake Sampler is the 13th interim TPA milestone and this study reviews sampling methodologies for meeting M-10-13.

The waste materials in the tanks originate from nearly 50 years of defense production activities at the Hanford site and are comprised of highly radioactive fission products and chemical wastes generated during processing of the defense materials. The wastes originate from a variety of processing operations and have been subjected to many treatments, including evaporation, cesium and strontium stripping, precipitation with ferrocyanide, and others.

This resulted in more than 150 tanks with mixtures of solids, slurries, sludges, and saltcakes with variable concentrations of fission products and chemicals, and in many cases, stratified layers of different compositions within one tank. The sampling systems must therefore be able to retrieve representative samples from all levels within the tanks. In addition, core samples of the sludges and salt cakes must be undisturbed to permit physical properties measurements to be performed in the lab.

Because of the radioactive components in the wastes, one of the primary concerns is in limiting exposure to operating personnel collecting the samples. This concern presents unique problems in designing shielding, containment and sample retrieval. The safety problem is further complicated by the fact that the wastes may contain flammable, explosive and/or highly hazardous or toxic chemical compounds. The sampling systems must be designed and operated in a manner that minimizes or eliminates the potential for an accident that could release the wastes into the environment or endanger human health.

Numerous approaches for sampling these wastes are possible. The purpose of this report is to compile a listing of potentially viable sampling methods, assess the feasibility of these methods against the sampling performance criteria, and to compare and rate the systems that can meet the mandatory criteria.

As a subset of the sampling alternatives assessment, a review of alternatives for core sample retrieval is presented. Core samples may be cut by either rotary, impact, or push mode samplers. Retrieval of the core sample from the waste tank can be done in a variety of ways. Approaches for sample retrieval device closures which have been considered are also presented.



This report will also assess alternatives for monitoring bit temperatures during rotary drill core sampling of hard saltcakes. Bit temperature monitoring is necessary to assure safety during sampling of potentially flammable or explosive saltcakes with samplers that can generate heat at the salt cake-bit interface. Testing in Hanford labs has shown that the chemical reactions of concern cannot be initiated at salt temperatures less than 180°C. To provide a safety margin, the maximum allowable bit temperature has been set at 150°C.

Various fluids that might be applicable for use as hydrostatic balancing fluids when sampling waste tank solids are also identified and assessed. Hydraulic head fluids are used to assure displacement of liquid wastes from the core sampling apparatus during sample retrieval.

## 2.0 Recommendations and Conclusions

The truck mounted rotary drill rig utilizing the "universal or tandem sampler" meets all of the criteria set established for the sampling system. While this system does not have direct measurement of bit temperature, preliminary testing has shown that the bit temperature can be reliably limited to less than 150°C by maintaining a purge gas flow at .57 cubic meters per minute (20 scfm) or greater during drilling. Final gas flow requirements will be established during "safety envelope" tests. In addition, the "universal sampler can be used as a liquid sampler, thereby permitting the sampling of all tanks, including multiphase tanks, with one device.

The drill head and a shielded sample retrieval system are mounted on a turntable which allows placement of the appropriate system over the drill string safely and with a minimum of effort. The design is the result of several evolutions and represents an integration of conventional equipment and the adaptations required to assure safe handling of highly radioactive and hazardous wastes.

An enhancement to the current rotary drill may be the addition of a vibratory or "sonic" capability to the package. A specially designed transducer transmits variable frequency and amplitude soundwaves down the drill string to fracture the material being drilled, thereby allowing a much lower rotational speed to be used for an equivalent penetration rate. It may be

possible to adapt a transducer to the existing rotary drill rig and achieve acceptable penetration rates without generating enough heat to reach the 150°C temperature limit.
Further exploration of this application is recommended.

Other types of drilling techniques, such as vibratory, impact or gas jet drilling, could be used in conjunction with the "universal sampler", making them acceptable from the retrieval standpoint. Because of the extensive time required to develop or adapt these systems for radioactive service and test them, there appears to be little advantage over the current design drill rig and drill bit. All of these techniques appear to have the potential to generate sufficient heat such that bit temperature monitoring would be required.



The two "bottle-on-a-string" methods of sampling received the next highest ratings (after the "universal" sampler when assessed against the criteria applicable to sampling liquids and slurries). There is, however, a higher risk of spreading contamination and of receiving more operator dose than the current method.

The method involves lowering a weighted, corked bottle on a wire through a riser and down to the depth desired. The cork is also attached to the wire in such a manner that it can be removed by sharply pulling the wire upward. This allows a sample to be taken at any depth in the tank. The bottle is then pulled back up through the riser, quickly capped, rinsed and placed in a shielded container. Contamination and dose experience in the past has been acceptable, however the success of the activity is highly dependent on the experience and skill of the personnel taking the samples.

Past attempts to develop a shielded system with full containment for use with the bottle-on-a-string approach have not been successful. Transfer of samples from the shielded receiver to a shielded transfer cask have also been problematic. Further development is required to refine a design for replacement of the bottle-on-a-string method.

# 3.0 Sampling System Alternatives

## 3.1 Sampler Performance Criteria

The following criteria describe the desired performance capabilities of a system for sampling the wastes in the Hanford single and double shell tanks.

* The system shall be able to obtain the required samples through tank-top risers with diameters of between 10 and 30 cm (4 and 12 inches nominal).

* The system shall be able to sample liquids and slurries.

* The system shall be able to sample sludges, soft saltcake, and hard saltcake and combinations thereof.

* The system must be able to sample the entire depth of waste material from the top surface to within three inches of the bottom. This is about 11 meters (35 feet) of depth maximum.

* Core samples must contain a minimum of 4.7 $cm^3$ of waste material per centimeter of depth.

* Liquid samples must be at least 100 mL in volume.

* The system shall not alter the physical properties of the material being sampled. Undisturbed, representative samples of the solid waste materials are required to allow determination of properties such as density, moisture content, shear strength, viscosity, stratification, and crystalline structure. Dilution by supernate or hydrostatic head fluid must not occur. Liquid samples containing suspended solids must be representative.

* The system shall not alter the chemical properties of the sample, including organic and inorganic constituents, radioisotopes, pH, heavy metals, etc. Dilution or dissolution of salts by supernate or hydrostatic head fluid must not occur. Cross-contamination of samples and contamination from the supernate or hydrostatic head fluid must not occur.

* The system shall not cause harm to the tank floors or wall. (Maintaining tank integrity is of prime importance.)

* The system must be highly reliable. It shall recover at least 90% of a full sample 90% of the time.

* Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C.

* Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C on any portion that contacts the waste.

* Retrieved samples and associated hardware must fit in the existing Hanford hot cell facilities.

* Sampler vertical position must be measurable within 2.5 cm (1 inch).

* Sampler must remain operational after exposure to the tank contents for at least three weeks. Radiation doses of up to 2000 R/hr and corrosive solutions with pH in excess of 12 may be present.

* The system must be designed to limit the exposure of operating personnel to ionizing radiation to ALARA. In no case shall the dose rate for an individual exceed 300 mrem/week.

* Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented.

* The system shall be designed to prevent the spread of radioactive contamination or the release of hazardous materials into the environment.

* The system shall be able to obtain a full length sample in a reasonable length of time, not to exceed 2 weeks for a full length sample.

* Generation of secondary wastes shall be minimized.

* The system must operate safely in an environment potentially containing explosive gases and flammable liquids or vapors, i.e., no sparks or other ignition sources are permitted.

* The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds.

* The sampler support system must be reusable, mobile, and maintainable.

* The system should be capable of taking more than one sample from a given riser. This is desirable should resampling because of poor recovery or to confirm prior sample results become necessary.

* All sampling hardware must be retrievable from the tank after completion of sampling activities.

* The system must be fabricated or procured, tested, approved for use, and ready for full field operation by April 1, 1993.

### 3.2 Sampling System Alternatives

The alternatives that have been considered for sampling the Hanford waste tanks are listed in Table 1.

### 3.3 Sampling System Evaluation

Tables 2 and 4 (Sampler Conformance Matrices) present the evaluation of each of the sampling systems against the performance criteria established in section 3.1 of this study. A yes-no indication is provided for each criterion for each sampler system. The number of yes indications is then summed at the bottom of the table to provide a composite rating of the system. The higher the number rating, the better the alternative was deemed to be.

In addition, ten of the criteria were identified as mandatory. These are highlighted in Tables 2 and 4 by shading. If a system failed to meet any of the mandatory criteria, then it has "failed" overall. Table 3 presents summary justifications for the pass/fail decisions for the solids samplers.

## 4.0 Sample Retrieval Alternatives

### 4.1 Sample Retrieval System Performance Criteria

The following criteria describe the desired performance capabilities of sample retrieval systems to be used during core sampling of sludges and saltcake wastes in the Hanford single and double shell tanks.

* The system must operate inside the drill string of the core drill system in use.
* Placement of an empty sampler and grappling of a full sampler must be accomplished with an enclosed, shielded device at the top of the tank riser used for sampling.
* The retrieval system should be an integral part of the core drilling system.
* The system must be able to retrieve at least 90% of the core segment 90% of the time.
* The system must be able to retain sludge, granular salts, hard saltcake, and interstitial liquids.
* The system must be able to section or break off a hard saltcake core segment at

the bottom of cored sample. Some of the hard saltcakes are highly cemented.

* The system must not disturb the structure of the core. Physical properties tests that are to be run on the sample depend on obtaining an undisturbed sample to assure accuracy.

* The system must fit in the space envelope of the laboratory hot cells and must interface with the sample extrusion equipment that is available. Alternate sample extrusion or recovery systems may be provided as an integral part of the retrieval system.



## 4.2 Sample Retrieval System Alternatives

The alternatives that have been considered for sample retrieval systems during rotary mode sampling of the Hanford waste tanks are listed in Table 5.

# 5.0 Rotary Bit Temperature Monitoring Alternatives

## 5.1 Temperature Monitoring Performance Criteria

The following criteria describe the desired performance capabilities of a system for monitoring the drill bit temperature during rotary mode sampling of hard saltcake wastes in the Hanford single and double shell tanks.

* The system must be capable of sensing drill bit temperature on a real time basis and providing the operator of indication that the bit temperature has exceeded the 150°C operating limit. Continuous temperature monitoring is desirable.

* A real-time audio-visual alarm that trips at 150 $\pm$ 5°C must be provided at the sampler drill rig control station.

* The bit temperature monitoring system must operate safely in an environment potentially containing explosive gases and flammable liquids or vapors (i.e., the system must be intrinsically safe).

* The system must fit in the existing space envelope of the rotary bit/ universal sampler.

* The system must work reliably in the operating environment of the waste tanks. Corrosive aqueous solutions (7.0 to 12.5 pH) and organics may be present. The

maximum waste temperature is approximately 92°C.

* The temperature sensing elements and associated wiring must be able to withstand radiation damage from a 2000 R/hr field for three weeks.

* The temperature data transmission system, if fully contained in the drill bit, must withstand radiation damage from a 2000 R/hr field for 3 weeks. If the data transmission system is mounted on the sampler, it need only withstand the radiation damage for 1 week.

* For methods that attach directly to the bit, four temperature sensors are required (two on each row of bit teeth).

* The temperature sensor mounting must be able to withstand up to 682 kg (1500 pounds) of compressive force which is applied to the bit face during drilling.

* The drill string and bit will rotate at up to 50 rpm during drilling operations. The sampler rotation is independent from the grapple cable during sampling. Counter forces may cause some cable rotation.

* The temperature data transmission system must accommodate the fact that the drill string is extended in successive 0.49 meter (19 inch) sections as the drilling and sampling operation proceeds.

* If telemetry or transmitters are mounted to the bit, power supplies must last for a 3 week period.

* Liquids and nitrogen gases will flow down the inside of the drill string and return with dust and muds along the outside of the drill string.

## 5.2 Bit Temperature Monitoring System Alternatives

The alternatives that have been considered for monitoring the drill bit temperature during rotary mode sampling of the Hanford waste tanks are listed in Table 6.

# 6.0 Hydrostatic Head Fluid Alternatives

## 6.1 Hydrostatic Head Fluid Performance Criteria

The following criteria describe the desired performance capabilities of hydrostatic head fluids used during sampling of sludges and saltcake wastes in the Hanford single and double shell tanks. These criteria have been excerpted from some of applicable references (listed in section 8.0)

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- The density of the fluid must be less than that of the wastes, preferably less dense than water (1 $g/cm^3$) to minimize sample contamination.
- The fluid should be immiscible and insoluble in water.
- The fluid must not dissolve the waste and should be immiscible in the waste.
- The fluid must not react with the waste.
- The fluid must have a low volatility and be nonflammable.
- The fluid must be nontoxic.
- The fluid must be stable to radiation, heat and normal atmospheric exposure.
- The fluid must be readily available and inexpensive.

## 6.2 Hydrostatic Head Fluid Alternatives

The alternatives that have been considered for hydrostatic head fluids during rotary mode drilling and sample retrieval in the Hanford waste tanks are presented below.

### 6.2.1 Organic Liquids

Many organic compounds are liquid at the temperatures encountered in the waste tanks and meet the density requirements. The main problem with any compound that has hydrocarbon components is that they can mask other organics that may be present in the saltcake, making detection difficult. A possible solution to the masking problem would be to "tag" the organic fluid with a radioactive tracer such as deuterium. Resolving the tracer from the other radioactive emitters would be difficult.

Organic liquids, when used with a purge gas clearing and cooling system, are forced into the waste matrix and remove soluble wastes after each sample exchange.

NPH, a mixture of straight chain (normal) hydrocarbons of the range from C-10 to C-14, has been used extensively in the past as a hydrostatic fluid in sampling the waste tanks. It has a density of about 0.72 $g/cm^3$, is immiscible in the aqueous supernate, does not react with the waste, is radiation resistant and is non-toxic. NPH, however, prevents proper inventorying of solvents already in the tank since NPH was used in many of the extraction processes.

Other normal hydrocarbons are possible candidates, however many of them share the same problems of volatility, flammability, and contamination of the sample. A number of the glycols and organic alcohols might also meet many of the requirements, however these tend to be soluble in the aqueous phase and may react with the wastes.

Halogenated hydrocarbons are generally more stable and many are immiscible in the aqueous phase. The primary issue with these compounds is that they tend to be volatile and are in the center of the ozone depletion concern. Densities of many of these compounds are too high.

Polydimethylsiloxanes are commercially available in various formulations that have custom viscosities and other properties. These compounds appear to meet all requirements except for the presence of the methyl radical which may mask other hydrocarbons. Since the methyl radical is small this impact on the lab may be negligible.

6.2.2 Water and Water Solutions

Use of pure water for the hydrostatic head fluid meets many of the criteria, however some of the constituents in the saltcake are very soluble in water and will leach from the sample into the fluid. In addition, the analysis of the moisture content of the samples cannot be made unless the amount of water added to the sample from the hydrostatic fluid can be determined.

One approach to the moisture content determination is to add tracers to the water used for hydrostatic fluid so that an adjustment can be made to the analyzed moisture content, based upon the amount of tracer present. Radioactive tracers are attractive since the determination can be made simultaneously with the gamma analysis normally performed on the sample. The tracer must be of a short half-life (to allow for resampling of the same tank) and must be readily measurable in the presence of the other radioactive constituents. Only a limited number of suitable isotopes are commercially available. Handling of these tracers in the sampling operations increases the risk of excess dose to the operators.

#### 6.2.3 Gases

Gases have been considered for the hydrostatic fluid, including air, nitrogen and argon. If the newly design rotary drill is used, which requires gas purging and cooling of the bit, then the same gas should be used for the hydrostatic displacement. Inert gas may further reduce the risk in the tanks containing hydrogen or flammable organics, however the cost is significantly higher than using air. Another concern with the use of air or inert gas is that the volume of gas added eventually is discharged to the atmosphere through the tank vents. A modular exhauster may be required to satisfy current environmental and operating requirements. Another alternative may be to recycle the air or inert gas by installing a compressor or blower whose inlet is connected to the tank exhaust riser. This approach would limit the amount of gas discharged to the atmosphere.



## 7.0 In situ Analysis

### 7.1 In situ Analysis Alternatives

The waste materials in the SST's and DST's must be analyzed for composition and properties in order to characterize them under RCRA and to provide data for development of retrieval systems and pretreatment/vitrification flowsheets. Typical analyses are presented in reference 2 and include those for heavy metals, radionuclides, organics, chemical compounds such as nitrates and nitrites, pH, and physical properties such as density, specific gravity, moisture content, hardness and shear strength. It is possible that some of these analyses could be performed in the tank, thereby eliminating the need for some samples. Alternatives that have been considered for this in-place or in situ analysis are described below. In most cases, development and testing programs would be required to assess the effectiveness of the systems.

* Magnetic - Magnetometer measurements could be made inside the tanks. Interpretation of the results might provide information on locations of liquid "pockets" of liquid or voids.

* Electronic - Ultrasonic and radar measurements could be used to more accurately define the volume and surface features of the saltcakes

* Seismic - A miniature accelerometer could be inserted into a drill string to measure responses of the saltcake. Vibrations could be induced by impacting the saltcake surface from another riser. Saltcake densities and void locations could

be inferred from the data.

* Radiographic - In-place gamma spectrometry measurements could be made by lowering a detector down the inside of the drill string. The radiation field would probably require a substantial attenuator be used which would significantly reduce the resolution. An alternative approach would be to heavily shield the detector and use a small diameter path to the detector to limit the countrate. The current 5 cm (2 inch) inside diameter of the drill string would probably limit this technique to the use of a GM tube or a sodium iodide crystal, neither of which offer good spectrum resolution.

  Adaptations of neutron activation, x-ray fluorescence, and critical edge absorption techniques might also be employed for remote determination of certain elements, however the size restrictions and background radiation fields present probably make these approaches impractical.



* Temperature measurement - Infrared devices (pyrometers) are available which can provide data on the surface temperatures of the crusts, saltcakes or liquids. Since this type of device only senses surface temperature, it is of limited use, however it has the advantage of sensing through the riser openings. Direct reading temperature devices such as thermocouples or resistance thermometers can be inserted into the drill string to measure local temperatures.

* In situ chemical measurement - Sensors for measurement of pH, resistivity, and conductivity are available. Ion specific electrodes might be used for some measurements. Fiber optic systems have been developed that utilize chemical specific activated surfaces and laser-induced fluorescence for remote analysis. Solution polarimetry, refractive index and optical absorption measurements could also be made using fiber optics.

* Penetrometer - This type of device could be used to obtain strength and hardness measurements of the surface materials.

* Nuclear densitometer - This type of equipment is routinely used to measure in-place densities and moisture contents of soils. This device might be adapted for measuring saltcake density and moisture content.

* Shear vane - This device can be used to determine fluid flow properties remotely by measuring the torque required to rotate a paddle or shear vane suspended in the fluid. A further application might be to measure strength properties of the saltcakes.

## 8.0 References

1. HW-74040, "Sampling Process Waste Sludge in Underground Storage Tanks by Rotary Core Drilling," J.P. Duckworth, et. al., 6/29/62.

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## Table 1 - Sampling System Alternatives

| ALTERNATIVE | WASTE FORM[1] | SYSTEM DESCRIPTION | ADVANTAGES | DISADVANTAGES | VIABILITY | | REFERENCES[3] |
|---|---|---|---|---|---|---|---|
| | | | | | CODE[2] | JUSTIFICATION | |
| **SOLID SAMPLERS** | | | | | | | |
| Crane supported rotary drill with carbide bit | S,H | A Longyear rotary core drill was suspended from a boom crane allowing "remote" placement into a riser for sampling. | * No equipment on tank top.<br>* Operators protected by distance from riser and sampling equipment. | * Potential to drop sampler.<br>* Lack of containment.<br>* Difficult to operate.<br>* Bit temperature concerns.<br>* High industrial safety risks. | P | Functional for core sampling, but truck mounted rotary drill has advantages. | 1,3 |
| Tripod mounted rotary sampler | H | Scaffold mounted water sluicing method. | * Commercially available. | * Sample physical properties disturbed.<br>* Excessive secondary waste.<br>* Industrial safety issues. | N | Sample retrieval impractical.<br>Excessive equipment contamination. | |
| Truck mounted rotary drill with carbide bit | S,H | Specially designed rotary core drill with sample segment retrieval system, which utilizes an automatic grappling latch for shielded sample retrieval. Also utilizes reverse rake angle bit. | * Low dose rates to operator.<br>* Can sample all materials when used with universal sampler.<br>* System fully operational, good reliability and operability experienced. | * Could cut bottom of tank.<br>* Truck on top of tank.<br>* Bit temperature concerns.<br>* Containment concern if inert gas backpressure used. | A | Drill bit could penetrate tank bottom. | 3,4 |
| Truck mounted rotary drill with soft metal bit and universal sampler | L,S,H | Specially designed rotary core drill with sample segment retrieval system, which utilizes an automatic grappling latch for shielded sample retrieval. Also utilizes reverse rake angle bit. | * Low dose rates to operator.<br>* Can sample all materials when used with universal sampler.<br>* System fully operational, good reliability and operability experienced.<br>* Bit does not cut steel tank. | * Truck on top of tank.<br>* Bit temperature concerns.<br>* Containment concern if inert gas backpressure used. | A | When utilized with universal sampler, currently meets all criteria except for bit temperature limit and temperature monitoring. New design with gas cooling will limit temperature. Monitoring needs to be provided or established via a safety envelope. | 3,4 |
| Truck mounted rotary drill with diamond bit | S,H | Rotary core drill with diamonds imbedded in bit. Bit tested was specially designed not to cut steel. | * Commercially available.<br>* Does not cut steel. | * Does not cut hard saltcake. | N | Will not cut hard saltcake. | 5 |
| Vibration assisted rotary drilling with universal sampler | S,H | Core drilling system that uses ultrasonic vibration to "cut" through matrix. Could be used with existing universal sampler. | * Low speed rotation may limit bit temperature. | * Adaptation to existing equipment may be expensive. | P | Needs testing to evaluate.<br>May eliminate bit temperature concerns. | |
| Rotary cut and chip | H | Rock drill used in mining and construction. Chips are transported to surface pneumatically or with drilling mud. Requires casing from riser to surface of saltcake. Pneumatic system may use cyclone separator. | * Easily drills saltcake. | * Disturbs physical properties of sample.<br>* Collection of sample would involve excessive contamination and exposure.<br>* Use of mud creates excess secondary waste and contaminates sample. | N | Too "dirty".<br>Excess secondary waste. | |

1. "Waste Form" refers to the form of the material that can be sampled with the individual alternative. The Waste Form Code is as follows: L -- Liquid or mixed slurry; S -- Sludge or soft saltcake; H -- Hard saltcake.
2. "Viability Code" is the assessment of the applicability of a sampling system. The Viability Code is as follows: N -- Not viable; P -- Possibly usable - Meets some criteria; A -- Acceptable - Meets most or all criteria.
3. See Reference Section of Report - reports listed sequentially by number.

# Table 1 - Sampling System Alternatives

| ALTERNATIVE | WASTE FORM[1] | SYSTEM DESCRIPTION | ADVANTAGES | DISADVANTAGES | VIABILITY CODE[2] | VIABILITY JUSTIFICATION | REFERENCES[3] |
|---|---|---|---|---|---|---|---|
| Reverse circulation | H | Typically used with air or liquid to transport chips to surface mounted cyclone separator. Utilizes secondary caisson for airflow in annulus. | * Easily drills saltcake. | * Disturbs physical properties of sample.<br>* Collection of sample would involve excessive contamination and exposure.<br>* Only functional for dry saltcake.<br>* Requires additional casing for down flow of air. | N | Extensive equipment contamination.<br>Extensive support equipment required.<br>System design not initiated. | |
| Churn drill | H | Indexing percussion drill. | * Commercially available. | * Disturbs sample.<br>* Cross contamination of sample. | N | No advantage over rotary drill. | 10 |
| Hand operated ward drill | H | Hand operated version of churn drill. | * Commercially available. | * Disturbs sample.<br>* Cross contamination of sample. | N | No advantage over rotary drill. | 10 |
| Reciprocal (washing machine) drill | S,H | Occellating rotation of bit at low speeds. | * No total rotation, permitting electrical connections to monitoring instrumentation. | * Low drilling speed.<br>* Disturbs physical properties of sample. | P | Low drilling speed possible bit temperature control. | |
| Rotated casing drill | S,H | Casing with drilling shoe rotated into cake. Secondary drilling of casing interior required. | * Precludes caving in of hole in soft materials. | * Requires secondary drilling to retrieve sample. | P | Could be used in sludge and salt cake. | |
| Raise drill | H | Pilot drill thru tank bottom with bit attached from beneath tank and raised through lava cake. | * Commercially available. | * Violates tank confinement.<br>* Sample recovery impractical.<br>* Disturbs physical properties of sample. | N | Violates tank integrity. | |
| Percussion drill with separator | H | Hammer drill utilizing pneumatic transport of chips and dust to surface mounted cyclone separator. | * Easily drills saltcake.<br>* Commercially available. | * Disturbs physical properties of sample.<br>* Collection of sample would involve excessive contamination and exposure.<br>* Only functional for dry saltcake. | N | Extensive equipment contamination.<br>Extensive support equipment required.<br>System design not initiated. | |
| Cable tool | S,H | Impact driven, open sampler tube using cable driven hammer. | * Relatively inexpensive.<br>* Commercially available. | * Sludge sample retrieval problems.<br>* Mechanical generation of sparks.<br>* Limited core length.<br>* Could penetrate tank bottom. | P | Could be used for hardcake. | |
| Vibratory drill | S,H | Core drilling system utilizes vibration to cut through matrix. Cuttings can be transported pneumatically. | * Low heat generation.<br>* Commercially available. | * Poor penetration of hard saltcake.<br>* Disturbs physical properties of sample.<br>* Potential drill string temperature concerns. | N | Tested 1989 -- failed to penetrate saltcake. | |
| Down hole hammer drill | S,H | Pneumatic percussion drill with head and bit. Requires high pressure air supply down drill string. | * Reduced stresses on drill string. | * Disturbs physical properties of sample.<br>* Not able to core sample small diameters. | N | | |
| Pneumatic impact drill (Jack Hammer) | H | Impact driven open sampler tube using pneumatic impact drive head. | * Simple approach.<br>* Relatively inexpensive. | * Limited core length.<br>* Sludge retrieval problem. | P | Could be used for hardcake. | |

1. "Waste Form" refers to the form of the material that can be sampled with the individual alternative. The Waste Form Code is as follows: L -- Liquid or mixed slurry; S -- Sludge or soft saltcake; H -- Hard saltcake.
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# Table 1 - Sampling System Alternatives

| ALTERNATIVE | WASTE FORM[1] | SYSTEM DESCRIPTION | ADVANTAGES | DISADVANTAGES | VIABILITY CODE[2] | VIABILITY JUSTIFICATION | REFERENCES[3] |
|---|---|---|---|---|---|---|---|
| Surface auger sampler | S,H | Hand driven auger with containment and shroud assembled down 4" riser. | * Simple.<br>* Equipment inexpensive. | * High exposure to radioactivity using unshielded containment.<br>* Sample physical properties disturbed. | P | Potential dose rates high.<br>Potential for environmental release. | |
| Composite core sampler | S,H | Casing is advanced into saltcake by an internal bit/mixer which "homogenizes" the core samples of mixed waste retrieved for analysis. | * Single sample required to characterize entire core. | * Disturbs physical properties of core.<br>* Retrieval of samples at different depths difficult. | N | Purposely disturbs physical properties of sample by homogenizing. | 9 |
| Auger casing with percussion sampler | S,H | Auger type rotated casing with use of percussion sampler to retrieve sample in casing | * Can be used in sludge. | * Requires secondary drilling to retrieve sample.<br>* May disturb physical properties of sample.<br>* Casing abandoned in tank. | N | Could be used in sludge or soft cake.<br>Casing abandoned in tank. | |
| Auger casing with universal sampler | S,H | Auger type rotated casing with rotary core drill and universal sampler to retrieve sample in casing. | * None. | * Requires secondary drilling to retrieve sample.<br>* Cannot penetrate hard saltcake.<br>* Casing abandoned in tank. | N | No advantage over truck mounted rotary core drill.<br>Casing abandoned in tank. | |
| Mechanical post hole digger | S,H | Auger type machine, truck or tractor mounted, similar to those used for placing power poles. | * Simple | * Can't access waste in tanks.<br>* Disturbs physical properties of sample.<br>* Excessive dose and contamination potential. | N | Dose rates and potential for environmental release unacceptably high.<br>Impractical mechanical constraints. | None |
| Modified hand auger | S,H | Hand driven auger pulls material to surface. Can be designed to take a core sample. | * Simple.<br>* Equipment very inexpensive. | * High exposure to radioactivity and toxic chemicals.<br>* No containment.<br>* Sample physical properties disturbed. | N | Dose rates and potential for environmental release high. | 6,7 |
| "One-piece" core sampler | H | One piece sampler of length adequate to sample entire solids depth. | * Commercially available.<br>* Relatively inexpensive. | * Sludge sample retrieval problems.<br>* Limited core length. | P | Could be used for hardcake. | |
| Hydraulic push mode | S,H | A sample tube is pushed into waste, filling the tube with a sample. When tube is removed, sample is retained in end by friction. Can be taken as a full depth core or in segments. | * Simple approach. | * Can't penetrate most hard saltcakes.<br>* Full core tube can't be handled outside of tank or at analytical hot cell.<br>* Could penetrate tank bottom.<br>* Segmented sampling requires removal of the drill string to retrieve the segment.<br>* Cross-contamination from waste sloughing into hole is likely.<br>* Excessive equipment weight may exceed tank capacity.<br>* Drill string may buckle without mechanical support. | P | Could be used for crust or surface samples, not viable for full core. | 5 |

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| ALTERNATIVE | WASTE FORM[1] | SYSTEM DESCRIPTION | ADVANTAGES | DISADVANTAGES | VIABILITY | | REFERENCES[3] |
|---|---|---|---|---|---|---|---|
| | | | | | CODE[2] | JUSTIFICATION | |
| Sludge dart sampler | S | Tapered sampler dropped vertically to penetrate sludge. Sampler retrieved by cable tether. | * Simple.<br>* Relatively inexpensive. | * Limited to surface sampling<br>* High exposure to radioactive and toxic materials. | P | Successfully tested for special condition only. | 8 |
| Backhoe | S,H | Tractor or track mounted backhoe with scoop shovel. | * Commercially available<br>* Simple to use.<br>* Rugged | * Can't access wastes in tank.<br>* Excessive dose. | N | Dose rates and potential for environmental release unacceptably high.<br>Impractical mechanical constraints. | None |
| Hand shovel or post hole digger | S,H | Manually operated shovel, post hole digger or similar tool. | * Simple.<br>* Inexpensive. | * Can't access wastes in tanks.<br>* Excessive dose.<br>* Disturbs physical properties of sample. | N | Dose rates and potential for environmental release unacceptably high.<br>Impractical mechanical constraints. | None |
| Clam shell shovel | S,H | Miniature spring closure clam shell - suspended from crane hook. Used to sample sludges in canyon facilities. | * Inexpensive.<br>* Can fit in 8-12" via. riser.<br>* Tested in radioactive materials. | * Disturbs physical properties of sample.<br>* Limited to shallow holes and soft materials.<br>* High exposure and contamination potential upon retrieval. | P | Possible application with a robotic arm to sample specific shallow target areas. | |
| Dozer trenching | H | Dozer physically trenching surface of saltcake. | * Commercially available. | * Can't access waste in tanks.<br>* Radiation dose and contamination levels unacceptable. | N | Cannot access waste.<br>Doses would be intolerable. | None |
| Water jet cutting | S,H | High pressure water jet used to cut materials. Existing applications can cut 5" of steel. | * Low temperature, not rotational. | * Excessive volume of water generated.<br>* Dilution/contamination of sample probable.<br>* External high pressure required. | N | Not tested.<br>Generates excess liquid waste.<br>Dissolves some of sample. | |
| Laser cutting | H | Laser cutting of core. | * Technology available. | * High temperature.<br>* Cuts bottom of tank.<br>* Excessive power supply requirements. | N | Excessive temperature precludes use in tank environments. | |
| Gas jet cutting, with grit | H | High pressure gas discharge at bit with abrasive grit. | * Reduced heat generation at bit. | * Sample cross contamination.<br>* Sample erosion.<br>* Extensive support systems required. | N | Would require extensive testing. | |
| Gas jet cutting, without grit | H | High pressure gas discharge at bit. | * Reduced heat generation at bit. | * Sample cross contamination.<br>* Sample erosion.<br>* Extensive support systems required. | N | Would require extensive testing. | |
| Saw cut sampler | H | Chain saw used to cut blocks of hard saltcake. (Possibly from robotic arm.) | * Commercially available. | * Retrieval of cores difficult.<br>* Depth of sample limited to blade length. | N | Potential for environmental release.<br>Impractical mechanical constraints. | |

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|---|---|---|---|---|---|---|---|
| | | | | | CODE[2] | JUSTIFICATION | |
| Robotic sampler | L,S,H | Robotic arm inserted through larger riser with telescopic, or folding extensions. Remotely guided with closed-circuit television. Coupled with a movable sampler, possibly a miniature rotary drill that is placed on the surface of the saltcake by the robotic arm. | * Could obtain samples in areas of the tank not through existing risers. | * Expensive.<br>* Extensive development and testing required.<br>* Probably limited in depth of sample that can be taken.<br>* May disturb physical properties of sample. | P | May be necessary to allow special sampling of areas inaccessible from risers. | |
| **LIQUID/SLURRY SAMPLERS** | | | | | | | |
| Bottle on a string | L | A weighted bottle with a cork inserted is lowered into the tank. At the desired depth the string, which is also attached to the cork, is jerked pulling out the cork. The bottle fills with solution and is then retrieved through the riser hand-over hand. | * Simple.<br>* Inexpensive.<br>* Can sample at different depths in the liquid. | * No containment during retrieval.<br>* Risk of spilling solution, spread of contamination.<br>* Dose can be high if not done properly.<br>* Bottle open -- some mixing with upper solution as sample retrieved. | A | Obtains acceptable liquid or slurry sample with acceptable operator exposure. | |
| Modified bottle on a string | L | Same as described above (Bottle on a string), with the addition of a self closing lid which improves sample integrity. | * Simple.<br>* Inexpensive.<br>* Can sample at different depths in the liquid. | * No containment during retrieval.<br>* Risk of spilling solution, spread of contamination.<br>* Dose can be high if not done properly. | A | Better sample than open bottle. | |
| Dip sampler | 1. | Open topped sampler on a long metal rod. Manipulated from a crane into riser. Plunger operated ball valve on bottom to allow "remote" transfer of sample to shield bottle. | * Simple<br>* Inexpensive.<br>* Doesn't require hands-on operation by personnel. | * No containment during retrieval.<br>* Risk of spilling solution spreading contamination.<br>* Sample mixed with solution above desired sample level. | P | Limited dose advantage over bottle on a string. Might be desirable for sampling NCAW. | |
| Kemmerer Sampler | L | Developed for deep ocean sampling. Opens at desired depth upon signal from surface, then recloses. | * Tested technology<br>* High integrity sample<br>* Will work in depths of solution in tanks. | * Opening and closing mechanism would need to be custom designed.<br>* Expensive compared to bottle on string.<br>* No containment during retrieval.<br>* Probably wouldn't fit in existing shielded sample carriers. | N | No advantages over existing bottle on string. More difficult to use. | |
| Automated "vial on a pulley" | L | Similar to bottle on a string except that system includes mechanical reel retrieval, shielded receiver and containment. | * Less chance of contamination spread or excess exposure than bottle on a string. | * More expensive.<br>* Not developed and tested.<br>* Transfer to closed, shielded sample carrier difficult. | P | Needs development to provide reclosure of vial and transfer to shielded sample carrier. | |
| Evacuated sampler | J. | Similar to bottle on a string but utilizing evacuated container with valve. | * Representative sample at all levels.<br>* Container sealed during retrieval. | * Expense of evacuated container. | P | Potential for environmental contamination. | |

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| ALTERNATIVE | WASTE FORM[1] | SYSTEM DESCRIPTION | ADVANTAGES | DISADVANTAGES | VIABILITY | | REFERENCES[3] |
|---|---|---|---|---|---|---|---|
| | | | | | CODE[2] | JUSTIFICATION | |
| Cryogenic sampler | L | Small bottle filled with liquid nitrogen is lowered into waste tank. Solution freezes to outside of bottle. Sample retrieved and thawed. | ▪ Simple<br>▪ Inexpensive | ▪ Potential for contamination spread.<br>▪ Sample may not be representative of solution in tank. Separation may occur during freezing.<br>▪ Safety problems with handling liquid nitrogen. | N | No advantage over bottle on a string. Several additional problems result. | |
| West Valley Thorex Sampler | L | Recirculating sampler utilizing water jet as motive force. | ▪ Existing design.<br>▪ Provides confinement of sample. | ▪ Adds water to tank volume. | N | Water addition not desirable. | |
| Peristaltic pump sampler | L | Recirculating sampler utilizing peristaltic pump for confined motive force. | ▪ Totally confined system. | ▪ Pump may need to be located in tank/liquid to overcome hydrostatic pressure/suction head. | N | Potential hydrostatic problems with pump design capabilities. | |
| Air-lift assisted, vacuum operated sampler | L | Recirculating sampler utilizing vacuum as motive force with pressurized air lift to suction leg to attain high lift. | ▪ Capable of lifting solution to top of tank.<br>▪ Demonstrated design.<br>▪ Provides confinement of sample. | ▪ Potential for contamination spread from vacuum source. | P | Provides confinement of sample. | |
| Sludge sampler | L,S | Push mode core sampling truck | ▪ Provides confinement of sample.<br>▪ Provides shielding of sample.<br>▪ Known sample depth | ▪ More expensive than bottle on a string.<br>▪ More labor intensive than bottle on a string. | A | Provides acceptable sample of liquid and sludge mediums with confinement and shielding. | |
| Universal sampler | L,S,H | See truck mounted rotary drill. (See page 16) | ▪ Provides confinement of sample.<br>▪ Provides shielding of sample. | ▪ More expensive than bottle on a string.<br>▪ More labor intensive than bottle on a string. | A | Provides acceptable sample of all mediums with confinement and shielding. | |

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3. See Reference Section of Report - reports listed sequential by number.

# TABLE 2
# SAMPLER CONFORMANCE MATRIX
# SOLID SAMPLERS

| SAMPLER METHOD | Crane supported rotary drill with carbide bit | Tripod mounted rotary sampler | Truck mounted rotary drill with carbide bit | Truck mounted rotary drill with modified bit and universal sampler | Truck mounted rotary drill with diamond bit | Vibration assisted rotary drilling with universal sampler |
|---|---|---|---|---|---|---|
| DESCRIPTION<br>CRITERIA | A Longyear rotary core drill was suspended from a boom crane allowing "remote" placement into a riser for sampling. | Scaffold mounted water sluicing method. | Specially designed rotary core drill with sample segment retrieval system, which utilizes an automatic grappling latch for shield sample retrieval. | Specially designed rotary core drill with sample segment retrieval system, which utilizes an automatic grappling latch for shield sample retrieval. | Rotary core drill with diamonds inbeded in bit. Bit tested was specially designed not to cut steel. | Core drilling system that uses ultrasonic vibration to "cut" through matrix. Could be used with existing universal sampler. |
| Obtain samples from 10 to 30 cm tank-top risers. | Y | Y | Y | Y | N | Y |
| The system shall be able to sample liquids and slurries. | N* | N* | N* | Y | N* | Y |
| Sample sludges, soft and hard saltcake and combinations. | Y | Y | Y | Y | N | Y |
| Sample the entire depth of waste from the top surface to within 8 cm of the bottom, about 11 meters of depth maximum. | Y | Y | Y | Y | N | Y |
| Contain a minimum of 4.7 cm³ of material per cm of core. | Y | Y | Y | Y | Y | Y |
| Liquid samples must be at least 100 ml in volume. | N/A | N/A | N/A | Y | N/A | Y |
| Not alter the physical properties of sampled material. Undisturbed, representative samples are required. | Y | N | Y | Y | Y | Y |
| The system shall not alter the chemical properties. | Y | Y | Y | Y | Y | Y |
| The system shall not cause harm to the tank floors or wall. | Y | Y | N | Y | Y | Y |
| Shall recover at least 90% of a full sample 90% of the time. | Y | Y | Y | Y | N | Y |
| Waste material shall not exceed 180°C. Sampling apparatus temperature shall be less than 150°C. | N | Y | N | Y | Y | Y |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C. | N | N | N | N | N | N |
| Samples and associated hardware must be compatiable with existing site hot cell facilities and equipment. | Y | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 1 inch. | Y | Y | Y | Y | Y | Y |
| Must remain operational after tank exposure for 3 weeks with doses of 2000 R\hr and solutions with pH >12. | Y | Y | Y | Y | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | Y | Y | Y | Y | Y | Y |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Y | Y | Y | Y | Y |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. | Y | Y | Y | Y | Y | Y |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | Y | Y | Y | N | Y |
| Generation of secondary wastes shall be minimized. | Y | Y | Y | Y | Y | Y |
| Must operate safely in an environment containing explosive gases and flammable liquids or vapors. | Y | Y | Y | Y | Y | Y |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | Y | Y | Y |
| The sampler support system must be reusable, mobile, and maintainable. | Y | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | Y | Y | Y | Y | Y | Y |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | Y | Y | Y | Y | Y | N |
| Composite Rating (number of Y's) | 22 | 22 | 22 | 25 | 18 | 24 |
| Pass/Fail – Critical Criteria (shaded boxes) | Fail | Fail | Fail | Pass | Fail | Pass |

N* If universal sampler is used in these applications, a liquid sample could be taken, however it is not currently adapted to these systems.

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# TABLE 2 -- CONTINUED
# SAMPLER CONFORMANCE MATRIX
# SOLID SAMPLERS

| SAMPLER TYPE | Rotary cut and chip | Reverse circulation | Churn drill | Hand operated ward drill | Reciprocal (washing machine) drill | Rotated casing drill |
|---|---|---|---|---|---|---|
| DESCRIPTION | Rock drill used in mining and construction. | Typically used with air to transport chips to surface mounted cyclone separator. Utilizes secondary caissons for airflow in annulus. | Implexing percussion drill. | Hand operated version of churn drill. | Occillating rotation of bit at low speeds. | Casing with drilling shoe rotated into cake. Secondary drilling of casing interior required. |
| CRITERIA | | | | | | |
| Obtain samples from 10 to 30 cm tank-top risers. | Y | N | Y | Y | Y | Y |
| The system shall be able to sample liquids and slurries. | N | N | N* | N* | N* | N* |
| Sample sludges, soft and hard saltcake and combinations. | Y | Y | Y | Y | Y | Y |
| Sample the entire depth of waste from the top surface to within 8 cm of the bottom, about 11 meters of depth maximum. | Y | Y | Y | N | Y | Y |
| Contain a minimum of 4.7 cm³ of material per cm of core. | Y | Y | Y | Y | Y | Y |
| Liquid samples must be at least 100 ml in volume. | N/A | N/A | N | N | N | N/A |
| Not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | N | N | N | N | N |
| The system shall not alter the chemical properties. | N | N | Y | N | Y | Y |
| The system shall not cause harm to the tank floors or wall. | N | Y | N | Y | Y | N |
| Shall recover at least 90% of a full sample 90% of the time. | Y | Y | Y | N | Y | Y |
| Waste material shall not exceed 180°C. Sampling apparatus temperature shall be less than 150°C. | N | Y | N | Y | U* | Y |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C. | N | N/A | N | N | N | N/A |
| Samples and associated hardware must be compatiable with existing site hot cell facilities and equipment. | Y | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 1 inch. | Y | Y | Y | N | Y | N |
| Must remain operational after tank exposure for 3 weeks with doses of 2000 R\hr and solutions with pH >12. | Y | Y | Y | Y | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | Y | Y | Y | N | Y | N |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Y | Y | N | Y | Y |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. | Y | Y | Y | N | Y | Y |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | Y | Y | N | Y | Y |
| Generation of secondary wastes shall be minimized. | N | N | Y | Y | Y | Y |
| Must operate safely in an environment containing explosive gases and flammable liquids or vapors. | Y | Y | Y | Y | Y | Y |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | Y | Y | Y |
| The sampler support system must be reusable, mobile, and maintainable. | Y | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | N | N | Y | N | Y | Y |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | N | N | N | N | N | N |
| Composite Rating (number of Y's) | 16 | 17 | 19 | 12 | 20 | 18 |
| Pass/Fail -- Critical Criteria (shaded boxes) | Fail | Fail | Fail | Fail | Fail | Fail |

N* If universal sampler is used in these applications, a liquid sample could be taken, however it is not currently adapted to these systems.

U* Unknown.

# TABLE 2 -- CONTINUED
# SAMPLER CONFORMANCE MATRIX
# SOLID SAMPLERS

| SAMPLER TYPE | Raise Drill | Percussion drill with separator | Cable tool | Vibratory drill | Down hole hammer drill | Pneumatic impact drill (Jack Hammer) |
|---|---|---|---|---|---|---|
| DESCRIPTION | Pilot drill thru tank bottom with bit attached from beneath tank and raised through lava cake | Hammer drill utilizing pneumatic transport of chips and dust to surface mounted cyclone separator. | Impact driven, open sampler tube using cable driven hammer. | Core drilling system utilizes vibration to cut through matrix. Cuttings can be transported pneumatically. | Pneumatic percussion drill with head at bit. Requires high pressure air supply down drill string. | Impact driven open sampler tube using pneumatic impact drive head. |
| CRITERIA | | | | | | |
| Obtain samples from 10 to 30 cm tank-top risers. | N | N | Y | N | Y | Y |
| The system shall be able to sample liquids and slurries. | N | N | N | N* | N* | N |
| Sample sludges, soft and hard saltcake and combinations. | Y | Y | Y | Y | Y | Y |
| Sample the entire depth of waste from the top surface to within 8 cm of the bottom, about 11 meters of depth maximum. | Y | Y | Y | N | Y | Y |
| Contain a minimum of 4.7 cm³ of material per cm of core. | Y | Y | Y | Y | Y | Y |
| Liquid samples must be at least 100 ml in volume. | N | N/A | N | N/A | N | N |
| Not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | N | N | N | N | N |
| The system shall not alter the chemical properties. | Y | N | Y | Y | Y | N |
| The system shall not cause harm to the tank floors or wall. | N | N | N | Y | N | N |
| Shall recover at least 90% of a full sample 90% of the time. | Y | Y | Y | Y | Y | N |
| Waste material shall not exceed 180°C. Sampling apparatus temperature shall be less than 150°C. | N | Y | Y | Y | N | Y |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C. | N | N/A | N | N | N | N |
| Samples and associated hardware must be compatible with existing site hot cell facilities and equipment. | Y | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 1 inch. | Y | Y | N | Y | Y | N |
| Must remain operational after tank exposure for 3 weeks with doses of 2000 R\hr and solutions with pH > 12. | Y | Y | Y | Y | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | N | Y | Y | Y | Y | N |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | N | Y | Y | Y | Y | N |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. | N | Y | Y | Y | Y | N |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | Y | Y | N | Y | Y |
| Generation of secondary wastes shall be minimized. | N | Y | Y | Y | Y | Y |
| Must operate safely in an environment containing explosive gases and flammable liquids or vapors. | Y | Y | Y | Y | Y | N |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | Y | Y | Y |
| The sampler support system must be reusable, mobile, and maintainable. | Y | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | N | N | Y | Y | Y | N |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | N | N | N | Y | N | N |
| Composite Rating (number of Y's) | 13 | 17 | 19 | 19 | 19 | 12 |
| Pass/Fail -- Critical Criteria (shaded boxes) | Fail | Fail | Fail | Fail | Fail | Fail |

N* If universal sampler is used in these applications, a liquid sample could be taken, however it is not currently adapted to these systems.

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# TABLE 2 -- CONTINUED
# SAMPLER CONFORMANCE MATRIX
# SOLID SAMPLERS

| SAMPLER TYPE | Surface auger | Composit core sampler | Auger casing with percussion sampler | Auger casing with universal sampler | Mechanical post hole digger | Hand auger |
|---|---|---|---|---|---|---|
| DESCRIPTION | Hand driven auger with containment and shroud assembled down 4" riser. | Casing is advanced into saltcake by an internal bit/mixer which "homogenizes" the core samples of mixed waste retrieved for analysis. | Auger type rotated casing with use of percussion sampler to retrieve sample in casing. | Auger type rotated casing with rotary core drill and universal sampler to retrieve sample in casing. | Auger type machine, truck or tractor mounted, similar to those used for placing power poles. | Hand driven auger pulls material to surface. Can be designed to take a core sample. |
| CRITERIA | | | | | | |
| Obtain samples from 10 to 30 cm tank-top risers. | Y | N | Y | Y | Y | N |
| The system shall be able to sample liquids and slurries. | N | N | N | N | N | N |
| Sample sludges, soft and hard saltcake and combinations. | Y | Y | Y | Y | Y | Y |
| Sample the entire depth of waste from the top surface to within 8 cm of the bottom, about 11 meters of depth maximum. | Y | N | Y | Y | N | N |
| Contain a minimum of 4.7 cm³ of material per cm of core. | Y | Y | Y | Y | Y | Y |
| Liquid samples must be at least 100 ml in volume. | N/A | N/A | N/A | Y | N/A | N/A |
| Not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | N | N | Y | N | N |
| The system shall not alter the chemical properties. | N | Y | Y | Y | N | N |
| The system shall not cause harm to the tank floors or wall. | Y | Y | N | N | N | Y |
| Shall recover at least 90% of a full sample 90% of the time. | Y | N/A | Y | Y | Y | Y |
| Waste material shall not exceed 180°C. Sampling apparatus temperature shall be less than 150°C. | Y | Y | Y | Y* | N | Y |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C. | N | N/A | N/A | N | N | N/A |
| Samples and associated hardware must be compatible with existing site hot cell facilities and equipment. | Y | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 1 inch. | Y | N/A | Y | Y | N | N |
| Must remain operational after tank exposure for 3 weeks with doses of 2000 R\hr and solutions with pH > 12. | Y | Y | Y | Y | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | N | Y | Y | Y | N | N |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Y | Y | Y | N | N |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. | Y | Y | Y | Y | N | N |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | Y | Y | Y | Y | N |
| Generation of secondary wastes shall be minimized. | Y | Y | Y | Y | N | Y |
| Must operate safely in an environment containing explosive gases and flammable liquids or vapors. | Y | Y | Y | Y | Y | Y |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | Y | Y | Y |
| The sampler support system must be reusable, mobile, and maintainable. | N | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | Y | Y | N | N | N | N |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | N | Y | Y | Y | Y | Y |
| **Composite Rating (number of Y's)** | 18 | 18 | 20 | 22 | 12 | 13 |
| **Pass/Fail -- Critical Criteria (shaded boxes)** | Fail | Fail | Fail | Fail | Fail | Fail |

N* If universal sampler is used in these applications, a liquid sample could be taken, however it is not currently adapted to these systems.

# TABLE 2 -- CONTINUED
# SAMPLER CONFORMANCE MATRIX
# SOLID SAMPLERS

| SAMPLER TYPE | "One-piece" core sampler | Hydraulic push mode | Sludge dart sampler | Backhoe | Hand shovel or post hole digger | Clam shell shovel |
|---|---|---|---|---|---|---|
| DESCRIPTION | Impact driven, open sampler tube using cable driven hammer. | A sample tube is pushed into waste, filling the tube with a sample. When tube is removed, sample is retained in end by friction. Can be taken as a full depth core or in segments. | Tapered sampler dropped vertically to penetrate sludge. Sampler retrieved by cable tether. | Tractor or track mounted backhoe with scoop shovel. | Manually operated shovel, post hole digger or similar tool. | Miniature spring closure clam shell - suspended from crane hook. Used to sample sludges in canyon facilities. |
| CRITERIA | | | | | | |
| Obtain samples from 10 to 30 cm tank-top risers. | Y | N | N | N | N | N |
| The system shall be able to sample liquids and slurries. | N | Y | N | N | N | N |
| Sample sludges, soft and hard saltcake and combinations. | Y | Y | Y | Y | Y | Y |
| Sample the entire depth of waste from the top surface to within 8 cm of the bottom, about 11 meters of depth maximum. | Y | N | N | N | N | N |
| Contain a minimum of 4.7 $cm^3$ of material per cm of core. | Y | Y | Y | Y | Y | Y |
| Liquid samples must be at least 100 ml in volume. | N | Y | N/A | N/A | N/A | N/A |
| Not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | N | N | N | N | N |
| The system shall not alter the chemical properties. | Y | N | N | N | N | N |
| The system shall not cause harm to the tank floors or wall. | N | N | Y | N | Y | Y |
| Shall recover at least 90% of a full sample 90% of the time. | Y | N | N | Y | Y | N |
| Waste material shall not exceed 180°C. Sampling apparatus temperature shall be less than 150°C. | Y | Y | Y | Y | Y | Y |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C. | N | Y | N/A | N/A | N/A | N/A |
| Samples and associated hardware must be compatible with existing site hot cell facilities and equipment. | N | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 1 inch. | Y | Y | N | N | N | N |
| Must remain operational after tank exposure for 3 weeks with doses of 2000 R\hr and solutions with pH > 12. | Y | Y | Y | N | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | Y | Y | N | N | N | Y |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Y | N | N | N | N |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. | Y | Y | N | N | N | N |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | Y | N | N | N | N |
| Generation of secondary wastes shall be minimized. | Y | Y | Y | N | Y | Y |
| Must operate safely in an environment containing explosive gases and flammable liquids or vapors. | Y | Y | Y | N | Y | Y |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | Y | Y | Y |
| The sampler support system must be reusable, mobile, and maintainable. | Y | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | Y | Y | Y | N | N | Y |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | N | Y | Y | Y | Y | Y |
| Composite Rating (number of Y's) | 19 | 20 | 13 | 9 | 13 | 14 |
| Pass/Fail -- Critical Criteria (shaded boxes) | Fail | Fail | Fail | Fail | Fail | Fail |

N* If universal sampler is used in these applications, a liquid sample could be taken, however it is not currently adapted to these systems.

# TABLE 2 -- CONTINUED
# SAMPLER CONFORMANCE MATRIX
# SOLID SAMPLERS

| SAMPLER TYPE | Dozer trench | Water jet cutting | Laser cutting | Gas jet cutting, with grit | Gas jet cutting, without grit | Saw cut sampler |
|---|---|---|---|---|---|---|
| DESCRIPTION | Dozer physically trenching surface of saltcake. | High pressure water jet used to cut materials. Existing applications can cut 5" of steel. | Laser cutting of core. | High pressure gas discharge at bit with abrasive grit. | High pressure gas discharge at bit. | Chain saw used to cut blocks of hard saltcake. (Possibly from robotic arm.) |
| CRITERIA | | | | | | |
| Obtain samples from 10 to 30 cm tank-top risers. | N | Y | Y | Y | Y | N |
| The system shall be able to sample liquids and slurries. | N | N | N | N | N | N |
| Sample sludges, soft and hard saltcake and combinations. | Y | Y | Y | Y | Y | Y |
| Sample the entire depth of waste from the top surface to within 8 cm of the bottom, about 11 meters of depth maximum. | N | Y | N | Y | Y | N |
| Contain a minimum of 4.7 cm³ of material per cm of core. | Y | Y | Y | Y | Y | Y |
| Liquid samples must be at least 100 ml in volume. | N/A | N/A | N/A | N/A | N/A | N/A |
| Not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | N | N | N | N | Y |
| The system shall not alter the chemical properties. | N | N | Y | N | Y | N |
| The system shall not cause harm to the tank floors or wall. | N | N | N | N | N | N |
| Shall recover at least 90% of a full sample 90% of the time. | Y | N | N | Y | Y | Y |
| Waste material shall not exceed 180°C. Sampling apparatus temperature shall be less than 150°C. | Y | Y | N | Y | Y | N |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C. | N/A | N/A | N/A | N/A | N/A | N |
| Samples and associated hardware must be compatiable with existing site hot cell facilities and equipment. | Y | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 1 inch. | N | N | N | Y | Y | N |
| Must remain operational after tank exposure for 3 weeks with doses of 2000 R\hr and solutions with pH > 12. | Y | Y | Y | Y | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | N | Y | Y | Y | Y | N |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | N | Y | Y | Y | Y | N |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. | N | Y | Y | Y | Y | N |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | N | Y | Y | Y | Y | Y |
| Generation of secondary wastes shall be minimized. | N | Y | Y | N | Y | Y |
| Must operate safely in an environment containing explosive gases and flammable liquids or vapors. | N | Y | N | Y | Y | N |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | N | N | Y |
| The sampler support system must be reusable, mobile, and maintainable. | Y | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | N | N | Y | Y | Y | Y |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | Y | N | N | N | N | Y |
| Composite Rating (number of Y's) | 10 | 16 | 15 | 17 | 19 | 13 |
| Pass/Fail -- Critical Criteria (shaded boxes) | Fail | Fail | Fail | Fail | Fail | Fail |

N* If universal sampler is used in these applications, a liquid sample could be taken, however it is not currently adapted to these systems.

# TABLE 2 -- CONTINUED
# SAMPLER CONFORMANCE MATRIX
# SOLID SAMPLERS

| SAMPLER TYPE | Robotic sampler | | | | | |
|---|---|---|---|---|---|---|
| DESCRIPTION / CRITERIA | Robotic arm inserted through larger riser with telescopic, or folding extensions. Remotely guided with closed-circuit television. Coupled with a movable sampler, possibly a miniature rotary drill. | | | | | |
| Obtain samples from 10 to 30 cm tank-top risers. | Y | | | | | |
| The system shall be able to sample liquids and slurries. | Y | | | | | |
| Sample sludges, soft and hard saltcake and combinations. | Y | | | | | |
| Sample the entire depth of waste from the top surface to within 8 cm of the bottom, about 11 meters of depth maximum. | Y | | | | | |
| Contain a minimum of 4.7 $cm^3$ of material per cm of core. | Y | | | | | |
| Liquid samples must be at least 100 ml in volume. | N/A | | | | | |
| Not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | | | | | |
| The system shall not alter the chemical properties. | N | | | | | |
| The system shall not cause harm to the tank floors or wall. | Y | | | | | |
| Shall recover at least 90% of a full sample 90% of the time. | Y | | | | | |
| Waste material shall not exceed 180°C. Sampling apparatus temperature shall be less than 150°C. | Y | | | | | |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C. | Y | | | | | |
| Samples and associated hardware must be compatiable with existing site hot cell facilities and equipment. | Y | | | | | |
| Sampler vertical position must be measurable within 1 inch. | Y | | | | | |
| Must remain operational after tank exposure for 3 weeks with doses of 2000 R\hr and solutions with pH > 12. | Y | | | | | |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | Y | | | | | |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | | | | | |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. | Y | | | | | |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | | | | | |
| Generation of secondary wastes shall be minimized. | Y | | | | | |
| Must operate safely in an environment containing explosive gases and flammable liquids or vapors. | Y | | | | | |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | | | | | |
| The sampler support system must be reusable, mobile, and maintainable. | Y | | | | | |
| The system must be capable of taking more than one sample from a given riser. | Y | | | | | |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | | | | | |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | N | | | | | |
| Composite Rating (number of Y's) | 21 | | | | | |
| Pass/Fail -- Critical Criteria (shaded boxes) | Fail | | | | | |

N* If universal sampler is used in these applications, a liquid sample could be taken, however it is not currently adapted to these systems.

# TABLE 3
# SOLID SAMPLERS -- MANDATORY CRITERIA
# PASS/FAIL JUSTIFICATION

| SAMPLE METHOD / CRITERIA | Crane supported rotary drill with standard bit | | Tripod mounted rotary sampler | | Truck mounted rotary drill with standard bit | | Truck mounted rotary drill with modified bit and universal sampler | | Truck mounted rotary dri'l with diamond bit | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | N | Will not cut hard saltcake. |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | N | Will not cut hard saltcake. |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | Y | Technology demonstrated. | N | Sample mixing and secondary waste. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated except for hard saltcake. |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | By bit design. |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | N | Excessive temperature generated at bit face. | Y | Technology demonstrated. | N | Excessive temperature generated at bit face. | Y | Testing shows temperature can be maintained as long as purge gas flow is maintained at a minimum. | Y | By administrative control via operating procedure. |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | N | Drill head tends to spin when bit sticks, worker hazard. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. | Y | Technology demonstrated. |
| PASS/FAIL | Fail | Excessive temperature and worker hazard. | Fail | Sample mixing and secondary waste. | Fail | Excessive temperature. | Pass | Past performance has demonstrated acceptability. | Fail | Unable to sample hard saltcake. |

## TABLE 3 – CONTINUED
## SOLID SAMPLERS – MANDATORY CRITERIA
## PASS/FAIL JUSTIFICATION

| SAMPLE METHOD / CRITERIA | Vibration assisted rotary drill with universal sampler | | Rotary cut and chip | | Reverse circulation | | Churn drill | | Hand operated ward drill | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | Y | Technology demonstrated when used with existing equipment. | Y | By design requirements. | N | Only functional for dry saltcake. | Y | By design requirement. | Y | By design requirement. |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | Y | Technology demonstrated when used with existing equipment. | Y | By design requirements. | Y | By design requirements. | Y | By design. | N | Weight of the tool would be excessive for manual operation. |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | Y | Technology demonstrated when used with existing equipment. | N | Sample mixing. | N | Sample mixing. | N | Core disturbed by impact of drilling. Sample mixing likely. | N | Sample mixing likely. |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | Y | Technology demonstrated when used with existing equipment. | N | May penetrate tank floor. | Y | By administrative control via operating procedure. | N | May damage tank floor. | Y | By administrative control via operating procedure. |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | Y | By administrative control via operating procedure. | N | High friction. | Y | By administrative control via operating procedure. | N | High friction. | Y | Low friction. |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | Containment designs for segmented drill rod are developed and demonstrated. |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | Containment designs for segmented drill rod are developed and demonstrated. |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | Y | Technology demonstrated when used with existing equipment. | Y | No ignition source. | Y | By design requirement. | Y | No ignition source. | Y | No ignition source. |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Technology demonstrated when used with existing equipment. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Technology demonstrated when used with existing equipment. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. |
| **PASS/FAIL** | Pass | Sample mixing. | Fail | Multiple failures. | Fail | Dry saltcake only and sample mixing. | Fail | Mixing, friction and tank damage. | Fail | Sample mixing and excessive weight. |

## TABLE 3 – CONTINUED
## SOLID SAMPLERS – MANDATORY CRITERIA
## PASS/FAIL JUSTIFICATION

| SAMPLE METHOD / CRITERIA | Reciprocal (washing machine) drill | | Rotated casing drill | | Raise drill | | Percussion drill with separator | | Cable tool | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | Y | By design requirement. | Y | By design requirement. | N | Bottom entry through tank floor. | N | Only functional for dry saltcake. | Y | By design requirement. |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | Y | By design requirement. | Y | By design requirement. | Y | By design requirements. | Y | By design requirements. | Y | Capable of continuous coring. |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | Sample mixing. | N | Sample mixing. | N | Sample mixing. | N | Sample mixing. | N | Impacts from driving core may disturb core. |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | Y | By administrative control via operating procedure. | N | Casing may damage floor. | N | Violates tank confinement. | N | May penetrate tank floor. | N | Hammer driven, may damage floor. |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | U* | No prototype available for testing. | Y | By administrative control via operating procedure. | N | High speed, high friction. | Y | By administrative control via operating procedure. | Y | Low friction. |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | No technology for sample transfers. No containment. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | No technology for sample transfers. No containment. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | Y | No ignition source. | Y | No ignition source. | Y | No ignition source. | Y | By design requirement. | N | Mechanical generation of sparks. |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | By design requirements. | Y | By design requirement. | Y | By design requirement. | Y | By design requirements. | Y | By design requirements. |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | By design requirements. | Y | By design requirement. | Y | By design requirement. | Y | By design requirements. | Y | By design requirements. |
| **PASS/FAIL** | Fail | Sample mixing. | Fail | Sample mixing and tank damage. | Fail | Violates tank confinement, sample mixing, friction and no containment. | Fail | Dry saltcake only, sample mixing and tank damage. | Fail | Sample mixing, tank damage and spark generation. |

U* – Unknown.

# TABLE 3 -- CONTINUED
## SOLID SAMPLERS -- MANDATORY CRITERIA
## PASS/FAIL JUSTIFICATION

| SAMPLE METHOD / CRITERIA | Vibratory drill | | Down hole hammer drill | | Pneumatic impact drill (Jack Hammer) | | Surface auger | | Composite core sampler | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | N | Poor penetration of hard saltcake observed in testing. | Y | By design requirement. | Y | By design requirements. | Y | By design. | N | Sample mixing. |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | N | Poor penetration of hard saltcake. | Y | By design requirement. | Y | By design requirements. | Y | A "continuous" sample can be obtained by repeated insertion of the sampler into the same location. | N | Sample mixing. |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | Disturbs core. | N | Sample mixing. | N | Sample mixing during segmental sampling. | N | Core is broken and mixed by the sampler. | N | Sample mixing. |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | Y | By administrative control via operating procedure. | N | May damage floor. | N | Could penetrate tank floor. | Y | Technology demonstrated. | Y | By administrative control via operating procedure. |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | Y | By administrative control via operating procedure. | N | High friction. | Y | Low friction. | Y | Technology demonstrated. Low friction, low heat generation. | Y | By administrative control via operating procedure. |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | By administrative control via operating procedure. | N | No technology to handle full core sample. No containment. | Y | Technology demonstrated. (No containment.) | Y | By administrative control via operating procedure. |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | By administrative control via operating procedure. | N | No technology to handle full core sample. No containment. | Y | Technology demonstrated. (No containment.) | Y | By administrative control via operating procedure. |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | Y | No ignition source. | Y | No ignition source. | N | Mechanical spark generation. | Y | Technology demonstrated. | Y | No ignition source. |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | By design requirement. | Y | By design requirement. | Y | By design requirement. | Y | Technology demonstrated. | Y | By design requirement. |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | By design requirement. | Y | By design requirement. | Y | By design requirement. | Y | Technology demonstrated. | Y | By design requirement. |
| **PASS/FAIL** | Fail | Unable to sample hard saltcake and core disturbed. | Fail | Sample mixing, tank damage and high friction. | Fail | Sample mixing, no containment and spark generation. | Fail | Cannot provide undisturbed core samples. | Fail | Sample mixing. |

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## TABLE 3 -- CONTINUED
## SOLID SAMPLERS -- MANDATORY CRITERIA
## PASS/FAIL JUSTIFICATION

| SAMPLE METHOD / CRITERIA | Auger casing with percussion sampler | | Auger casing with universal sampler | | Mechanical post hole digger | | Hand auger | | "One-piece" core sampler | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | N | Can't access tank waste. | Y | By design requirement. |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | Y | By design requirements. | Y | Technology demonstrated. | N | Won't access entire waste depth. | N | Can't access tank waste. | Y | By design. |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | Sample mixing. | Y | Technology demonstrated. | N | Sample mixing. | N | Sample mixing. | N | Sample mixing. |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | N | Casing may damage floor. | N | Casing may damage floor. | N | May penetrate tank floor. | Y | Insufficient motive force. | N | Hammer driven, may penetrate floor. |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. | N | High friction. | Y | Low friction. | Y | Low friction. |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | No technology developed for sample transfers. No containment. | N | Intolerable exposure. | Y | Containment designs for segmented drill rod are developed and demonstrated. |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Containment designs for segmented drill rod are developed and demonstrated. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | No technology developed for sample transfers. No containment. | N | Intolerable exposure. | Y | Containment designs for segmented drill rod are developed and demonstrated. |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | Y | No ignition source. | Y | No ignition source. | Y | No ignition source. | Y | No ignition source. | Y | No ignition source. |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. |
| PASS/FAIL | Fail | Sample mixing and tank damage. | Fail | Tank damage. | Fail | Multiple failures. | Fail | Multiple failures. | Fail | Sample mixing and tank damage. |

## TABLE 3 – CONTINUED
## SOLID SAMPLERS – MANDATORY CRITERIA
## PASS/FAIL JUSTIFICATION

| SAMPLE METHOD / CRITERIA | Hydraulic push mode | | Sludge dart sampler | | Backhoe | | Hand shovel or post hole digger | | Clam shell shovel | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | N | Can't penetrate most hard saltcakes. | N | Not able to provide a "continuous" non-mixed sample. Limited to surface sampling. | N | Cant access tank waste. | N | Can't access waste. | N | Won't sample hard saltcake. |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | N | Can't penetrate most hard salt cakes. | N | Not able to provide a "continuous" non-mixed sample. Limited to surface sampling. | N | Can't access tank waste. | N | Can't access waste. | N | Surface samples only. |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | Sample mixing during segmental sampling. | N | Not able to provide a "continuous" non-mixed sample. Limited to surface sampling. | N | Can't access waste. | N | Sample mixing. | N | Sample mixing. |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | N | Could damage tank floor. | Y | This device can only penetrate the first 3 - 4 inches of saltcake. | N | Could penetrate tank wall, damage roof. | Y | Insufficient motive force. | Y | By design. |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | Y | Low friction. | Y | No heat generation source. | Y | Low friction. | Y | Low friction. | Y | Very low friction. |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | No technology for sample transfers. No containment. | N | No containment. | N | Intolerable exposure. | N | High exposure. No containment. |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Containment designs for segmented drill rod are developed and demonstrated. | N | No technology for sample transfers. No containment. | N | No containment. | N | Intolerable exposure. | N | No containment. |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | Y | No ignition source. | Y | No ignition source. | N | Mechanical spark generation. | Y | No ignition source. | Y | No ignition source. |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | By design requirement. | Y | By design requirements. | Y | By design requirement. | Y | By design requirements. | Y | By design requirements. |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | By design requirement. | Y | By design requirements. | Y | By design requirement. | Y | By design requirements. | Y | By design requirements. |
| PASS/FAIL | Fail | Unable to sample hard saltcake, sample mixing and tank damage. | Fail | Will not sample entire waste depth, sample mixing occurs. | Fail | Can't access tank wastes. | Fail | Multiple failures. | Fail | Multiple failures. |

## TABLE 3 – CONTINUED
## SOLID SAMPLERS – MANDATORY CRITERIA
## PASS/FAIL JUSTIFICATION

| SAMPLE METHOD | Dozer trench | | Water jet cutting | | Laser cutting | | Gas jet cutting, with grit | | Gas jet cutting, without grit | |
|---|---|---|---|---|---|---|---|---|---|---|
| **CRITERIA** | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | N | Can't access tank wastes. | Y | By design requirements. | Y | By design requirement. | Y | By design requirement. | Y | By design requirement. |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | N | Surface samples only. | Y | By design requirements. | N | Not able to access entire waste depth. | Y | By design requirement. | Y | By design requirement. |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | N | Sample mixing. | N | Sample mixing. Secondary waste. | N | Sample mixing. | N | Cross contamination. | N | Cross contamination. |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | N | Potential tank damage. | N | High pressure water could cut tank walls, floor. | N | Could cut tank floor, walls. | N | Could cut tank floor, walls. | N | Could cut tank floor, walls. |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | Y | Low friction. | Y | No friction. | N | Very high temperature. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | N | Intolerable exposure. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | N | Intolerable exposure. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. | Y | By administrative control via operating procedure. |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | N | Mechanical spark generation. | Y | No ignition source. | N | High temperature. | Y | No ignition source. | Y | No ignition source. |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | N | Cross contamination. | N | Cross contamination. |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. | Y | By design requirements. |
| **PASS/FAIL** | Fail | Multiple failures. | Fail | Sample mixing and secondary waste. | Fail | Multiple failures. | Fail | Cross contamination and tank damage. | Fail | Cross contamination and tank damage. |

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## TABLE 3 -- CONTINUED
## SOLID SAMPLERS -- MANDATORY CRITERIA
## PASS/FAIL JUSTIFICATION

| SAMPLE METHOD | Saw cut sampler | | Robotic sampler | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CRITERIA | Y/N | JUSTIFICATION | Y/N | JUSTIFICATION | | | | | | |
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | N | Surface sample only, hard saltcake only. | Y | By design requirement. | | | | | | |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | N | Surface sample only, hard saltcake only. | N | Won't access entire waste depth. | | | | | | |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required. | Y | For hard saltcake. | N | Sample mixing. | | | | | | |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | N | Could cut tank floor, walls. | Y | By administrative control via operating procedure. | | | | | | |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | N | High friction. | Y | By administrative control via operating procedure. | | | | | | |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | N | No containment. | Y | By administrative control via operating procedure. | | | | | | |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | N | No containment. | Y | By administrative control via operating procedure. | | | | | | |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids. | N | Mechanical spark generation. | Y | No ignition source. | | | | | | |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | By design requirements. | Y | By design requirements. | | | | | | |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | By design requirements. | Y | By design requirements. | | | | | | |
| PASS/FAIL | Fail | Multiple failures. | Fail | Won't access entire waste depth and sample mixing. | | | | | | |

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**TABLE 4**
**SAMPLER CONFORMANCE MATRIX**
**LIQUID/SLURRY SAMPLERS**

| SAMPLER TYPE / CRITERIA | Bottle on a string | Modified bottle on a string | Dip sampler | Truck mounted rotary drill with universal sampler | Kemmerer Sampler | West Valley Thorex Sampler |
|---|---|---|---|---|---|---|
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | Y | Y | Y | Y | Y | Y |
| The system shall be able to sample liquids and slurries. | Y | Y | Y | Y | Y | Y |
| The system shall be able to sample sludges, soft saltcake, and hard saltcake and combinations thereof. | N | N | N | Y | N | N |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | Y | Y | Y | Y | Y | Y |
| Core samples must contain a minimum of 4.7 $cm^3$ of waste material per cm of core. | N/A | N/A | N/A | N/A | N/A | N/A |
| Liquid samples must be at least 100 ml in volume. | Y | Y | Y | Y | Y | Y |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required for determination of density, moisture content, shear strength and rate, viscosity, stratification, and crystalline structure. Dilution by supernate or hydrostatic head fluid must not occur. Liquid samples containing suspended solids must be representative. | Y | Y | Y | Y | Y | Y |
| The system shall not alter the chemical properties, including organic and inorganic constituents, radioisotopes, pH, heavy metals, etc. Dilution or dissolution of salts or cross-contamination of samples from the supernate or hydrostatic head fluid must not occur. | N | Y | N | Y | Y | Y |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | Y | Y | Y | Y | Y | Y |
| The system must be highly reliable. It shall recover at least 90% of a full sample 90% of the time. | Y | Y | N | Y | Y | Y |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | N/A | N/A | N/A | N/A | N/A | N/A |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C on any portion that contacts the waste. | N/A | N/A | N/A | N/A | N/A | N/A |
| Samples and associated hardware must fit in existing Hanford hot cell facilities utilizing existing extrusion equipment. (Segments no larger than 48 cm long by 2.5 cm dia.) | Y | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 2.5 cm. | Y | Y | Y | Y | Y | Y |
| Sampler must remain operational after exposure to tank contents for at least three weeks, radiation doses of 2000 R\hr, and corrosive solutions with pH in excess of 12. | Y | Y | Y | Y | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | Y | Y | Y | Y | Y | Y |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Y | Y | Y | Y | Y |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Y | N | Y | Y | Y |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | Y | Y | Y | Y | Y |
| Generation of secondary wastes shall be minimized. | Y | Y | Y | Y | Y | Y |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids or vapors. | Y | Y | Y | Y | Y | Y |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | Y | Y | Y |
| The sampler support system must be reusable, mobile, and maintainable. | Y | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | Y | Y | Y | Y | Y | Y |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | Y | Y | Y | Y | N | N |
| Composite Rating (number of Y's) | 21 | 22 | 19 | 23 | 21 | 21 |
| Pass/Fail -- Critical Criteria (shaded boxes) | Pass | Pass | Fail | Pass | Pass | Pass |

# TABLE 4 CONTINUED
# SAMPLER CONFORMANCE MATRIX
# LIQUID/SLURRY SAMPLERS

| SAMPLER TYPE / CRITERIA | Evacuated sampler | Cryogenic sampler | Peristaltic pump sampler | Air-lift vacuum sampler | Vial on a pulley | Push Mode Sludge Sampler |
|---|---|---|---|---|---|---|
| The system shall be able to obtain required samples through tank-top risers with diameters between 10 and 30 cm. | Y | Y | Y | Y | Y | Y |
| The system shall be able to sample liquids and slurries. | Y | Y | Y | Y | Y | Y |
| The system shall be able to sample sludges, soft saltcake, and hard saltcake and combinations thereof. | N | N | N | N | N | N |
| The system must be able to sample the entire depth of waste material from the top surface to within 8 cm of the bottom. This is about 11 meters of depth maximum. | Y | Y | N | Y | Y | Y |
| Core samples must contain a minimum of 4.7 $cm^3$ of waste material per cm of core. | N/A | N/A | N/A | N/A | N/A | Y |
| Liquid samples must be at least 100 ml in volume. | Y | Y | Y | Y | Y | Y |
| The system shall not alter the physical properties of sampled material. Undisturbed, representative samples are required for determination of density, moisture content, shear strength and rate, viscosity, stratification, and crystalline structure. Dilution by supernate or hydrostatic head fluid must not occur. Liquid samples containing suspended solids must be representative. | Y | Y | Y | Y | Y | N |
| The system shall not alter the chemical properties, including organic and inorganic constituents, radioisotopes, pH, heavy metals, etc. Dilution or dissolution of salts or cross-contamination of samples from the supernate or hydrostatic head fluid must not occur. | Y | N | Y | N | Y | Y |
| The system shall not cause harm to the tank floors or wall. Maintaining tank integrity is of prime importance. | Y | Y | Y | Y | Y | Y |
| The system must be highly reliable. It shall recover at least 90% of a full sample 90% of the time. | Y | N | N | Y | Y | Y |
| Operation of the sample system shall not cause the tank waste material temperature to exceed 180°C. The sampling apparatus temperature shall be less than 150°C. | N/A | N/A | N/A | N/A | N/A | Y |
| Direct temperature monitoring shall be provided if the sampling mechanism has the potential of exceeding 150°C on any portion that contacts the waste. | N/A | N/A | N/A | N/A | N/A | N/A |
| Samples and associated hardware must fit in existing Hanford hot cell facilities utilizing existing extrusion equipment. (Segments no larger than 48 cm long by 2.5 cm dia.) | Y | Y | Y | Y | Y | Y |
| Sampler vertical position must be measurable within 2.5 cm. | Y | N | Y | Y | Y | Y |
| Sampler must remain operational after exposure to tank contents for at least three weeks, radiation doses of 2000 R\hr, and corrosive solutions with pH in excess of 12. | Y | N | Y | Y | Y | Y |
| The system design and operation must consider ALARA. Individual dose shall not exceed 300 mrem\week. | Y | Y | N | Y | Y | Y |
| Exposure of personnel, either on-site or off-site, to hazardous or toxic chemicals shall be prevented. | Y | Y | Y | Y | Y | Y |
| The system shall minimize the spread or release of radioactive or hazardous materials into the environment. At no time should hazards be excessive. | Y | Y | Y | Y | Y | Y |
| The system shall be able to obtain a sample in a reasonable length of time (less than 2 weeks) for a full length sample. | Y | Y | Y | Y | Y | Y |
| Generation of secondary wastes shall be minimized. | Y | Y | Y | Y | Y | Y |
| The system must operate safely in an environment potentially containing explosive gases and flammable liquids or vapors. | Y | Y | Y | Y | Y | Y |
| The system must not react chemically or physically with nitrate, nitrite, caustic or organic compounds. | Y | Y | Y | Y | Y | Y |
| The sampler support system must be reusable, mobile, and maintainable. | Y | Y | Y | Y | Y | Y |
| The system must be capable of taking more than one sample from a given riser. | Y | Y | Y | Y | Y | Y |
| All sampling hardware must be retrievable from the tank after completion of sampling activities. | Y | Y | Y | Y | Y | Y |
| The system must be fabricated or procured, tested, approved for use, and ready for full operation by 4/1/1993. | Y | Y | Y | N | N | Y |
| Composite Rating (number of Y's) | 22 | 18 | 19 | 20 | 21 | 23 |
| Pass/Fail -- Critical Criteria (shaded boxes) | Pass | Pass | Pass | Pass | Pass | Pass |

# TABLE 5 -- CORE SAMPLE RETRIEVAL ALTERNATIVES

| ALTERNATIVES | DESCRIPTION | ADVANTAGES | DISADVANTAGES | VIABILITY | | REFERENCES[1] |
|---|---|---|---|---|---|---|
| | | | | RANK | JUSTIFICATION | |
| Ball Valve Closure Sampler | This system utilizes a modified ball valve at the bottom of the sampler which is closed by a spring driven mechanism upon filling the sampler. Triggering can be either automatically or by actuation with the grappling device. | * Reliably samples liquids and solids.<br>* Positive sample retention.<br>* Well developed and tested. | * Moderately complex mechanism.<br>* Fabrication expensive.<br>* Older design did not reliably shear off hard saltcake core. New design has stronger spring and may resolve problems. | 1 | Best all around, most reliable recovery.<br>Retains liquids. | 5 |
| Spring Finger Core Catcher | This system utilizes a set of spring-loaded fingers at the end of the sampler barrel which can be closed upon filling of the sampler. | * Mechanically simple.<br>* More reliable than collet. | * Won't retain liquids or slurries.<br>* Probably won't cut off hard saltcake. | 2 | More reliable recovery of solids.<br>Does not retain liquids. | 5 |
| Docking Ring Sampler | This system utilizes an elastomer tube at the bottom of the sampler which is closed by a heavy elastomer band (docking ring such as those used in docking sheeps' tails). The docking ring is held by fingers until the sampler is retracted at which time the docking ring slips off of the fingers and pinches the elastomer tube closed. | * Can possibly retain liquids and slurries.<br>* Mechanically simple.<br>* Relatively inexpensive. | * Ring release unreliable.<br>* Can't cut off hard saltcake core, probably wouldn't cut off packed granular material.<br>* Elastomer parts attacked by radiation, reuse limited. | 3 | More positive closure than iris valve. | 5 |
| Iris Valve Sampler | This system utilizes a double walled sampler with an elastomer tube joining the inner and outer wall. As the sampler is retracted, the inner wall is pulled upward inside the outer wall. A spiral slot and pin arrangement causes the inner tube to twist 180°C. This twists the elastomer tube, closing the end of the sampler. | * Can possibly retain liquids or slurries.<br>* Simple, inexpensive. | * Can't cut off hard or packed saltcakes.<br>* Elastomer parts damaged by radiation, reuse limited.<br>* Twist mechanism subject to jamming, therefore closure unreliable. | 4 | Positive sample retention. | 5 |
| Collet core catcher | This system utilizes a sampler with a tapered-down (internal taper) mouth and internal sliding catcher ring which is tapered to match the sampler mouth. As the sampler is withdrawn, the catcher ring slides downward into the tapered mouth, squeezing and retaining the core sample inside the sampler. | * Simpler to fabricate than ball closure.<br>* Less expensive than ball closure. | * Won't sample liquids or slurries.<br>* Sample recovery can be poor.<br>* May not cut off hard saltcake core. | 5 | More positive sample retention than split barrel or shelby.<br>Does not retain liquids. | 5 |
| Shelby tube sampler | This system is similar to the split barrel sampler except that it is a continuous tube. The sample must be extruded for inspection and evaluation. | * Commercially available.<br>* Widely tested.<br>* Inexpensive.<br>* Least expensive of the sample recovery systems. | * Poor retention of some material, won't sample liquids.<br>* Must be driven into media to work, drill rigs not equipped with drive tools.<br>* Must be extruded. | 6 | Does not retain liquids or slurries. | |
| Split barrel core sampler | This system is a standard core sampler for obtaining soils samples. It is normally driven ahead of the drill string at the depth of the desired sample and then retrieved. Sample is retained by friction. Upon retrieval, the end fittings can be unscrewed allowing the barrel to be opened lengthwise for sample evaluation. | * Commercially available.<br>* Widely tested.<br>* Inexpensive.<br>* No extrusion necessary. | * Poor retention of some material, won't sample liquids.<br>* Must be driven into media to work, drill rigs not equipped with drive tools. | 7 | Does not retain liquids, slurries or sludge. | 5 |

1. Listed by number -- See Reference Section

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## TABLE 6 – BIT TEMPERATURE MONITORING ALTERNATIVES

| ALTERNATIVE | DESCRIPTION | ADVANTAGES | DISADVANTAGES | STATUS[1] | VIABILITY CODE[2] | VIABILITY JUSTIFICATION |
|---|---|---|---|---|---|---|
| Thermocouple | In bit, groove in drill string.<br>Thermocouples mounted in drill bit.<br>The outside on the drill string-running to the top. | ▪ No electronics inside the drill string.<br>▪ Minimizes modifications to drill. | ▪ Addition of section, connection.<br>▪ Abrasion material.<br>▪ Tightening drill string moves grooves .31 cm.<br>▪ Epoxies take 24 hr & require refrigeration. | 4 | L | Some work has been done in the 305 Lab. |
| Piezoelectric Crystal, with battery | Battery driven power supply, crystal frequency changes with temperature.<br>Crystal mounted in bit area.<br>Frequency travels through metal drill string. | ▪ Could make use of drill string pipe as a transmitting medium.<br>▪ Minimizes modifications to drill. | ▪ To large power supply.<br>▪ 75 % signal loss over .6 meters.<br>▪ Component miniaturization required.<br>▪ Extension research and development. | 2 | M | Some testing has been done in the 305 Lab. |
| Low temperature material in a sealed bearing | Material melts in bearing at critical temperature, thus allowing drill bit teeth to stop while drill string is rotating. | ▪ Would not have to transmit data.<br>▪ Minimizes modifications to drill. | ▪ Cutting shear forces may exceed shear strength of low temperature materials.<br>▪ Cannot determine when sheared.<br>▪ Require monitoring torque.<br>▪ Extension research and development. | 1 | M | Cutting shear forces most likely will exceed material strength. |
| Radio transmitter in the outside part of drill string | Small transmitter mounted in drill string that would send a radio frequency signal up the outside of the drill string. | ▪ No wires to run up the drill string.<br>▪ Minimizes modifications to drill. | ▪ Large power supply.<br>▪ Small transmitter components.<br>▪ Abrasive of waste. | 2 | M | Some research has been done to find small micro-sized transmitters. |
| Heat transferring material/heat pipe | Material that transfers heat easier to sensor location. | ▪ Moves-temperature sensor away from bit. | ▪ May not be practical for long length of drill string.<br>▪ Rotary sensors on sampler<br>▪ Mode cover heat pipe.<br>▪ Extension research and development. | 2 | M | Reading rotating sensors reduces accuracy. |
| Temperature sensitive paint | Paint changes colors as temperature changes. | ▪ No electronics involved.<br>▪ Minimizes modification to drill. | ▪ No real time information.<br>▪ Must be visible.<br>▪ Must be dry area. | 4 | N/A | No real time information. |
| Infrared | An infrared scanner used to detect bit temperature. | ▪ Could sense large area for hot spots.<br>▪ Minimizes modification to drill. | ▪ Bit in waste not visible.<br>▪ Waste material temperature varies.<br>▪ Additional riser access.<br>▪ Indirect monitoring. | 4 | N/A | Can not sense bit temperature and unobstructed line of sight. |
| Laser and phosphors | Coat bit area with phosphors.<br>Excite phosphors with laser beam traveling through fiber optic cable. Light emissions given off correspond to temperature and would travel back through the cable. | | ▪ Space issue.<br>▪ Connection problem with fiber optics.<br>▪ Drill string bends.<br>▪ Sampler blocks laser from bit.<br>▪ Extensive research and development. | 2 | M | Extensive research and development needs. |
| Flash bulb and photo cell | A flash bulb turns ON or OFF at the critical temperature with a photo cell sensing the light at the top of the drill string. | ▪ Cheap. | ▪ Power supply.<br>▪ Not sure it is on.<br>▪ Drill string bends.<br>▪ Obstructed light path. | 3 | N/A | ▪ Power supply in bottom of bit to large for space.<br>▪ Light path obstructed by sampler. |

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|---|---|---|---|---|---|---|
| | | | | | CODE[2] | JUSTIFICATION |
| Acoustic pulse | Nickel exciter sends acoustic pulse through drill string, reading of reflections off of drill bit tip area will correspond to temperature. | • Makes use of drill string as transmitting media.<br>• Minimizes modification to drill. | • Change in temperature may not be large enough (90°C to 150°C) to cause detectable change in reflection.<br>• Requires calibration system.<br>• Upper reflexion changes with each new section.<br>• Extensive research and development. | 2 | P | Los Alamos plans to study further. |
| Fluid dynamic switch | Frequency whistle changes with temperature. | • No electronics needed.<br>• Minimizes modification to drill. | • Plugs with mud.<br>• Monitoring system for whistle.<br>• Frequency may vary due to gas flows or plugging.<br>• Extensive research and development for component modification. | 2 | M | Los Alamos plans to study further. |
| Curry point temperature switch | Switch activated by temperature. Possibly combined with whistle. | | • Extensive research and development. | 2 | M | Los Alamos plans to study further. |
| Tag gases, Krypton-85 | Emissions activated by temperature. Detection of emissions indicates temperature limit is reached. | | • Delays of gas to ventilation detection system.<br>• Low detection limits.<br>• Extensive research and development. | 4 | P | Delay in detection of over temperature problems. |
| Grapple wire sampler telemetry via slip ring quadralatch | Electronics package mounted in sampler tube with slip rings in quadralatch section to transmit signal from rotating drill string to electronics package. | • Hard wire method to get data to top of drill string from electronics package. | • Exposed slip ring connection, connecting to drill string.<br>• Modifications to sampler tube and grapple box rod cable.<br>• Major modification to drilling side of core sample truck. | 2 | P | Sandia Labs studying concept. |
| Grapple wire inductively coupled Resistance Temperature Detector | Resistance Temperature Detector mounted in bit. Signal and power transmitted from electronics package above. Sampler to rotating drill string via electromagnetic coupling. | • No slip rings exposed. | • Design time concerns.<br>• Power supply to bit.<br>• Frequency modulating electronic bit.<br>• Major modification to drilling side of core sample truck. | 2 | L | Sandia Labs studying concept. |
| Grapple wire above grapple latch telemetry | Electronics package mounted above sample tube and grapple attachment. Signals transmitted from drill string to package via slip rings. | • No modification to sample tube required. | • Exposed slip ring connection.<br>• Modification to grapple box and cable.<br>• Major modification to drilling side of core sample truck. | 2 | L | Sandia Labs studying concept. |
| Grapple, wire, sampler, heat tube | Electronics package above sample tube and grappler. Heat pipe runs from drill string section near package down to bit tip. | • No sensors needed in bit section. | • Tube size > .3 cm steel drill wall.<br>• Transfer from bit limited in area.<br>• Major modification to drilling side of core sample truck. | 1 | M | Problem of transferring heat pipe temperature to rotating sensors. |

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|---|---|---|---|---|---|---|
| | | | | | CODE[2] | JUSTIFICATION |
| Fiber optics transmission or signal | Fiber optic cable runs in groove along outside of drill string to carry data. | | ▪ Sensing package large.<br>▪ Connectors are large.<br>▪ Quartz fiber darkens in radio active environment.<br>▪ Major modification to drilling side of core sample truck.<br>▪ Extensive research and development. | 4 | M | Electronic connections for optic cable are too large.<br>Sensing package large. |
| Bimetallic diaphragm | Temperature activation of the diaphragm could be used to close off-gas passages (causing backpressure which could be monitored) or could activate a piezoelectric crystal. | | ▪ Size of diaphragm.<br>▪ Developing a surface indication. | 1 | M | Diaphragms too large for area in bit. |
| Piezoelectric power – piezoelectric transmitter | Vibration of the drill string would be used as a power source. Piezoelectric crystal would sense temperature. A transmitter would shift frequency to be sent up drill string. | ▪ Minimum modification to drill string.<br>▪ Use drill string as transmitting media.<br>▪ No power problem. | ▪ Signal losses during operation may be too large.<br>▪ Large development effort.<br>▪ Extensive research and development. | 2 | P | Los Alamos to study concept. |
| Wax or metal plug | A plug would melt at the critical temperature leaving an opening in the drill string thus causing a pressure decrease. | ▪ No electronics needed. | ▪ Loss of cooling air to bit.<br>▪ Can not be reset.<br>▪ Reading change on the surface. | 4 | P | Can be developed but would cause loss of cooling gas to bit. |
| Radio transmitter inside drill string | Signal would be sent to the top of the drill string with radio frequency. | ▪ No wires to run up drill string. | ▪ Large power supply in bit.<br>▪ Grapple wire will ground signal. | 3 | M | Require a large power supply in drill string. |
| Microwave/tag sensor | Use microwaves to sense temperature and send signal up to the top. | ▪ Minimum electronics down hole in drill string. | ▪ Wave guide 4.7 cm so frequency of 20 GHz required.<br>▪ Requires new microwave system.<br>▪ Few tags & accept local data.<br>▪ Extension research and development. | 1 | M | Microwave technology would need to be developed to improve the current 2 GHZ ability to 20 GHZ. |
| Drill string/grapple wiring | Use the drill string as the ground lead and isolate and use the grapple line as the positive lead. | ▪ Uses existing sources as transmitting media. | ▪ Grounding problem, must isolate grapple cable.<br>▪ Must have slip ring connection. | 1 | P | Sandia to study concept. |
| Drill string/waste leads | Drill string used as a lead and waste material used as a second lead. | ▪ Use existing sources as transmitting media. | ▪ Varying electric resistivity.<br>▪ Can not contact waste.<br>▪ Drill string contacts waste. | 4 | M | Difficult to electronically couple with waste.<br>Short-circuiting between drill string wall and waste probable. |
| Material destructing bit | Bit material self-destructs at critical temperature. | ▪ No electronics needed. | ▪ Stops cutting, starts grinding building heat.<br>▪ Replace bit. | 2 | M | Still generates heat through possibly at lower rate. |
| Tapping | Mechanical tapping at critical temperature on drill string. | ▪ Uses drill string as transmitting media. | ▪ Not real time.<br>▪ Large power supply. | 4 | N/A | No real time monitoring. |
| Mud stream telemetry | Send signal up waste material in drill string. | | ▪ Can not access waste flow.<br>▪ Mud would contaminate tank and sample. | 4 | N/A | Sample contamination unacceptable.<br>Media not used. |

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# TABLE 6 – BIT TEMPERATURE MONITORING ALTERNATIVES

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|---|---|---|---|---|---|---|
| | | | | | CODE[2] | JUSTIFICATION |
| Establish Safety Envelope | ▪ Testing.<br>▪ Thermal calculations.<br>▪ Statistical analysis of stimulant. | ▪ No temperature monitoring needed. | ▪ Not direct monitoring. | 2 | P | WHC proceeding with concept. |
| Radio frequency through metal drill string | Vibration of drill string to be read at wiper seal at the top of the drill string. | ▪ Uses drill string as transmitting media. | ▪ Power supply needed at bit.<br>▪ Major modification to drilling side of core sample truck. | 1 | M | Power supply needs too large for available space. |
| Parallel probe | Hole cut beside drill string, probe inserted to monitor bit temperature. | ▪ No modifications to drilling equipment. | ▪ Difficult to get probe through hard waste down to bit tip. | 4 | M | Difficult to assure position of temperature probe. |

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