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HAZARDS IDENTIFICATION AND EVALUATION FOR WASTE TANK CORE-SAMPLING EQUIPMENT

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1.0 INTRODUCTION

New equipment and techniques are being developed to extract samples from underground waste storage tanks. This Hazards Identification and Evaluation (HI&E) examines potential hazards associated with these operations. Transportation to, receipt of, and handling in the laboratory are addressed in the Core Sample Transfer Cask Safety Analysis Report for Packaging and the 222-S Laboratory Safety Analysis Report.[1,2]

Core samples of waste from storage tanks will be extracted to support the Waste Tank Characterization Program. This program will provide: (1) physical, chemical, and radionuclide data required to plan waste management operations and final disposition, (2) input for risk assessments and engineering analysis for final disposal, (3) validation of the TRAC (Track Radioactive Components) computer model (Ref. 3), and (4) validation of previously accumulated data. The 20-in.-long (currently 19 inches) core segments will be taken to the laboratory where each core volume will be independently characterized for radionuclide activity, chemical constituents, and physical measurements. The sample volume and the method for obtaining and transporting the samples will essentially duplicate those used in the core sampling program terminated in August 1980.

Design modifications in the sampling equipment have improved the sampling methods and produced the following benefits.

- The potential for radiological exposure to personnel has been decreased by enabling the work to be accomplished more efficiently.

- The need for a separate crane has been eliminated by mounting the drill rig, shielded receiver, and hand-operated crane on the rotary platform of the truck.

- The new sampling apparatus has been designed to perform the following functions:

  - Sample to within 3/8-in. of the tank bottom, with three redundant features to prevent drilling into the tank (described in Chapter 3.0)

  - Take one 20-in.-long core sample an hour and retain greater than 70% of each sample taken (rather than the previous 0% to 70%)

  - Allow operation with a smaller crew while reducing the potential for radiation exposure to individuals.

The waste storage tanks to be sampled are located in the tank farms in both the 200 East and 200 West Areas of the Hanford Site. The TY Tank Farm, to be sampled first, consists of six tanks in the Northwest quadrant of the 200 West Area.

The Waste Tank Characterization program will be implemented by the Applied Technology and Strategic Planning Section of the Rockwell Hanford Operations (Rockwell) Waste Management Program. The core-sampling equipment has been designed and a prototype has been fabricated and tested by Rockwell. Reliability testing of the core sampling equipment was performed at Westinghouse Hanford Company. Rockwell's Tank Farm Surveillance and Operations (TFS&O) Department will perform the core sampling operations.

The preparation of sampling equipment, operator training and certification program is completed. Sampling of the TY Tank Farm is scheduled to be completed first, and further sampling in other farms will continue until essentially all farms are characterized.

This HI&E was prepared to identify circumstances under which the core sampling operations could compromise the safety of the public and the occupational workers, notably by exposure to or release of radionuclides in the samplers being removed from the tanks. It addresses those operations performed at the tank to be sampled, from the first operational sequence step, when the vehicle has been positioned and the riser uncapped, to when the drill string has been withdrawn and the samples are loaded into the transport cask and taken from the Tank Farms. This HI&E follows the format and content suggested in RHO-HS-MA-1, Safety Analysis and Report Preparation Guide[4], and fulfills the requirements in DOE-RL Order 5480.5.[5]

2.0 SUMMARY

Tank Core Sampling Equipment for waste tank characterization has been designed, constructed, tested and proved operable. Experienced personnel from Process Engineering, Tank Farm Surveillance and Operations, and the Safety Integration Department have identified and evaluated the hazards associated with operating the equipment. Testing of a prototype of the core sampler is complete. Plant Operating Procedures have been prepared and approved which incorporate guidelines to mitigate against the identified hazards. Applicable Rockwell and DOE safety guidelines have been satisfied. Operability testing of the newly fabricated equipment is complete.

No credible accidents are identified from which the calculated consequences to a maximum individual (onsite or offsite) exceed the total dose equivalent of that for the low-hazard-level category.

Risks and mitigating barriers are acceptable and adequate. Special training and qualification of operating personnel is completed.

3.0 FACILITY AND PROCESS DESCRIPTION

There are now 149 single-shell and 20 double-shell underground storage tanks used to store radioactive wastes in the 200 West and 200 East Areas of the Hanford Site (Fig. 1). The location of these tank farms within the 200 Areas is shown on Figure 2. Initial hot sampling will be conducted at the TY Tank Farm in the 200 West Area.

Most of the material stored in these tanks is the result of three processes used for the recovery of plutonium from irradiated fuels: (1) the bismuth phosphate ($BIPO_4$) process, (2) the REDOX process and (3) the Plutonium-Uranium Extraction (PUREX) process. In addition, uranium metal from the bismuth phospate process was recovered using a tributyl phosphate (TBP) process. Various processes have been used to settle, evaporate, neutralize and otherwise condition these wastes before storage.

The underground storage tanks to be sampled are 20 to 75 ft in diameter with nominal capacities of 55,000, 530,000 and 1,000,000 gal. The sides and bottom of the single-shell tanks to be sampled are constructed of mild (under specification ASME A283 Grade C, except for AX farm tanks) steel, completely encased by a concrete shell (Fig. 3). The material was batch purchased from single-source fabricators (QA Level II). The dome-shaped concrete tops of the tanks are covered by 6 to 8 ft of overburden. Risers (4-, 6-, 8-, or 12-in.-diameter vertical pipe sections) extend from the tank top through the overburden and normally end 12 in. aboveground. The risers are fastened into the dome by bars extending radially from the penetration. The risers provide a pathway through which material samples are collected.

To prepare for sampling a tank,[6] the rotary bed vehicle (with the drill, shielded receiver, and hand-operated crane mounted on the rotary platform) is carefully positioned near the storage tank riser (Fig. 4). Jacks are set in place to prevent the truck from moving. In addition to the rotary truck, an electrical service trailer and a sample cask transport truck will also be provided. A portable exhaust and filter system will be used when no other active tank ventilation control is available. This exhaust system is required during the installation and removal of equipment from the tank (through the riser). After the equipment is installed, the wiper provides the seal between the tank atmosphere and the environs (Fig. 5).

An adapter, drill string washer, and clamping mechanism are fitted onto the riser (Fig. 5). The drill is lowered into a riser and then drills down through the stored material in 20-in. increments. The core drilling rig (a modified Model 34 Longyear) is fitted with a grapple mechanism and cable assembly (Fig. 6). With this mechanism, the grapple can be lowered within the drill string and latched onto a pull rod on the sampler* before drilling

*For each increment a sample vessel is lowered inside the drill string and locked at the bottom of the drill string before drilling. As the drill moves downward, material moves into the sampler and then the sampler is closed and withdrawn.

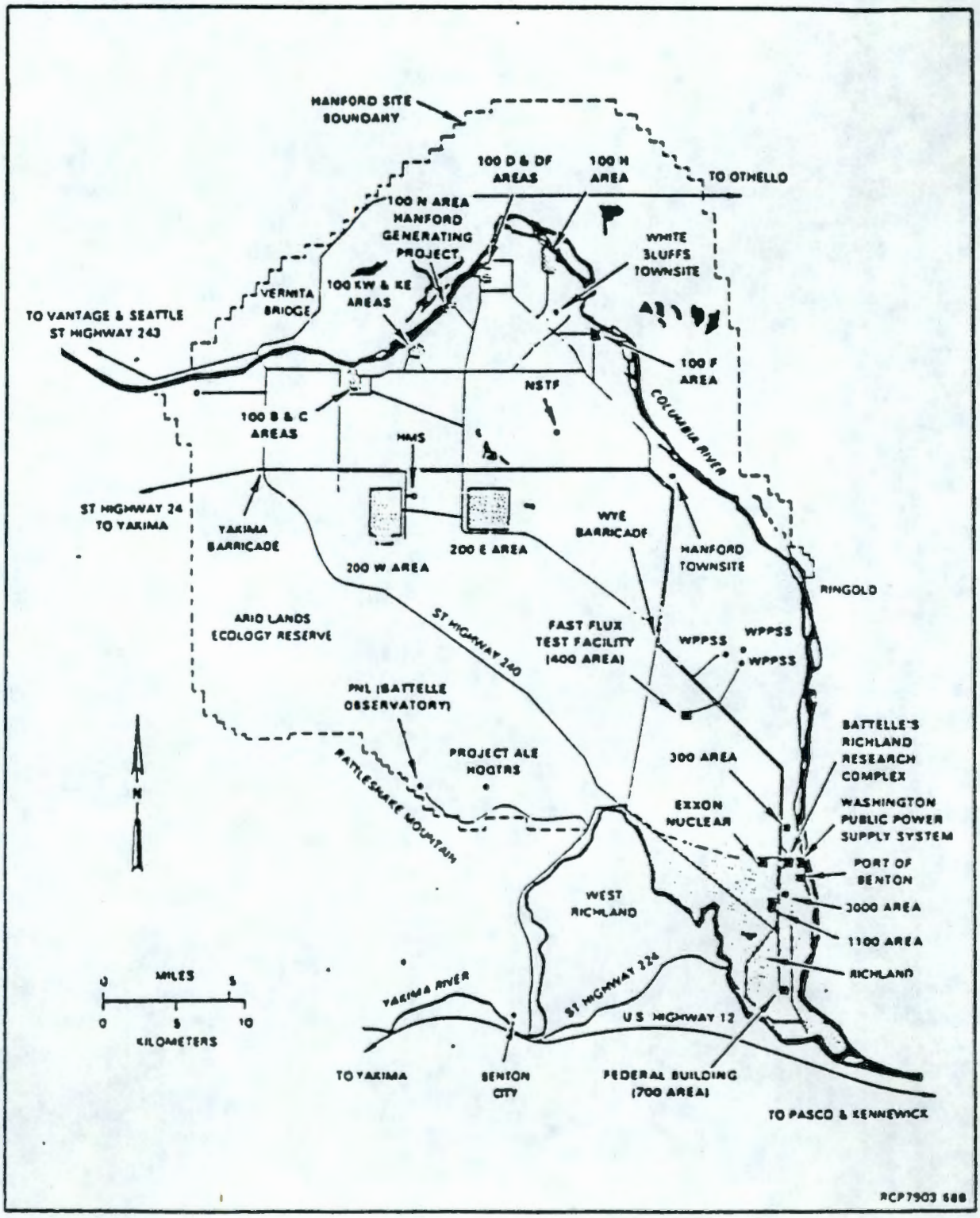


FIGURE 1. Hanford Site.

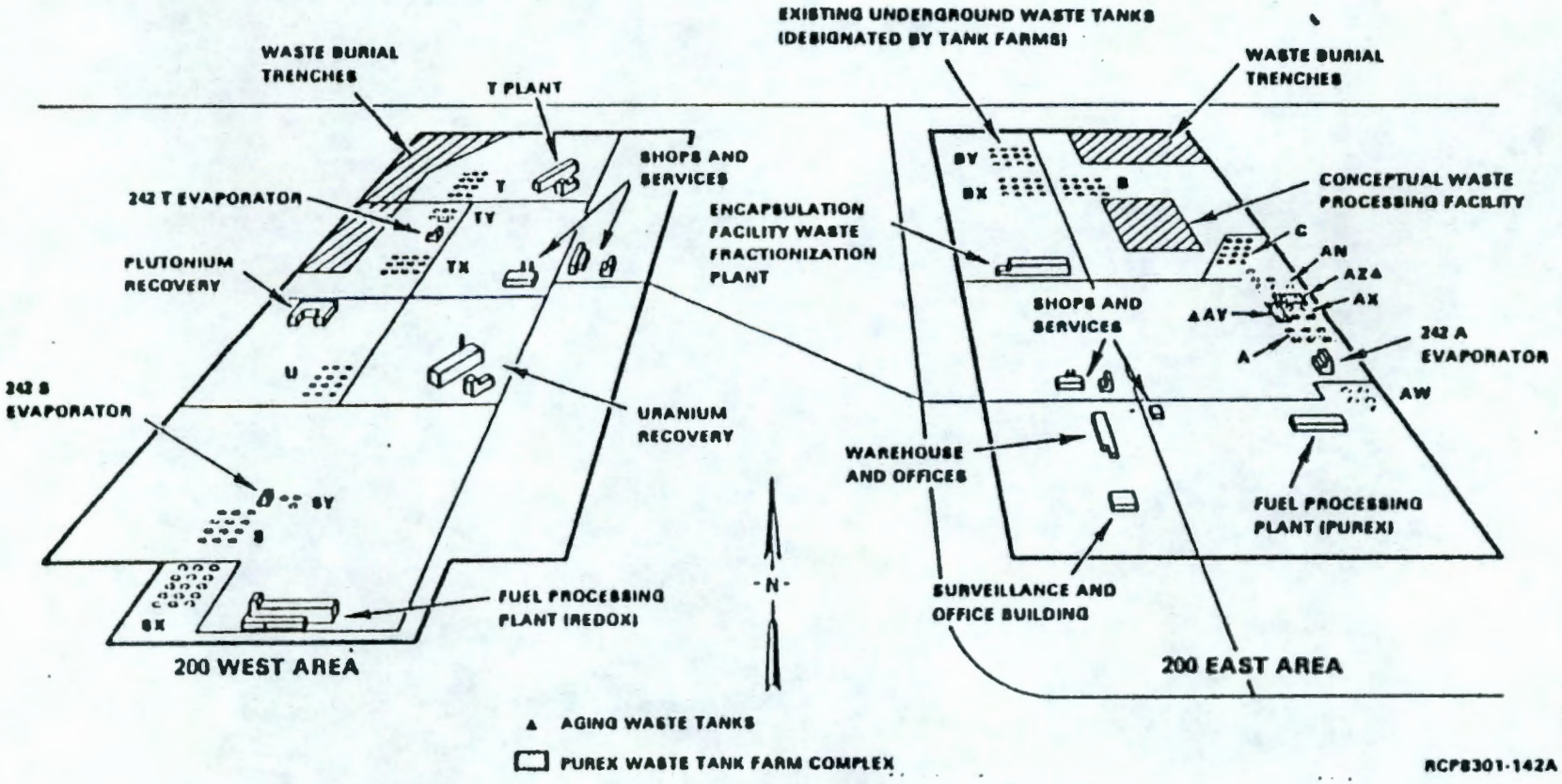


FIGURE 2. 200 Areas Processing and Waste Management Facilities.

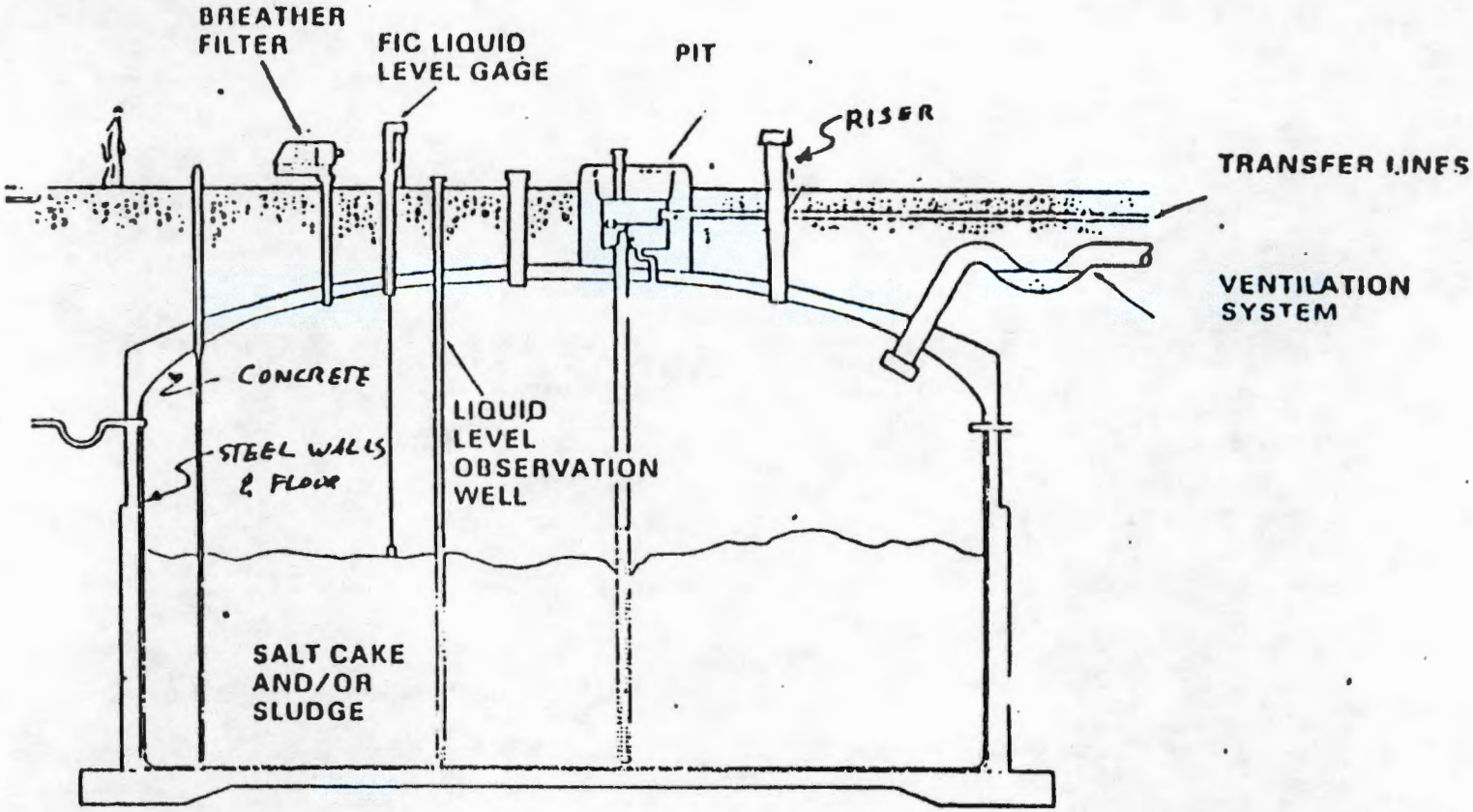


FIGURE 3. Underground Storage Tanks.

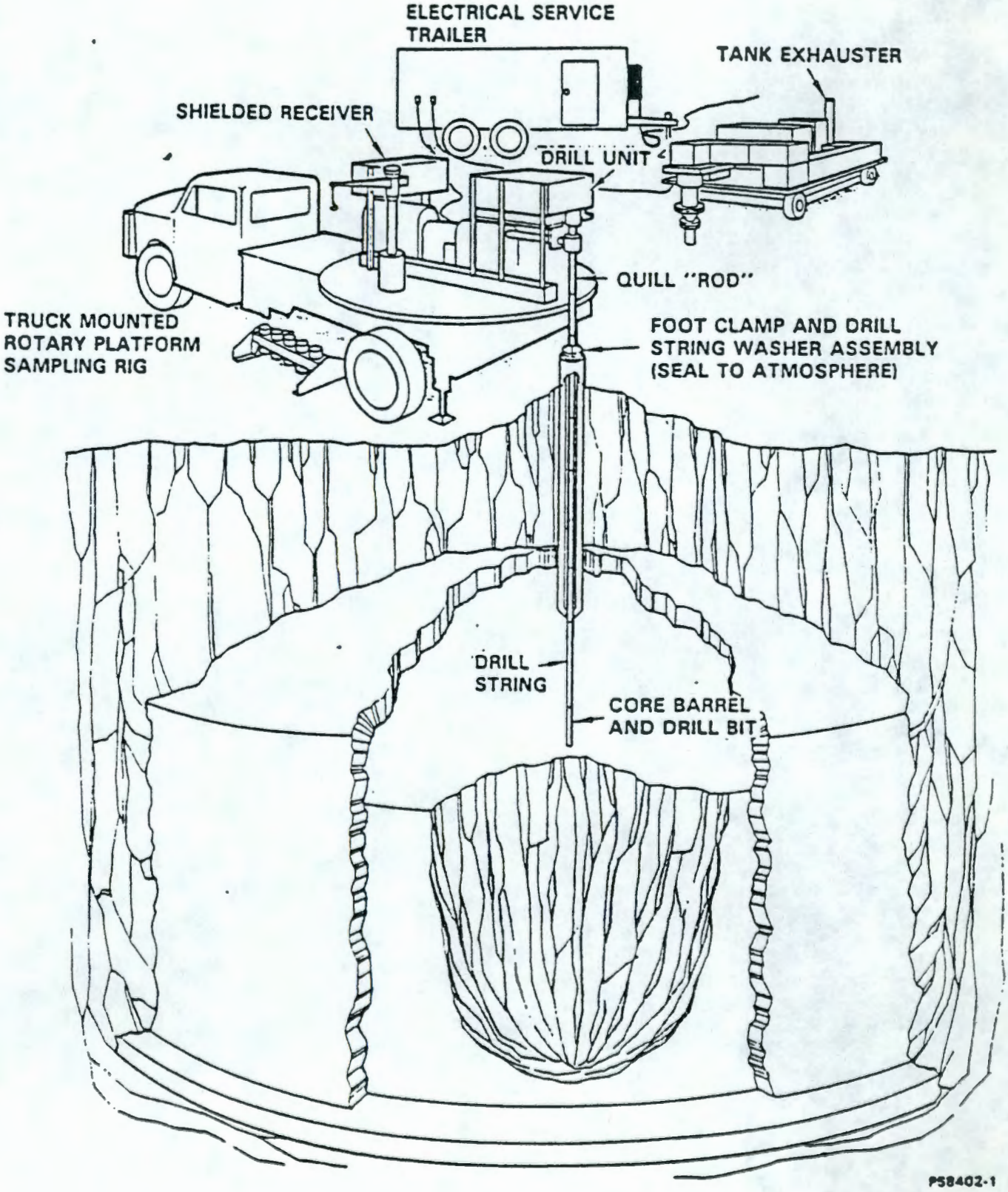


FIGURE 4. Core Drilling Operation.

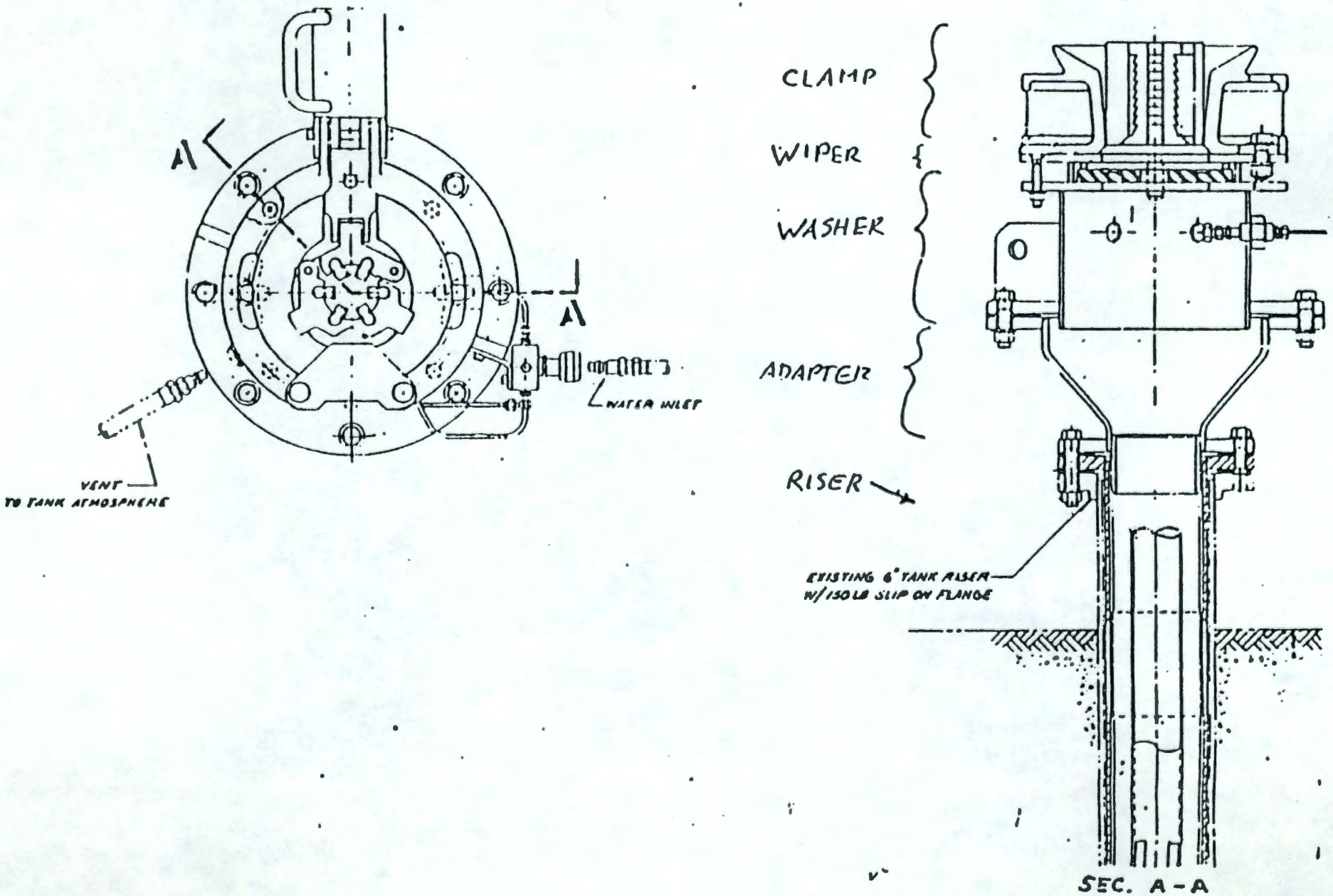
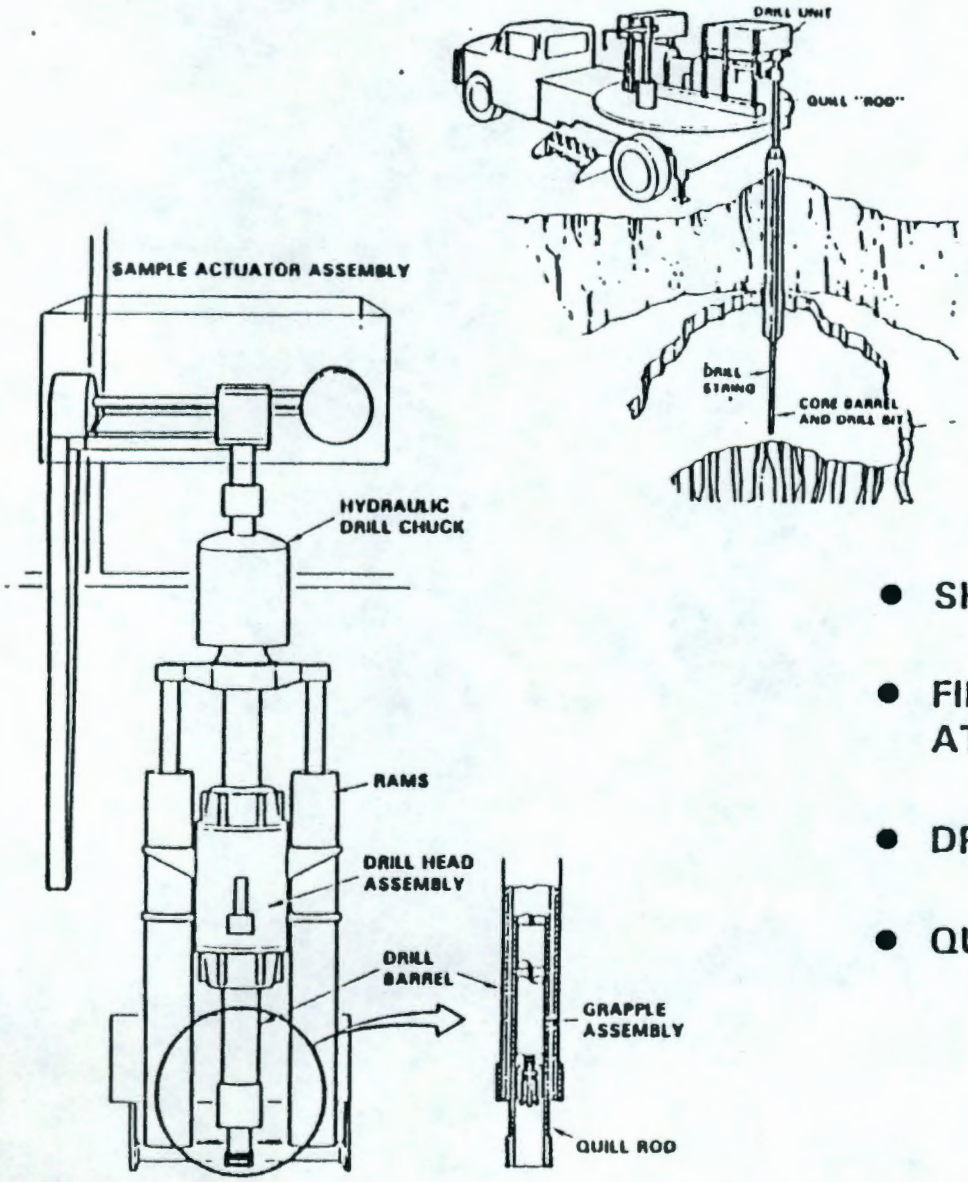


FIGURE 5. Adapter, Drill String Washer, and Clamping Mechanism.



- SHIELDED RECEIVER UNCOUPLED
- FIRST 20-in. SECTION OF DRILL STRING ATTACHED
- DRILL UNIT POSITIONED
- QUILL ROD ATTACHED

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FIGURE 6. Grapple Mechanism and Cable Assembly.

begins. During the drilling operation, the grapple holds the pull rod stationary. A piston on the bottom of the pull rod forms an upper seal for the sample as the sampler is worked down into the tank medium. When the sampler is full the grapple is raised to close the valve on the sampler and break the pull rod connection (Fig. 7).

The drill string is provided with a variable rotational speed drive. The maximum speed is not expected to exceed 500 rpm. An air compressor mounted on the truck supplies forced air (1 to 5 cfm) through the drill string to prevent the drilling bit from plugging. The portable exhaust system will maintain a negative pressure in the tank during the drilling operation.

The shielded receiver consists of a remote latching mechanism and cable/hoist system that lowers and retrieves a sample vessel (sampler) from the bottom of the drill string. A shielded enclosure is provided for the retrieved sample while it is being transferred to its shipping cask (Fig. 8). A ball valve is located on the bottom of the receiver to close off the receiver during the transfer to the shipping cask.

To obtain a sample, an empty clean sampler is drawn from the transport cask up into the shielded receiver. The truck platform is rotated until the shielded receiver is positioned and locked onto the drill string, then the sampler is lowered and latched into place at the bottom of the drill string. The rotary truck platform then positions the drill above the drill string and a 20-in. section is added to the drill string. With the open sampler locked at the bottom and grapple attached, the drill string is drilled down 20 in., the sampler closed off, and the grapple retracted. The truck bed is then rotated until the shielded receiver is again positioned over the riser and the remote latch is lowered down the drill string to retrieve the sampler back up into the shielded receiver. A kamloc adapter plug is used to isolate the tank atmosphere inside of the drill string while the drill rig is being rotated.

The drill string spray washer/wiper assembly is used to decontaminate the drill string as it is withdrawn from the tank after all sampling is completed (see Fig. 4 and 5). The washer is supplied with high pressure water from a 55 gallon drum. The amount of water that is added to any one single shell tank from the washer operation will be monitored and recorded. The amount of water to be added is expected to be less than 100 gallon per core sample. The total water added to any one tank will not exceed 500 gallon without prior permission from the managers of Tank Farm and Evaporator Process Engineering (TF&EPE) and Tank Farm Surveillance and Operation (TFS&O).

The ball valve on the shielded receiver allows it to be sealed off before it is disconnected from the drill string. A drip cup is also fitted under the ball valve to catch any drips from the valve. A cask rack is positioned alongside the truck bed; when the truck bed is rotated the shipping casks can be easily attached to the shielded receiver for transfer of the sampler through the ball valve and into the shipping cask (see Fig. 8).

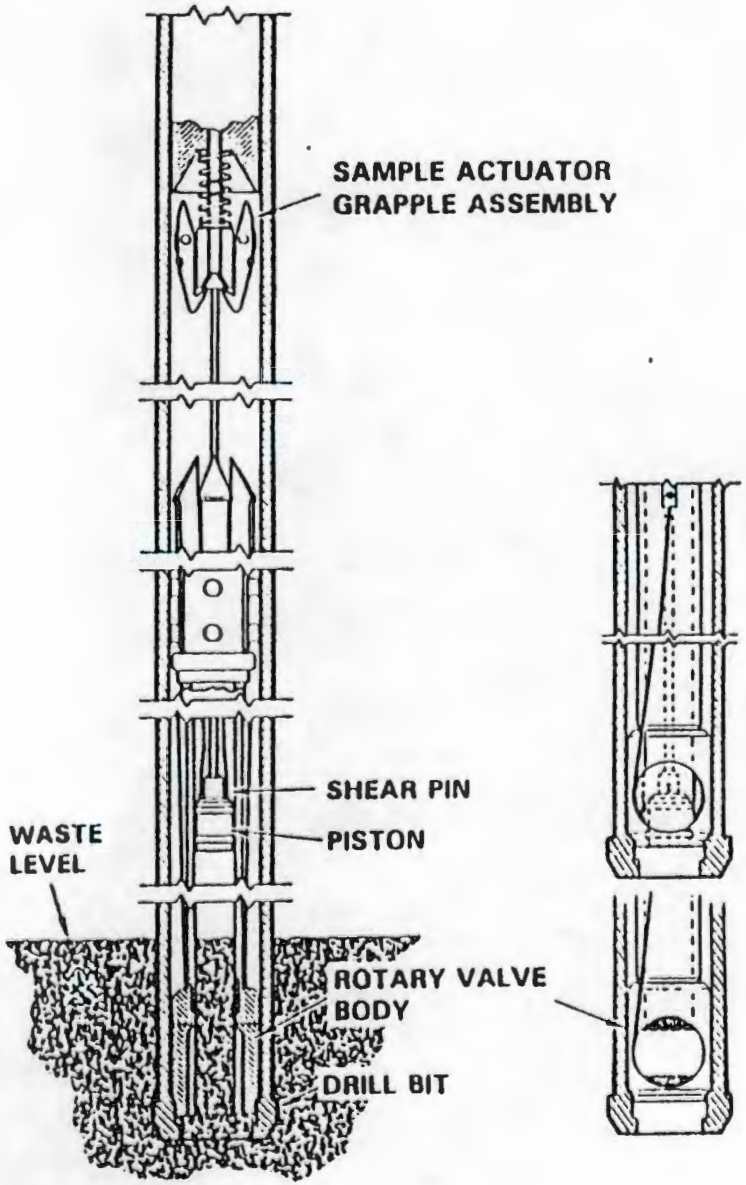
Three redundant features have been incorporated into the design of the new sampling apparatus to prevent drilling into the tank bottom:

- The drill is fitted with a hydraulic tank bottom detector to interrupt downward travel if resistance above that due to sampling occurs (Fig. 9).
- A special steel drill bit will prevent drilling into the tank bottom (no diamonds)
- Strict administrative and QA controls on the selection of the drill bit; calculation and selection of the drill string lengths are in effect.(6)

The rotary valve mechanism on the bottom of the samplers will provide a means of retaining virtually 100% of the collected sample (see Fig. 7). This feature, in addition to the capability of sampling near the tank bottom, will provide a vertical profile of the contents of the tank.

After the 1st sample is obtained, a measurement of the hydrostatic head at the drill bit for each successive sample is obtained. This measurement allows activation of a hydrostatic head liquid level addition system. A calculated quantity of fluid (equal to the measured head) is drained into the drill string prior to sample recovery to prevent the waste from rising up into the drill string. The hydrostatic medium is chosen so that it is less dense than that of the waste which prevents small waste particles from rising up the tube. Currently the hydrostatic media consists of freon and normal paraffin hydrocarbon (NPH) with density of 1.6 and 0.8 gm/cm^3 respectively. The hydrostatic liquids are expelled from the drill string into the waste by the air purge system prior to initiation of drilling. The air purge is used to keep the drill bit clean during the drilling operation. The volume of liquid NPH or freon which is added vaporizes and is exhausted through the ventilation system. A maximum quantity of 10 gallons is expected to be added to Tank 101A which has a waste level of about 364 inches.

A radiation detector is installed adjacent to the drill string above the riser which is used to detect the arrival of the sampler out of the tank. If the radiation level rises when the grapple and pintle are raised (prior to rotation to the shielded receiver) the grapple is lowered back into the tank and the TFS&O manager is notified.



- DRILL STRING DRIVEN (EITHER PUSHED OR ROTATED)
- AT 20 INCHES, ROTARY VALVE ROTATES TO CLOSED POSITION
- GRAPPLE CONTINUES TO RAISE PULL ROD - SHEAR PIN SHEARS AT 40-lb FORCE
- SAMPLE IS NOW ENCLOSED AND REMAINS LOCKED AT BOTTOM OF DRILL STRING IN CORE BARREL

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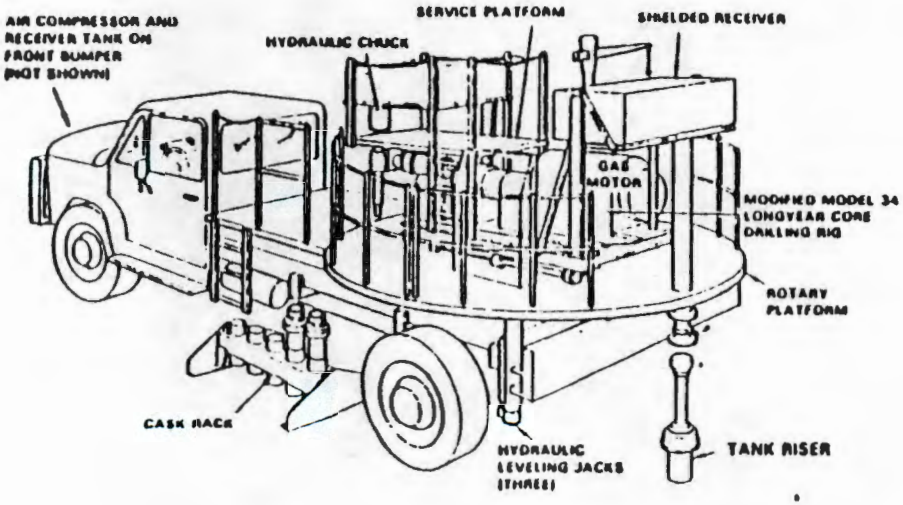
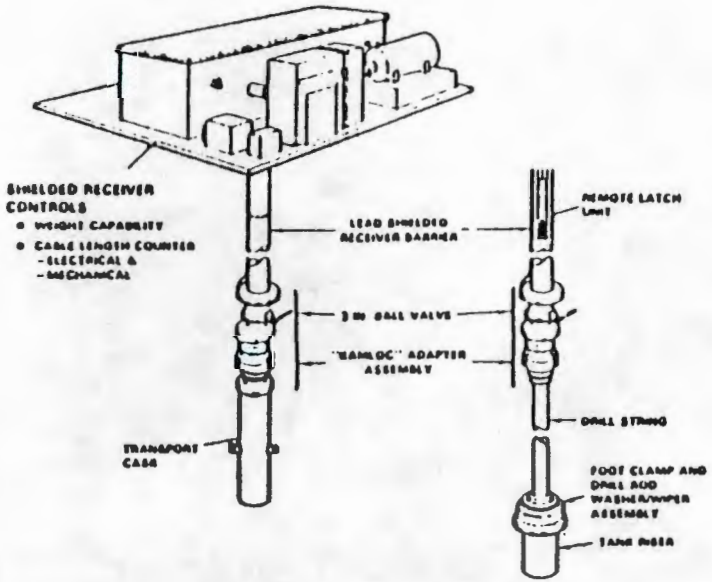
FIGURE 7. Sampling Mechanism.





- CLEAN SAMPLER TRANSFERRED FROM CASK RACK
- LOADED INTO SHIELDED RECEIVER,
- ROTATED TO DRILL STRING

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FIGURE 8. Shielded Receiver and Rotating Truck Platform.

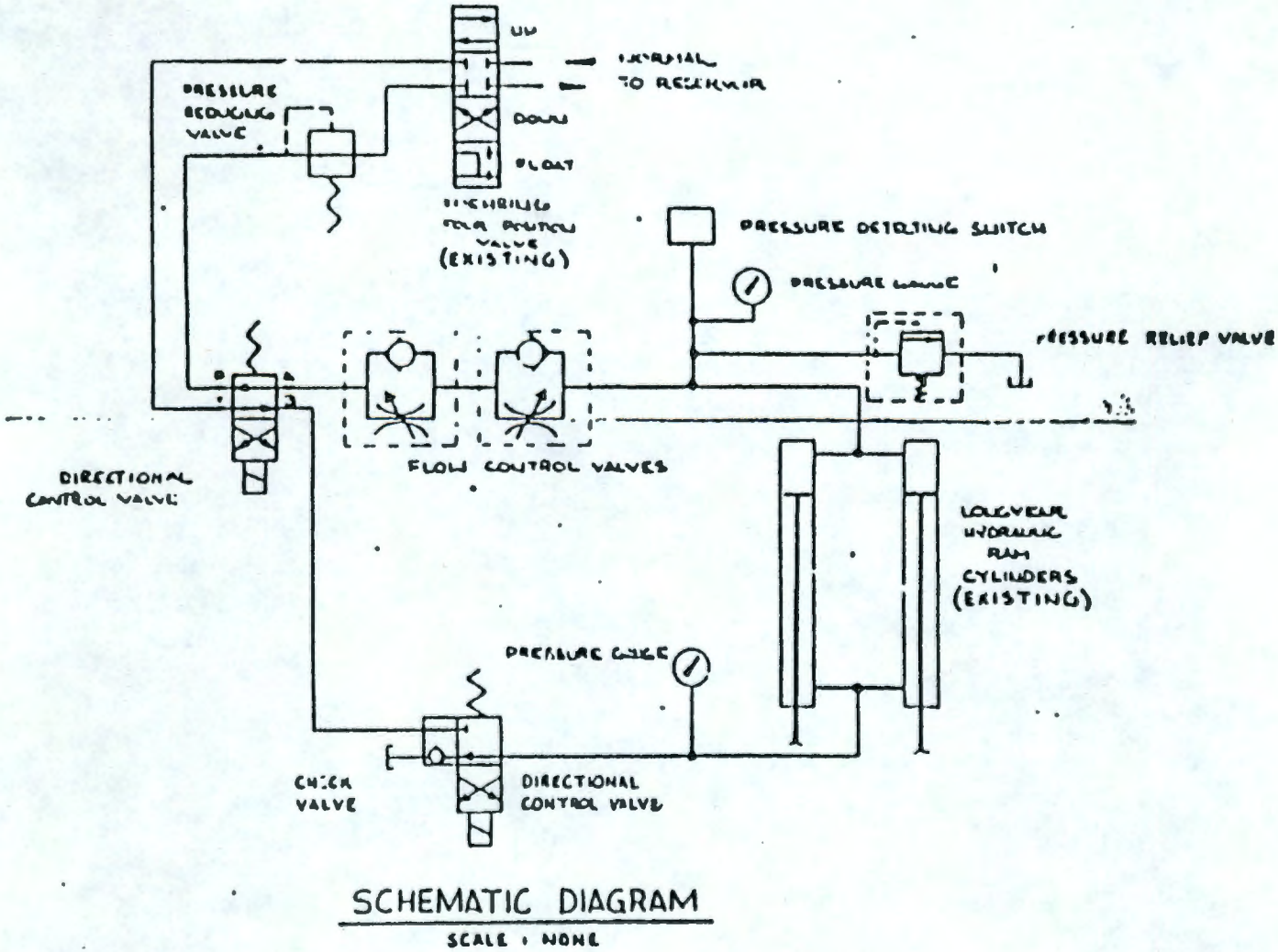

FIGURE 9. Hydraulic Tank Bottom Detector.

4.0 PRINCIPAL CRITERIA

Functional criteria and requirements for the underground storage tank sampling equipment are defined in three documents: RHO-CD-1412(7), for the sampler positive closure and actuator; RHO-CD-1274(8), for the shielded receiver; and RHO-CD-1141(9), for the rotary bed truck and equipment installation. An addendum to RHO-CD-1412 modified the pressure requirements for the actuator box and the shielded receiver.

4.1 MOBILE UNIT

The mobile unit design criteria defines the truck and drill rig requirements, and the size and weight constraints to make the unit compatible with the tank farm live load specifications. There is a requirement that the bed can be rotated without impacting adjacent risers, which could possibly damage the riser and allow an unplanned release of contaminated vapors.

Other requirements specify that the height and shape of the rotating platform shall permit the platform to rotate without striking equipment that has to be placed within reach of the shielded receiver. Such items include a sample cask stand fully loaded with five casks. One or more casks shall have an adapter and plug attached to its top, for mating with the shielded receiver. The overall height of the cask, adapter, and plug combination mounted in the sample cask stand shall be administratively controlled and determined by referring to the drawings in Reference 8, Page 3.

Rotating platforms could also cause personnel injury if a person were caught between a moving and a stationary object. The maximum speed of rotation is one revolution per minute, which would represent a linear speed of several inches per second for a 6-ft radius. Special attention shall be given to preventing personnel from being injured by the rotating platform. To the extent practical, pinch points that could trap personnel between rotating and nonrotating parts shall be minimized, covered, or shielded by a guardrail to prevent personnel from passing in such areas. Also, an audible signal shall sound on the vehicle whenever the rotating platform is in coarse motion and a 3-sec time delay shall occur before motion begins. Similar considerations shall apply to all other powered movements of equipment on the unit to warn and protect inattentive personnel.(9)

The truck design calls for a stationary platform adjacent to the rotary platform, with permanant ladders for access to the stationary platform. Guardrails are required on both platforms, with an access stile provided on each side of the drilling rig. Nonslip and uniform level walking surfaces are also required.

The location of individual controls shall be such that they can be clearly seen and easily reached by the operator. The coarse positioning control for the platform is accessible from the platform; others are segregated to avoid control errors. Controls for the hydraulic jacking and leveling system can be operated from the ground.

A special interlock is required to prevent coarse platform rotation until the drill rig and shielded receiver positions are horizontally centered on the rotating platform and vertically clear of the fixed platform. Other interlocks are provided to minimize operator error.

4.2 WASTE SAMPLER

The functional requirements for the waste sampler positive closure and sampler actuator system describe the physical characteristics of the system. Physical requirements and constraints on the physical dimensions are given to ensure compatibility with the other equipment.

Specific requirements are given for the core sampler envelope and the positive closure envelope. In general these physical requirements relate directly to the integrity of the closure for primary confinement which would limit the available material released into the secondary containment.

The waste sampler's positive closure provides primary containment and any loss of sample because of a malfunction of the gate would impact the amount of material available to leak from the secondary containment. The rotary valve is the barrier that provides the closure for the Core Sampler. It shall provide a positive, assured closure restricting solid particles and liquid from escaping the Core Sampler through or around it when closed. The closure shall ensure that no more than 1% of the total liquid volume initially contained within the Core Sampler shall leak out by way of the closure due to the gravitational body force for a minimum of 14 days after retrieving the sampler from the tank.(7)

Reliability and life cycles of the positive closure, the actuating system, and two alternative core samplers are given; the disposable sampler has a required life cycle of only one use, and the reuseable sampler five uses. The reusable positive closure also has a life cycle requirement for five uses. The actuating system has a life cycle of 845 cycles.(7)

4.3 SHIELDED RECEIVER

The Hanford Site shielded receiver is a modification of earlier prototype models with mechanical requirements and dimensional constraints to ensure that the unit will be compatible with other equipment components.

The requirements for raising and lowering the sampler include a minimum speed of 15 ft/min and a maximum speed of 30 ft/min. From the maximum speed the unit must stop in 0.17 sec, which is no greater than 1.0 in. The drum is to automatically stop when 0.5 in. or less slack is played off on the cable drum at zero cable tension. Other lifting requirements specify acceleration, drum and pulley dimensions, cable binding preventions and top end travel limit. This latter requirement is for an electrical shut-off to stop the sampler travel before the latch is drawn into the winch enclosure.

A cable wiper is required to wipe loose particles off the cable before it moves into the winch housing. The wiper is easily replaceable and may be cleaned for reuse.

A control console is to be provided to operate the winch, sample latch unit, and to house the cable tension transducer readout and latcher mode indicator. The requirements specified that the "reliability of functioning ... of the highest of all the other components," is for the cable length counter, requiring a repeatability for the counter length display with no more than 1/16-in. error. A force transducer for the support cable is required with a range of 0-100 lb., and with a readout resolution to 0.1 lb.

An equivalent of 2.5 cm of lead is required for the shielded receiver. The cable drum assembly enclosure must also provide shielding to restrict the exposure rate to the operators.

5.0 HAZARDS IDENTIFICATION AND ANALYSIS

The process of extracting samples of the material in the underground waste storage tanks has been performed successfully in the past. However, the equipment used was much slower, less efficient in recovering the samples, and provided more opportunities for release of materials to the environment than the system being considered here. Under certain circumstances, a greenhouse assembly was erected as a secondary confinement barrier.

The equipment examined in this study represents a second-generation design and as such has eliminated some of the situations where sample materials could escape confinement. The frequency of accidents and the quantities of material that could be lost in retrieving and packaging the samples are such that the risks are acceptable.

If the underground storage tanks are penetrated, loss of drainable interstitial liquids will occur. To prevent this from occurring, three safeguards would have to fail concurrently, which makes the probability extremely remote (see Section 3.0). The impact from this occurrence would be much less than 10^{-4} percent of the natural background over 10^4 yrs[10] (to 200 million persons).

Ferrocyanide precipitates were placed in the single shell tanks in the 1950's as a result of ferrocyanide scavenging to concentrate the process wastes. The right conditions could lead to a rapid exothermic reaction between these solids and the nitrate salts contained in the tanks. An explosion in the tanks would breach the filter and could result in a collapse of the dome. The onsite dose commitments as well as other consequences of an explosion in the tank would place this event in the high hazard level category. An exothermic reaction with pure ferrocyanide could be initiated at temperatures between 350°C and 400°C. An evaluation was performed of the maximum waste temperature which could be expected during the drilling operation.[11] The increase in waste temperature due to the drilling operation would be less than 20°C in the localized region of the sample. The resulting peak waste temperature for tanks which received ferrocyanide precipitates would be less than 100°C. Since it is very unlikely that the other conditions (Table 1) required to initiate the reaction exist in the tanks and since the temperatures are well below the minimum required for the reaction, the ferrocyanide explosion is judged to be incredible during sampling.

For other events identified, the quantities of sample material released would be small fractions of one sample (0.1%); a full sampler contains less than 260 cm^3 and a maximum of 300 mCi of ^{90}Sr. If 0.1% (300 μCi) is instantaneously released from a sampler to the environs, dilution, windspeed, and respirators will reduce the exposure to Onsite persons to insignificant levels.

For example, the annual allowable intake based on continuous exposures to Table II, Column 1, values for air is 2 μCi (equivalent to 0.5 rem).[12] The active breathing rate is 0.02 m^3/min. If 300 μCi is mixed instantly in about 5 m^3 of stagnant air, about 1 μCi (250 mrem) could be inhaled in 1 min. If the respirator has an efficiency of 99%, the resultant activity which is inhaled is 0.01 Ci (2.5 mrem). Of course, the air is moving and instant dilution of the initial concentration should occur.

The RHO-MA-111.5[13] postulates a dome collapse of a single-shell tank which releases 6 Ci of ^{90}Sr along with other isotopes. This indicates a 1-yr dose assessment of 230 rem to the bone at 100 m and 0.18 rem at the Site boundary. The bone dose is caused primarily by ^{90}Sr. The whole body dose is 0.33 of the bone dose. The release of the entire sampler content (0.3 Ci) would result in a dose of 11.5 rem to the bone at 100 m. If only 0.1% is released, the resulting dose would be 11.5 mrem to the bone in 1 yr, which is an acceptable risk.[4]

Other events postulated for initiating releases from SS and DS Tanks are discussed in RHO-CD-1415 and SD-WM-SAR-006.[14,15] An accident from chemical reactions initiated by the sampling activity is deemed incredible.

The sampler provides the primary containment, and procedures require a secondary containment at all times. If a sampler fails, material lost as the sampler is drawn up the drill string would fall back into the tank; therefore, losses during the transfer operations would be contained within the drill string and the tank.

Only those events that would result in release of radionuclides were examined. Situations that would result in equipment breakage, such as the sampler failing to lock in place within the drill, or the grapple cable breaking, were not examined because no containment would be lost. There were no scenarios, for example, where a seismic event would result in a release from core-sampling procedures. There were also no unique situations identified in the planned operations that would provide unusual risks for injury. (Procedures for operations with a rotating platform have been addressed in the functional requirements.)

Risks from exposure are derived from TRAC[3] data which are similar to that obtained from previous samples. Dose rate estimates were required for preparation of operating procedures, Radiation Work Permits (RWPs), and training. Dose rates between 200 to 300 mrem/hr at 1 ft are postulated for an unshielded sample for which the maximum exposure time is 20 s during transit to the shielded receiver. Dose rates and exposures for the sampling operations are administratively controlled by the RPT. Recovery from excessively high sample activity, or an unplanned event such as a dropped sample is provided by administrative controls imposed by the RWP requirements in RHO-MA-172.[16] The Hazards Identification and Evaluation for this operation is presented in Table 1.

TABLE 1. Hazards Identification and Evaluation. (Sheet 1 of 3)

Event	Possible sequence	Preventative design feature	Possible consequences	Mitigating measures
Open sampler withdrawn	Sample material is too dry and rigid to allow rotary valve to close or valve stop pin fails or valve closing wire breaks	Sample is inside secondary enclosure drill rod	Personnel contamination and exposure. Ground contamination and spread to other areas.	RHO-MA-172, Radiation Work Permit (Ref. 14). Drip cup placed underneath shielded receiver before transfer. SOP[a] check off and prior training require operators to close ball valve.
Sample falls out of shielded receiver	Sampler slips from remote latch and drops or receiver disconnected with ball valve open or ball valve fails during transit to cask.	Rotary valve is closed before sampler is transferred to shielded receiver. Ball valve is closed via SOP[a] check off. Remote latch failure indicated by weight transducer change	Personnel contamination and exposure. Ground contamination and spread to other areas.	RHO-MA-172, Radiation Work Permit (Ref. 14). Drip cup placed underneath shielded receiver before transfer. SOP[a] check off and prior training require operators to close ball valve.
Tank vents to atmosphere	Rotating platform hits riser, drill string, or cask stand or portable exhauster filter failure or hydraulic leveler fails	Truck bed and rotating platform designed to rotate without striking equipment or riser Maximum drop of 1 ft from hydraulic failure Pressure monitor across filter alarms and controls to shut down exhauster	Contaminated air released to environment Bent drill or quill rod replacement.	RHO-MA-172, Radiation Work Permit (Ref. 14). Design and operation prohibit truck and platform movement near riser. SOP[a] requires shutdown of exhauster if filter fails. Blocks used to assist jacks in lifting platform.
Washer fails	Washer water not available resulting from: • Supply lost • Jets plugged • Manifold leaks • Operator error • Air bleed valve open	Riser reduces exposure. Control of console Back flow restricted by check valves and positive displacement pump	Excessive contamination on drill string causes increase in exposure and increases probability of operator contamination.	RHO-MA-172, Radiation Work Permit (Ref. 14). Training for drill string removal. SOP[a] requires check of washer before it is used.

[a]Standard Operating Procedure

TABLE 1. Hazards Identification and Evaluation. (Sheet 2 of 3)

Event	Possible sequence	Preventative design feature	Possible consequences	Mitigating measures
Fire	Gasoline spills during fueling or Normal Paraffin Hydrocarbon (NPH) flash point is exceeded and ignition source is provided.	Fill system has shut-off mechanism. NPH storage tank has flame-arrestor cap and insulator blanket.	Truck catches on fire.	Gasoline is added at night; sampling is performed during the day. Limited quantity of NPH is added to the fill tank on the truck platform. No smoking is permitted.
Washer overflows	Rinse water does not enter tank because the sludge on drill rod which has entered waste blocks path between drill string and riser.	Supply tank is limited to 55 gal. Only 20 to 60 in. of drill rod has entered waste.	Some contaminated water released to ground. If drill string is not washed, excessive dose rate to operators will result.	RHO-MA-172, Radiation Work Permit (Ref. 14).
Drill string drops into tank	Foot clamp which holds drill string fails or operator fails to engage clamp or quill rod/drill string engagement fails	Foot clamp used to release drill rod for upward movement. Foot clamp is designed to fail closed.	Additional drill rod is contaminated with waste, increasing operator exposure and contamination potential. Loss of drill string.	RHO-MA-172, Radiation Work Permit (Ref. 14). Follow SOP[a] check off procedure.
Drill string becomes immobilized	Drill string freezes to sludge during standby.	Drill bit design prohibits entry into hard material. Auxiliary crane for drill string removal is available.	Increase in exposure due to extended time utilized for removal of drill string. Sludge may not wash off and cause washer overflow event.	RHO-MA-172, Radiation Work Permit (Ref. 14). Training and Standard Operation Procedures required.
Rotating platform truck movement injures operator	Operator between or behind rotating platform or moving truck and stationary/fixed objects.	Speed constraints	Minor, severe, or fatal injury.	RHO-MA-172, Radiation Work Permit (Ref. 14). SOP[a] require operator movement and space occupancy control.

TABLE 1. Hazards Identification and Evaluation. (Sheet 3 of 3)

Event	Possible sequence	Preventative design feature	Possible consequences	Mitigating measures
NPH or freon vapor escape	Liquids added to drill string; liquid is heated by waste; drill string is detached from quill rod; vapors escape.	Kamloc adapter plug isolates drill string atmosphere after disconnection from quill rod, until it is reconnected to the shielded receiver.	Exposure to toxic vapors.	Monitoring of effluents at position of operators is required to determine concentration-exposure-time relations. Detachment is made in open atmosphere.
Drill through bottom of tank	Hydraulic bottom detector fails and SOP QA check off of drill bit and drill string length not followed.	Pressure drop increase or power failure causes drill to be retracted.	Residual liquor leaks into groundwater.	Soil retention. SOP check off list requires QA signature for selection of drill and drill string.
Exothermic chemical reactions	• Large amount of concentrated ferrocyanide exists in local area of tank and • waste is compacted and dried before cyanide is decomposed by radiolysis and • reaction initiator exists (heat source >350°C) – shock waves or – contact friction or – high activity (decay heat) or – nitrite or nitrate organic salts are present in sufficient quantities or – easily oxidized organic are present to initiate the reaction.		Explosion in tank. Dome collapse. Release of toxic and radioactive materials to the environs.	Heat sinks exist in tanks (H_2O and salts). A temperature rise[11] of 20°C occurs in waste located in the sampler producing a peak waste temperature of 100°C during drilling; therefore, the scenario is deemed to be incredible.

6.0 OPERATIONAL SAFETY REQUIREMENTS

This chapter defines the Operational Safety Requirements (OSR) necessary to extract samples from underground tanks and to recover the sampling equipment used to obtain the samples. Operations are in compliance with requirements imposed by Department of Energy (DOE) and Rockwell Hanford Operations (Rockwell).

The OSR contained in RHO-CD-877[17] and RHO-CD-1415[14] define the conditions, safe boundaries, bases, and the management control required to ensure the safe operation of tank farm facilities. Core drilling and sampling does not violate or require modification of any existing OSR.

The operating specifications for tank farms are contained in the Operating Document Control Manual.[18] Criticality specifications are located in CPS-T-149-00010.[19]

Detailed requirements for preparing, reviewing, releasing, approving and revising Standard Operating Procedures, and training, operability and testing process specifications are in compliance with RHO-MA-115.[19]

Plant Operating Procedures for Core Sampling and the 1,000 cfm Portable Exhauster are approved.[6,21]

The operability test[22] compared the system and components functionability to the functional design requirements given in References 7, 8, and 9 and the drawings listed on the Core Sampler Drawing Index (H-2-91650). Component or operational procedure modifications resulting from the operational test which affect the assumptions used in the safety analysis of the core sampler equipment have been reviewed. The modifications improved the operation of the sampler system and the safety to the operators.[23]

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