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Equipment and Techniques for Remote Sampling of Stored Radioactive Waste

by
T. A. Nance
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

MASTER

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EQUIPMENT AND TECHNIQUES FOR REMOTE SAMPLING OF STORED RADIOACTIVE WASTE

T. A. Nance, Westinghouse Savannah River Company
Savannah River Site, Aiken, SC

ABSTRACT

Several tools have been developed at the Savannah River Site (SRS) to remotely sample stored radioactive waste. These sampling tools have been developed to determine the chemical characteristics of the waste prior to processing. The processing of waste material varies according to the chemical characteristics of the waste, which change due to additions, settling, mixing, and chemical reactions during storage. Once the waste has been sampled to identify its characteristics, the chemical composition of the waste can then be altered if needed to prepare for processing.

Various types of waste material in several types of containment must be sampled at SRS. Stored waste materials consist of liquids, floating organics, sludge, salt and solids. Waste is stored in four basic types of tanks with different means of access and interior obstructions. The waste tanks can only be accessed by small openings: access ports, risers and downcomers. Requirements for sampling depend on the type of tank being accessed, the waste within the tank, and the particular location in the tank desired for taking the sample.

Sampling devices have been developed to sample all of the waste material forms found in the SRS tank farms. The fluid type samplers are capable of sampling surface liquid, subsurface liquid at varying depth, surface sludge, subsurface sludge, and floating organics. The solid type samplers are capable of sampling salt, sampling a solid layer on the bottom of the tank, and capturing a small solid mass on the tank bottom.

The sampling devices are all designed to access the tanks through small access ports. The samplers are reusable and are designed to allow quick transfer of the samples to shielded packaging for transport, reducing the amount of radiation exposure to sampling personnel. The samplers are designed for easy decontamination and to withstand highly alkaline environments. The samplers weigh less than 100 lb. and are designed in sections to allow easy disassembly for storage and transport by personnel. The samplers also provide shielding over the tank access port during sampling to further reduce radiation exposure to personnel.

BACKGROUND

The sampling of tanks at the Savannah River Site has several aspects which add to the overall challenge of obtaining material from inside the tank. The numerous tanks to be sampled contain multiple riser ports that were intended for slurry pumps. These ports contain riser plugs with multiple smaller access ports., which are utilized for temporary work, such as depth soundings, and permanent structures such as thermocouple wells. Only non-dedicated riser ports can be feasibly utilized for

sampling. The smaller ports are easier to access due to the reduced size and weight of the riser plug to be removed. Smaller openings decrease the radiation exposure of the operating crew and decrease the possibility of dropping tools or other equipment into the tank.

The waste material in the tanks varies in location for each tank. The material location in each tank is determined by the type of waste material, the action of slurry pumps, additions to the tank, subtractions from the tank, and the locations of pipes in the tank. The location of an available riser port above the waste is desired but not always possible.

Risers are subject to load limitations. Support structures are built around risers intended for slurry pump mounting. The support structures provide an excellent platform to sample from but in some cases restrict the area around the riser port. The lifting requirements of operations personnel further limits the size of equipment to be used on top of the tank.

The majority of waste tanks at SRS are categorized by four types. Type I tanks contain interior columns as well as cooling coils. Type II and III tanks both contain an interior center column and cooling coils. Type IV tanks contain no columns or cooling coils. The tanks also contain other interior obstructions such as pumps and thermocouple well pipes from the riser ports. In addition, the tanks contain other interior interferences to sampling in the form of general debris.

The radioactive material within the tanks must be contained upon extraction to prevent contamination of the tank top and possible contamination of operations personnel. The radioactive sample must also be contained to prevent irradiation of the operations personnel. The radioactive waste material in the tanks also can expose personnel to radiation through an open riser.

Additions to the tanks are made to alter the chemistry of the waste material and to prepare the waste material for transfer. These additions are composed of inhibited water and alkaline solutions. The stored waste may produce gases which are explosive. The waste material in the tanks is in several forms: liquid, sludge, salt, and solid. The generation of additional waste volume in the process of sampling should be minimized.

SAMPLING DEVICE CRITERIA

The sampling devices must fit through a 6" to 24" diameter access port. The sample tool must be able to reach the waste material from the available access port. The tools must be small enough or sectioned to be able to be lifted by operations personnel and to be disposed of in a designated waste container. The sections of the tool must be capable of being assembled quickly to reduce the time operations personnel are dressed in uncomfortable protective clothing and are in proximity to an open riser.

The sections of the device that require disassembly in the process of using the sample tool should be connected using quick-disconnect pins or other quick and simple

types of connection. The quick-disconnect type of pin can be operated by gloved operations personnel easily and quickly to reduce the exposure time in proximity to the used sample tool and the radioactive waste sample it contains.

The device should be built with surfaces exposed for washing down and provide no place to carry contamination. The sampling device components which have contacted the waste material should be washed using a spray ring. The tool spray ring will clean off contaminants prior to removal of the tool from the riser. The tool should also have a flange for the tank top to decrease exposure of operations personnel to radiation from inside the tank.

The use of electrical components is limited by the explosivity of the contents of the particular tank to be sampled. Electrical components, such as a camera and lights, should be used as part of the sample tool only when a separate camera/light system is not available or practical. If electrical components are included as part of the sample tool, the cables must be managed to not interfere with the movement of the tool, not contact liquids unless the cabling is watertight, and not have catch points along the cabling.

The device should be built of materials as light as possible. The components of the device which will sample the waste material should be made of stainless steel. The stainless steel will provide protective shielding for the operations personnel upon extraction of the sample from the tank. The stainless steel also resists corrosion from the waste and other contents of the tanks and also provides a surface which can be decontaminated if required.

The device should be built as small in volume as possible to reduce the waste volume generated by sampling if decontamination of the device is not possible. The device needs to be built economically, since its useful life might only be a single sample extraction.

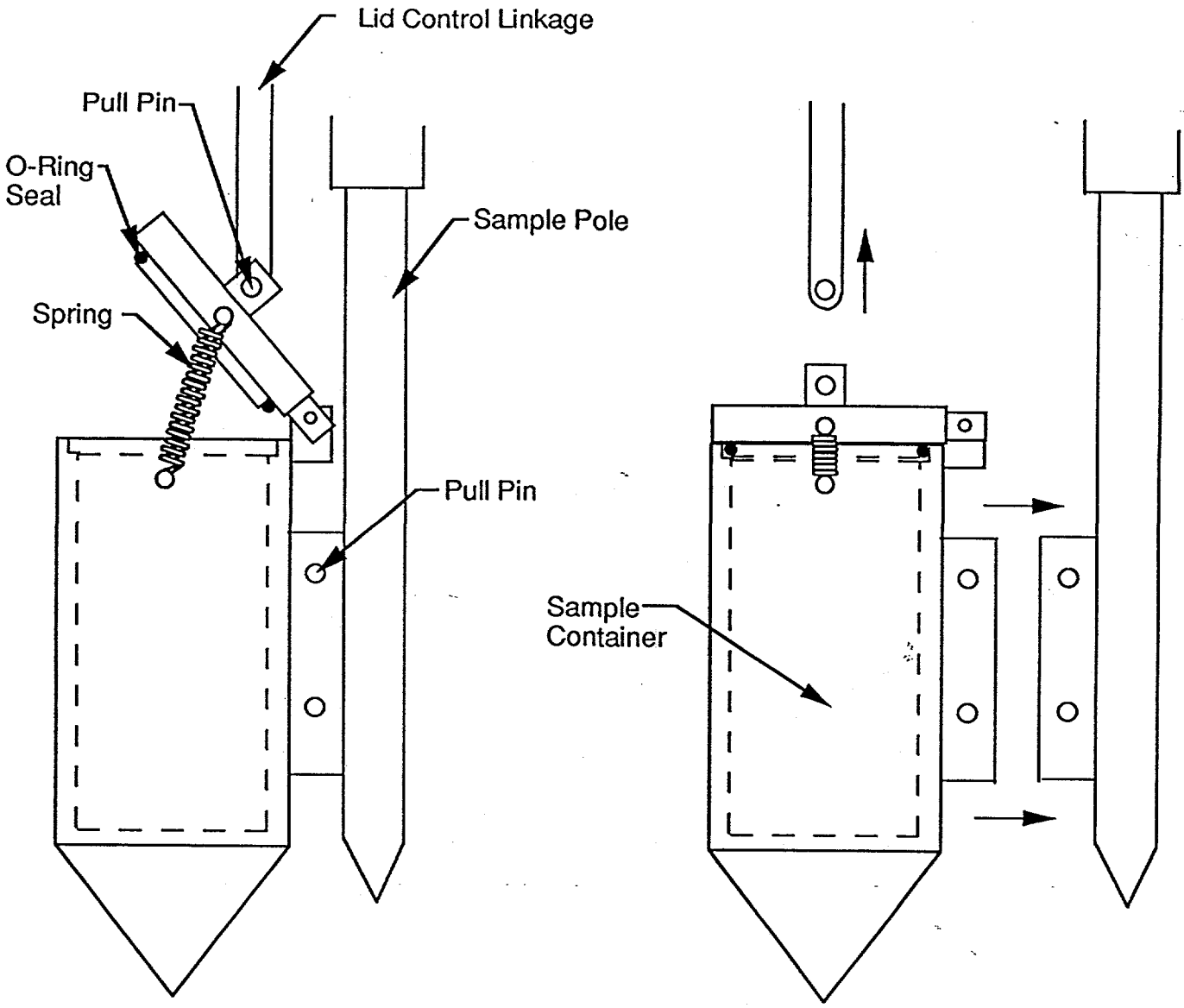
The sample cup that contains the waste sample must be shipped to a laboratory for analysis of the waste. The sample cup must be sized to fit within a lead-lined standard sample cask and should be detached from the sample device with only minimal contact of operations personnel.

SAMPLING DEVICES

The following descriptions are of sampling devices designed to handle the defined environment, and to meet the criteria defined for the sampling devices. Several of the sampling devices described below can be utilized for multiple types of waste material sampling, which is discussed in the following section.

I. Variable Depth Sampling Device

The Variable Depth Sampling Device (VDS) (See Fig. 1) can be sent to variable depths into liquid, sludge, or loose solids and take a sample. The VDS seals the vial empty for insertion into the waste, preventing mixing of the sample, and seals the sample vial after the sample is taken.



OPEN POSITION
Lid is opened by control linkage to obtain sample.

CLOSED POSITION
Lid is closed by spring. Sample container is removed from sample pole and lid control linkage. Ready for sample extraction.

Figure 1: Variable Depth Sampling Device

The VDS has a vial which has a spring-loaded lid with an o-ring to seal the vial. The lid has a control cable attached to actuate the lid at the desired depth. The vial is designed to be removed and placed directly in the sample cask. The VDS is either weighted or has drive rods attached to propel it to the desired depth to sample. The selection of the means of propulsion is determined by the waste material to be traveled through.

The VDS is lowered into the tank and pushed into the waste material until the correct depth is attained. The lid control cable is pulled opening the lid to sample. The lid control cable is then released, allowing springs to close the lid on the sample vial. The device is then removed from the tank, and the sample vial is removed and placed in a sample cask for shipment.

II. Sampling Arm Device

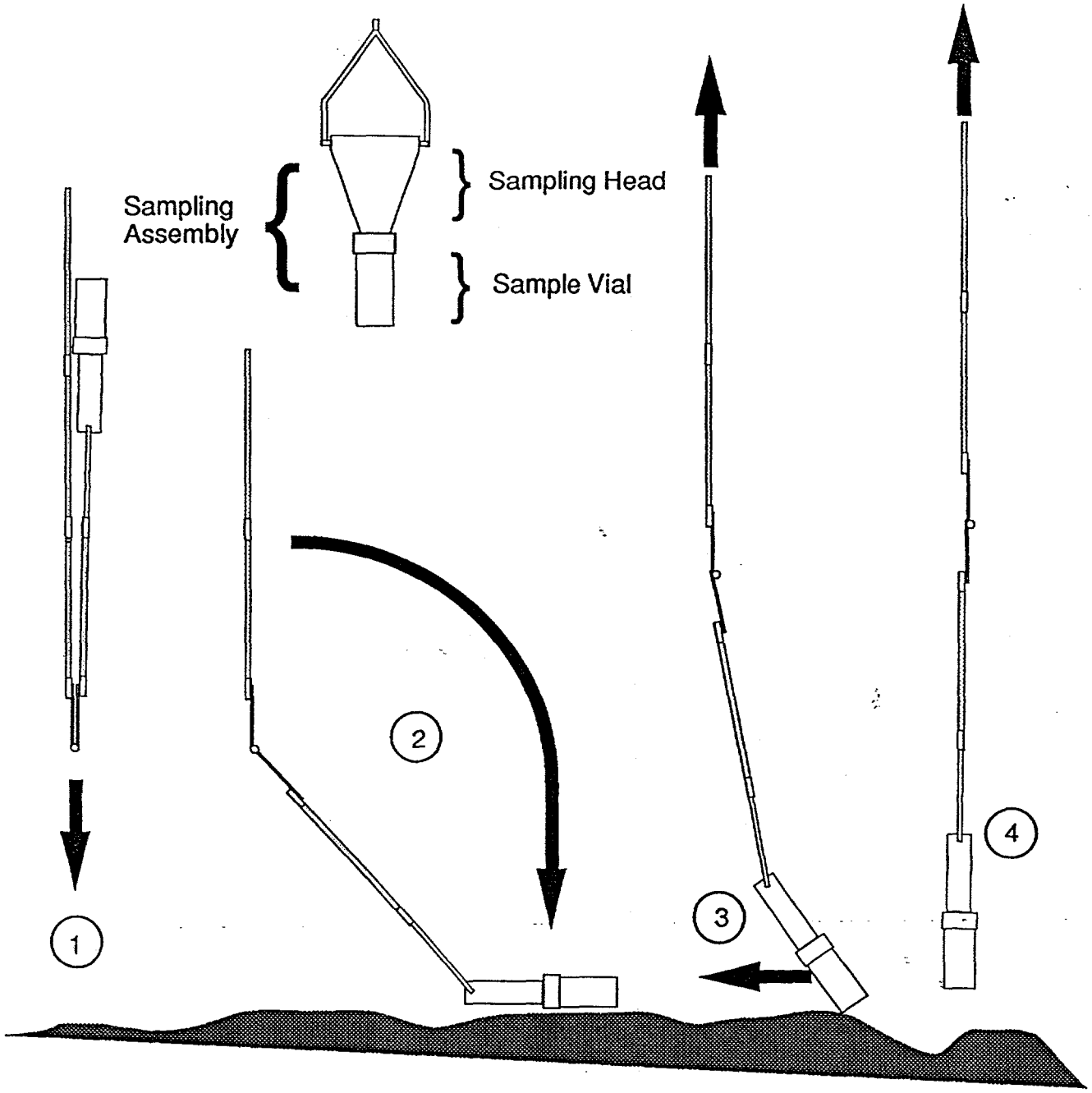
The Sampling Arm Device (SAD) (See Fig. 2) takes samples of liquid, sludge, salt, and solids several feet horizontally from the access port. The SAD is composed of a sample vial, a sampling head, a forearm section, an elbow, and an upper arm section.

The SAD is lowered into the tank with the forearm in the raised position. The elbow is lowered to the waste level, and the forearm is released. The forearm is rotated until the sampling head and vial hit the surface of the waste. The upper arm section of the device is then removed from the tank causing the sampling head assembly to travel across the bottom and scoop waste into the sampling head. The sample falls into the vial when the sampling assembly rotates to a vertical position during extraction. The sampling assembly is removed from the access port, and the sample vial is unthreaded from the sampling head and placed in a sample cask.

III. Remote Sampling Device

The Remote Sampling Device (RSD) (See Fig. 3) is a tethered remote control vehicle which carries a sampling assembly to the location of the desired sample. The sampling assembly is then deployed and retrieved, collecting a sample. The remote vehicle has a control cable, a power cable, and a retrieval cable as well as a sampling assembly holder. The sampling assembly is identical to that of the Sampling Arm Device with a sample vial and a sampling head. The sampling assembly is connected to a retrieval cable.

The remote vehicle is loaded with the sampling assembly. The RSD is then lowered into the riser until the vehicle is resting on the surface of the waste or bottom of the tank. The vehicle is then driven to the location of the desired sample, and the sampling assembly is deployed by pulling the retrieval cable. The sampling assembly is pulled along the bottom, taking in waste material, until it is directly below the access port. At this point, the sampling assembly is extracted out of the riser, and the sample vial is detached and placed in the sample cask. The remote vehicle is then extracted from the tank.



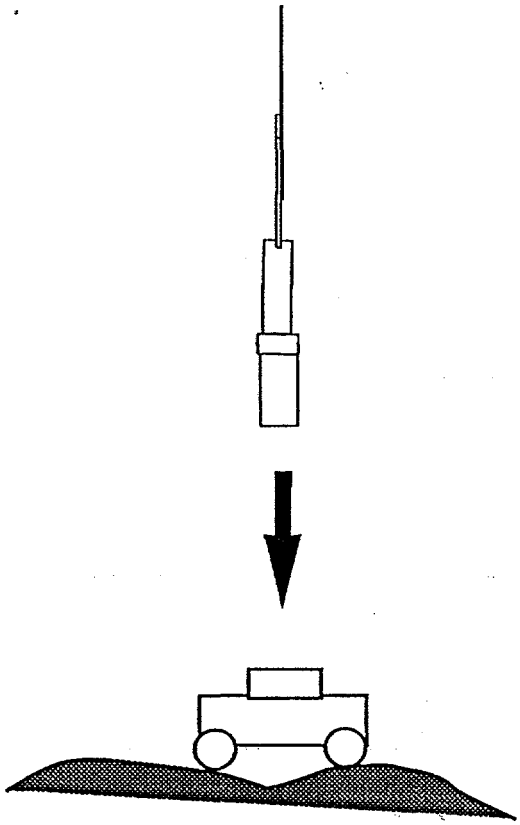
1 The Bottom Scrape Sampler is Inserted into the Tank.

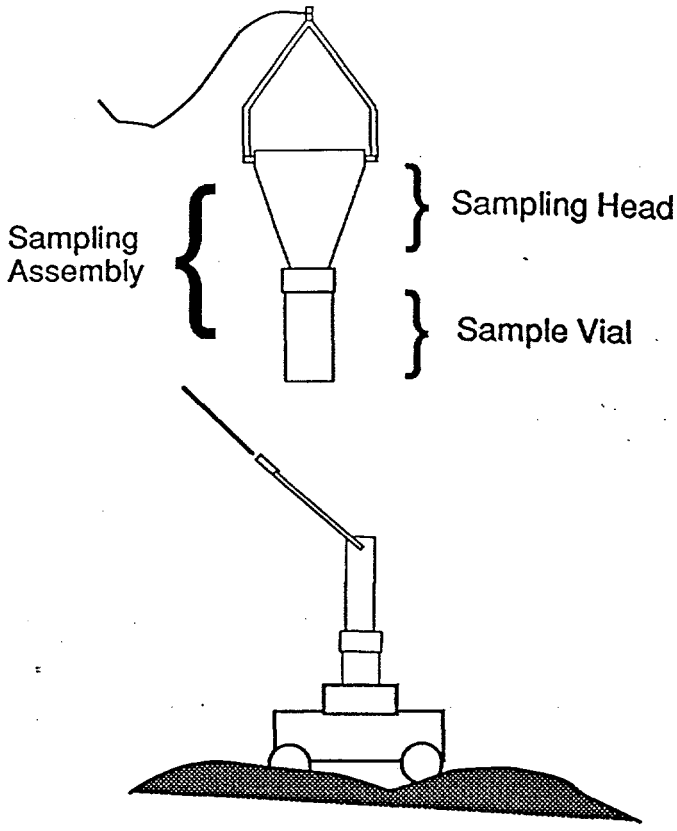
3 The Rods are Extracted causing the Bottom Scrape Sampler to be pulled across the Bottom and through the Sludge

2 The Bottom Scrape Sampler is Allowed to Rotate about its Hinge and Contact the Sludge.

4 Extraction is continued until the Sample Vial is clear of the Tank, Removed from the Sampler, Capped and Shipped in a Doorstop.

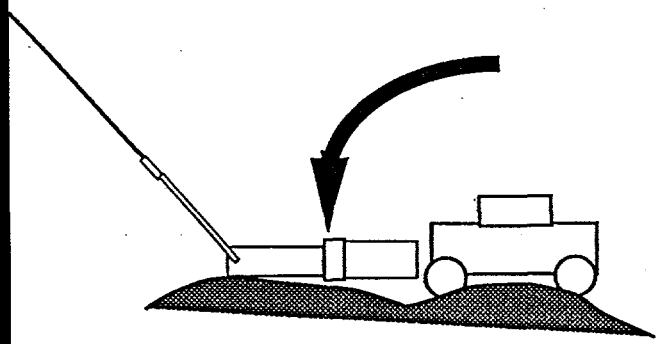
Figure 2: Sampling Arm Device

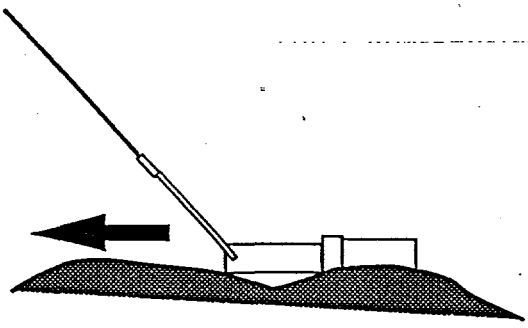




1 The Bottom Scrape Sampler is Inserted into the Tank and into the Remoted Vehicle.

2 The Remoted Vehicle is Driven to the Location of the Required Sampling.





3 The Bottom Scrape Sampler is Extracted from the Vehicle by Pulling the Extraction Cable.

4 The Bottom Scrape Sampler is Pulled across the Bottom of the Tank. Extraction is continued until the Sample Vial is clear of the Tank, Removed from the Sampler, Capped and Shipped in a Doorstop.

Figure 3: Remote Sampling Device

IV. Sludge/Solids Sampling Device

The Sludge/Solids Sampling Device (SSS) (See Fig. 4) is an assembly of numerous drive pipe sections with a sample cup on one end. The SSS provides a sample from directly below the riser. The device is composed of a mounting platform, a spray ring, sealed pipe sections, and a sample cup. The platform has the spray ring attached and a shaped cutout for a pipe with a quick-release pin through it. The pipe sections are connected using quick-release pins mounted at 90 degrees to the pin of the next section. These pins not only hold the device together, but they also act as a safety device. The pins only allow the device to fall a few feet through the cutout in the platform before catching a pin on the cutout opening.

The sample cup has a sharp edge for cutting through solid waste material on the tank bottom and has a one-way plastic basket retainer that allows the sample to enter the cup but not to leave the cup. The sample cup also contains a piston which protrudes from the cup as sample material fills the cup sample chamber. The operator can determine the volume of the sample taken by reading the graduated piston stem above the sample cup prior to placing the cup in the sample cask. The piston also aids the analytical laboratory in unloading the sample.

The SSS is lowered into the tank until the sample cup contacts the waste surface. The drive pipe assembly is then driven into the surface by hammering the top section of pipe using a protective pipe end cap. The waste travels into the sample cup and through the basket retainer into the sample chamber. The device is extracted from the tank, the sample cup removed, checked for sample quantity, and placed in a sample cask for shipment.

V. Counterweight Boom Sampling Device

The Counterweight Boom Sampling Device (CBS) (See Fig. 5) is a suspended boom which serves as a platform to deploy sample devices. The Boom Sample Device can deploy the sampling devices from directly below the riser to several feet horizontally away from the riser.

The CBS consists of multiple sections of structural members which are connected and suspended by a single support cable. The counterweight is attached to one end of the boom, and the sample device is suspended from the other end. Control cables are attached to each end of the boom to control its angle relative to a horizontal axis. A guide pipe inserted through the riser attaches to the boom to allow the operator to rotate the boom about the vertical axis. The sampling device deployed from the boom could be a sample vial, floating waste sampling device, or a spring-loaded oceanic type sampler (commercially available).

The CBS is lowered into the tank in a vertical position with the counterweight end leading. The guide pipe is then inserted through the riser and attached to the boom. The boom is rotated about the vertical axis and rotated about the horizontal axis to position the sampling device directly above the waste to be sampled. The sample device is lowered, capturing the desired sample. The device is then retrieved and the

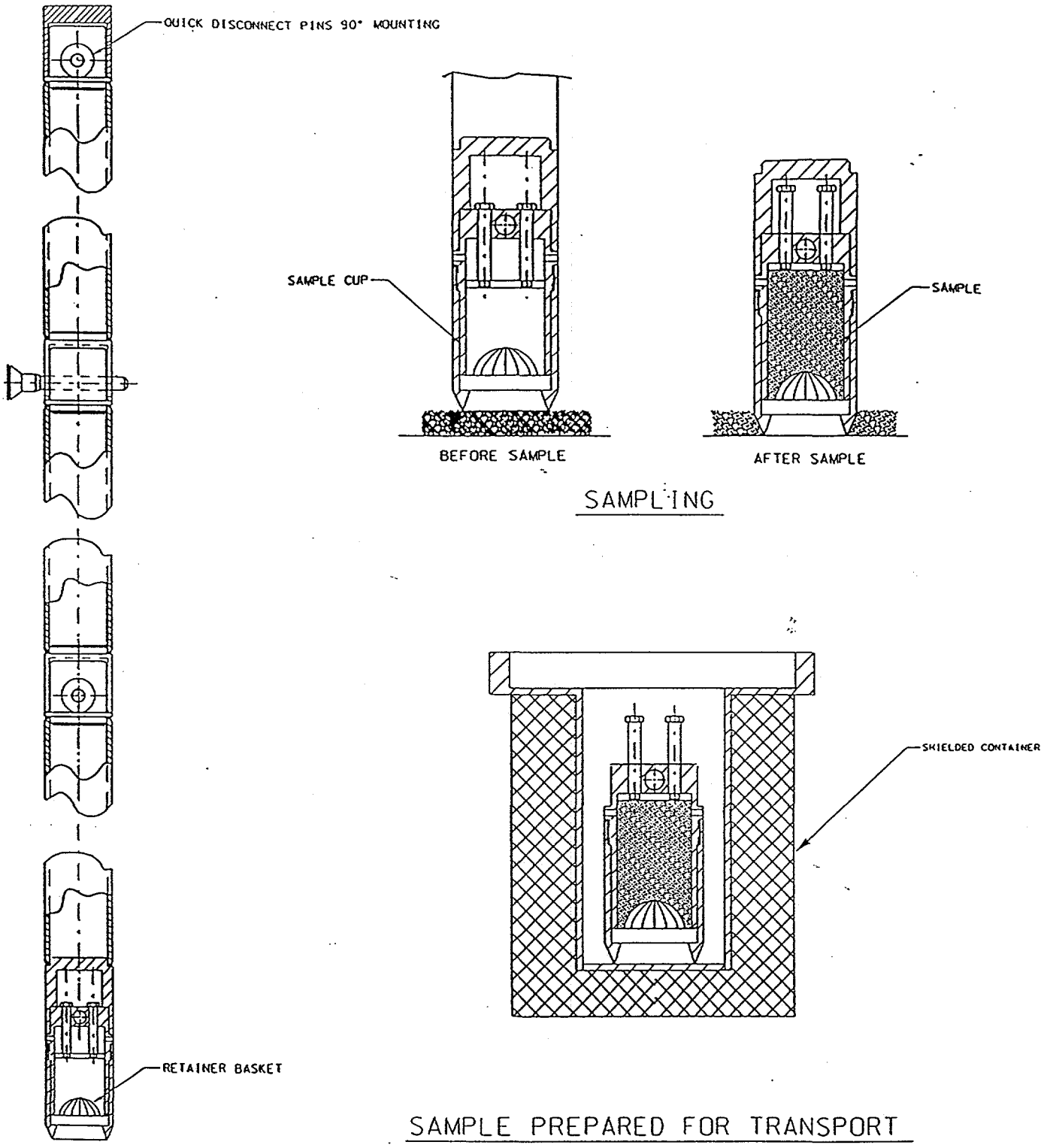


Figure 4: Sludge/Solids Sampling Device

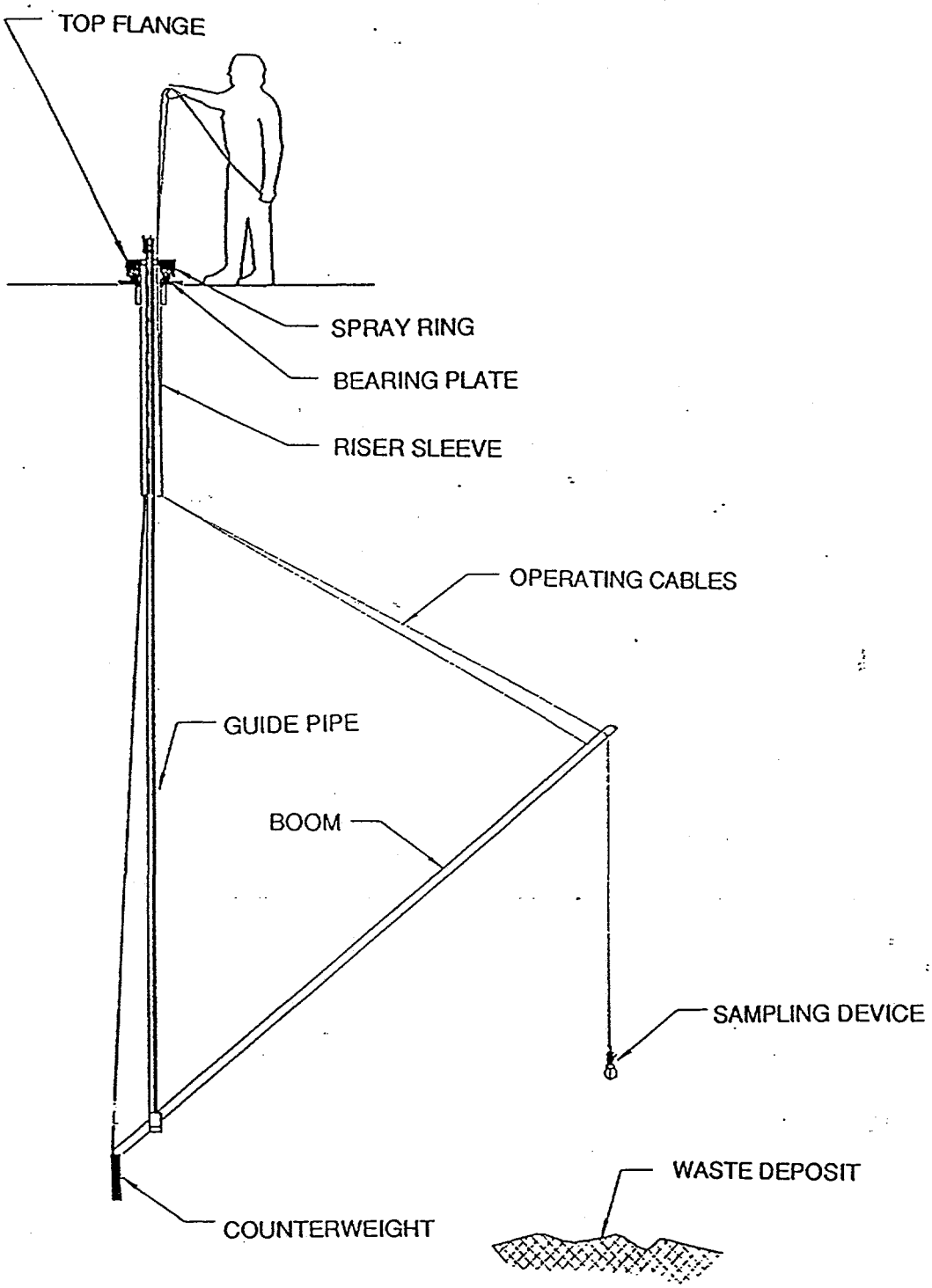


Figure 5: Counterweight Boom Sampling Device

boom rotated to allow the sample to be extracted from the tank and placed in a sample cask. Finally, the boom is extracted from the tank.

VI. Floating Waste Sampling Device

The Floating Waste Sampling Device (FWS) (See Fig. 6) is designed to sample floating waste without extracting liquid from the tank. Elimination of liquid from the sample reduces the radiation exposure of operations personnel and sample preparation in the laboratory.

The FWS is composed of a sample vial, a filter, and a ball check valve with a floating ball. The device is lowered into the liquid causing the floating ball to close the check valve preventing liquid from entering the vial from the bottom. The vial is lowered into the liquid further until the floating waste begins to pour into the cutout in the mouth at the top of the vial. The liquid and floating waste fill the vial. The sampling device is then extracted from the liquid, and the ball immediately falls, opening the valve. The liquid in the vial travels through the filter and out through the ball check valve leaving the floating waste in the filter of the sample vial. The process can be repeated several cycles to increase the amount of sample obtained. The sampling assembly is then extracted through the riser, and the sample vial is placed in a sample cask for shipment.

VII. Annulus Wall Scrape Sampling Device

The Annulus Wall Scrape Sampling Device (AWSS) (See Fig. 7) provides a scrape sample of a tank exterior wall from within the space contained between an inner and outer tank. The AWSS is composed of a main pole with an arm and a scrape sampling head attached. The scrape sampling head consists of a sampling vial, a camera and light for locating and for close observation of the tank wall, and multiple electromagnets to hold the scraping edge against the wall. The main pole consists of tubing sections connected by quick-release pins for easy operation. The arm is rotated vertically by taking up a control cable, and the scraping head is attached to the arm with multiple hinges to allow the head to contact the wall. The AWSS is inserted into the annulus using clamp blocks and a platform assembly designed to prevent the tool from falling into the annular space.

The process of sampling begins with the insertion of the vertically positioned sampling head into the access port with the platform in place over the port. Tubing sections are added until the sampling head is lowered directly below the area of the wall to be sampled. The tubing sections are secured in place using the clamp blocks, the magnets are fully powered, and the control cable is taken up to rotate the arm and head toward the wall. The head remains in a vertical position during the arm rotation until it contacts the wall and the magnets engage. Power to the magnets is then reduced to allow movement of the scraper across the wall surface. The control cable is taken up causing the head to scrape across the wall and the sample to fall into the sample vial. The magnets are then turned off, and the arm is lowered into a vertical position for removal from the annulus. The AWSS is removed from the annulus, and the vial is placed in a shielded transport container.

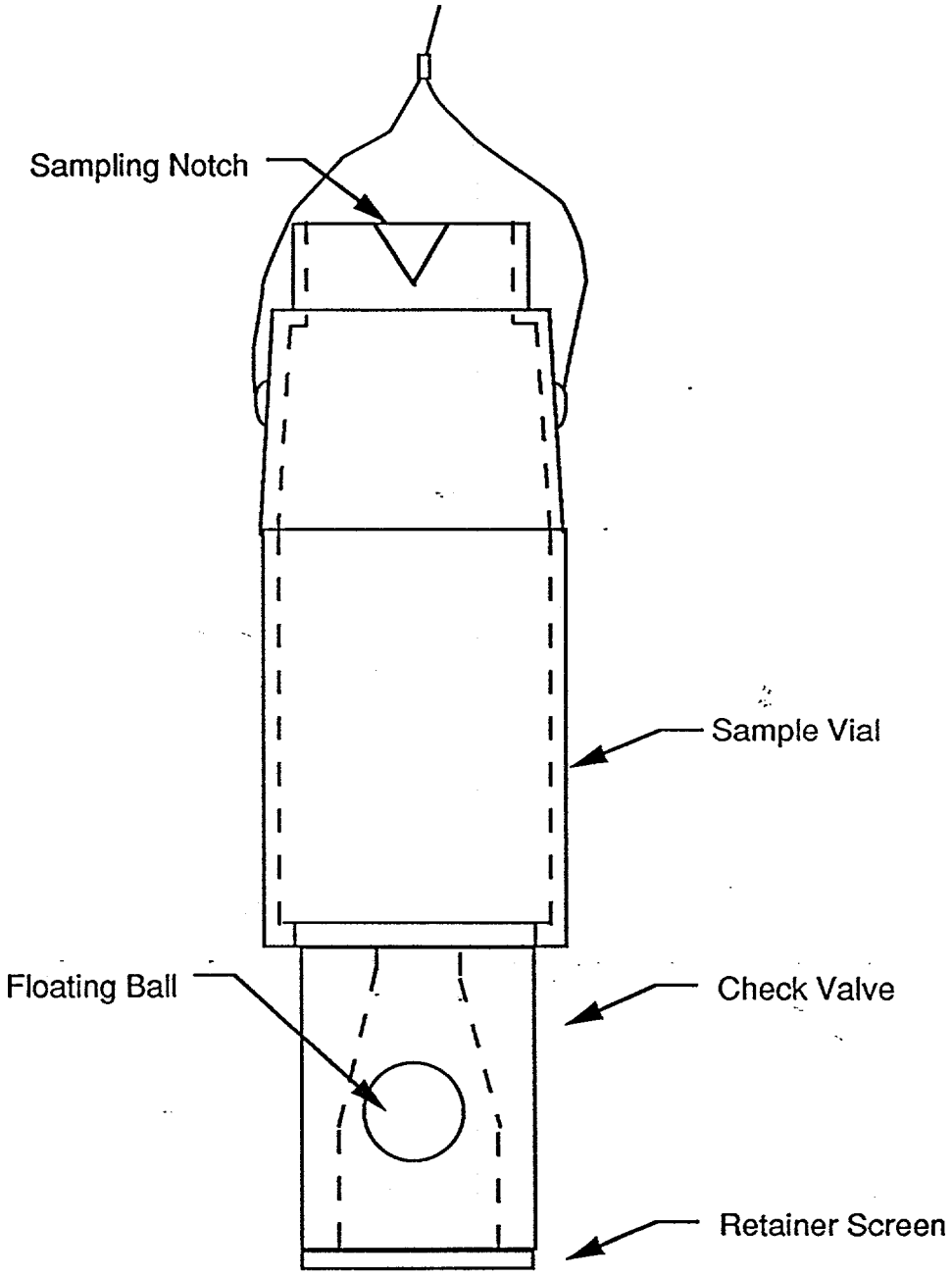


Figure 6: Floating Waste Sampling Device

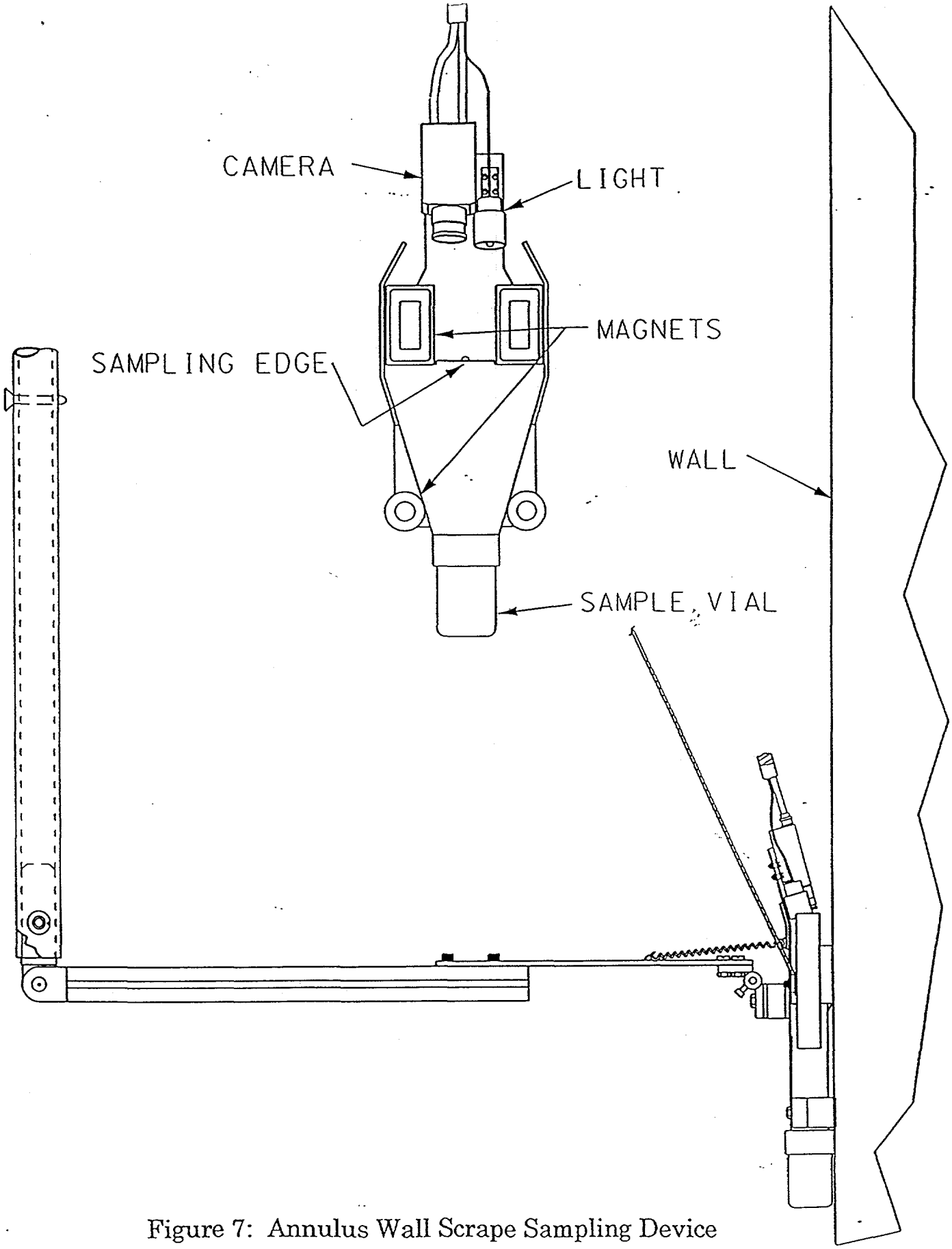


Figure 7: Annulus Wall Scrape Sampling Device

SAMPLING DEVICE SELECTION FOR UTILIZATION

The sampling devices described in the previous section can be used in various tank sample scenarios (See Fig. 8). The Variable Depth Sampling Device can be used on liquids or sludge waste material. The Sampling Arm Device can be used on liquids, sludge, salt, and solids but, can not sample sludge, salt, or solids if they are covered by a layer of liquid.

The Remote Sampling Device can take samples of liquids, sludge, salt, and solids. Like the Sampling Arm Device, a liquid layer above the waste material to be sampled eliminates use of this device. This device requires a surface to drive on and contains electrical components which could not function in liquid.

The Sludge/Solids Sampling Device can be used on sludge, salt and solids. A liquid layer above the material to be sampled is not desired since it could wash out some of the sample. The Sludge/Solids Sampling Device can only be used directly below the riser.

The Counterweight Boom Sampling Device can be used on any material to be sampled depending on the sample device it deploys.

The Floating Waste Sampling Device can be used to sample floating surface waste material.

The Annulus Wall Scrape Sampling Device can be used to sample any type of waste material present on the walls of the tank annulus.

FIELD USE OF SAMPLE DEVICES

The Sample Arm Sampling Device has been successfully used in a tank to obtain a sludge sample. The Sampling Arm sample was taken approximately twelve feet horizontally from the entry riser. The Sludge/Solids Sampling Device has been used in several tanks on salt and on a solid heel below a thin layer of liquid.

The Variable Depth Sampling Device, the Remote Sampling Device, the Counterweight Boom Sampling Device, the Floating Waste Sampling Device, and the Annulus Wall Scrape Sampling Device have been built and tested and are awaiting field deployment.

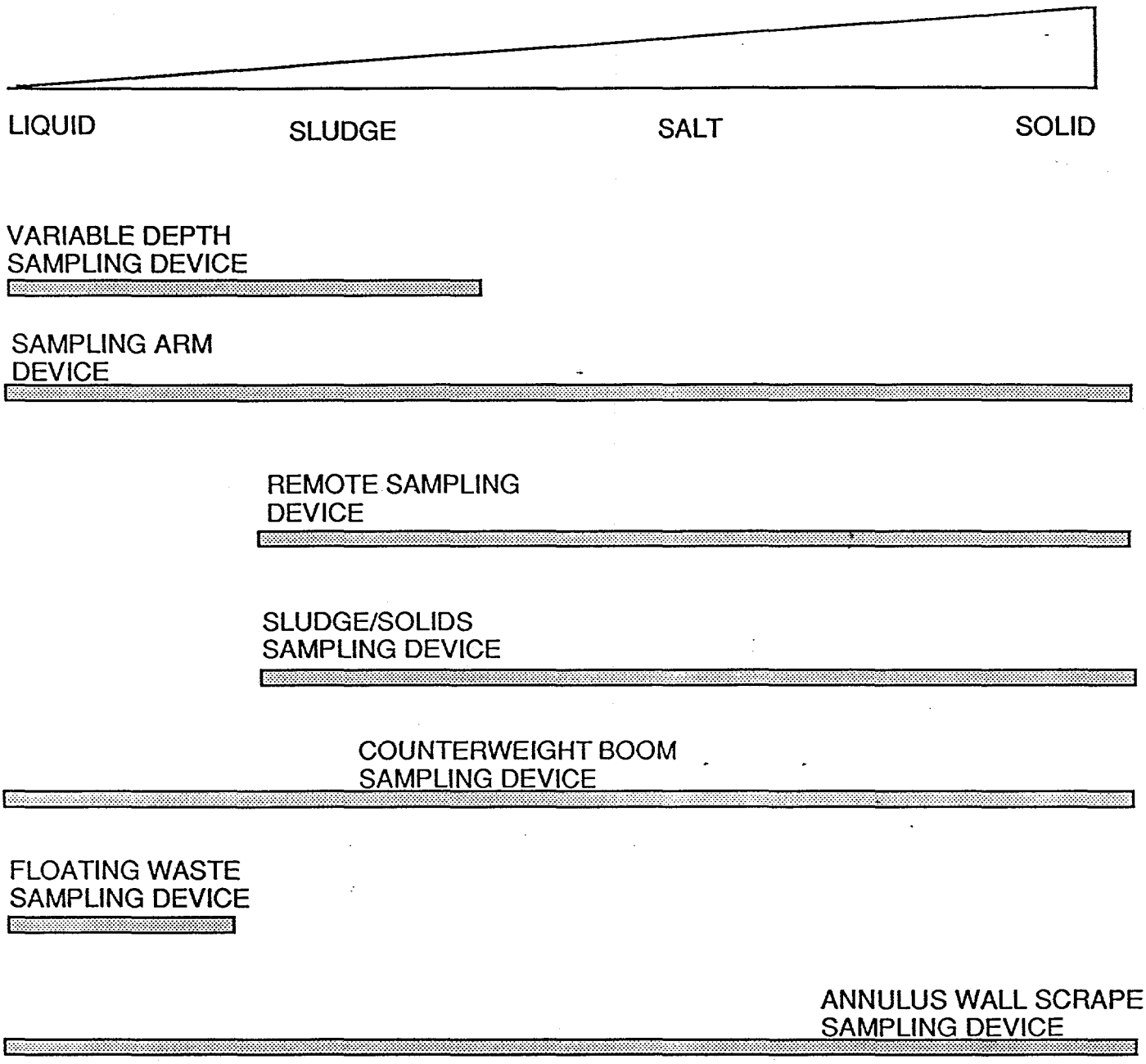


Figure 8: Sampling Device Selection for Utilization

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