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Planning Document for Spent Nuclear Fuel Cleanliness Inspection Process (OCRWM)

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Abstract: The specific processes and techniques are described that will be applied in perfroming the cleanliness inspection of Spent Nuclear Fuel after cleaning in the Primary Cleaning Machine.

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PLANNING DOCUMENT FOR SNF FUEL CLEANLINESS INSPECTION PROCESS

1.0 OBJECTIVE

The Fuel Retrieval System (FRS) Process Validation Procedure (Shen 1999) requires that a specified quantity of fuel processed through the Primary Cleaning Machine (PCM) be inspected for cleanliness during initial operational and process validation testing. Specifically, these inspections are performed to confirm that the PCM adequately cleans the fuel elements of canister sludge. The results of these inspections will be used to demonstrate that residual quantities of canister particulate on fuel elements loaded into Multi-Canister Overpacks (MCOs) are within projected levels used to establish safety basis limits (Sloughter 1998).

The fuel inspections performed as part of the validation process will be conducted during the Hot Operations portion of the Phased Startup Initiative (PSI) of the Fuel Retrieval and Integrated Water Treatment Systems (Pajunen 1999). Hot Operations testing constitutes Phases 3 and 4 of the PSI. The fuel assemblies in all candidate canisters will be thoroughly inspected during these test phases (highly degraded fuel assemblies are exempt from inspection). During subsequent production operation of the FRS, only periodic (every tenth canister) inspections for cleanliness will be performed and documented.

This document describes the specific processes and techniques that will be applied in performing the cleanliness inspections, and the methodology used to verify that the documented inspection results conform to Office of Civilian Radioactive Waste Management (OCRWM) requirements. The procedures and processes presented here are in conformance with the Quality Assurance Program Plan for Implementation of the OCRWM Quality Assurance Requirements and Description (QARD) for the Spent Nuclear Fuel Project (QAPP-OCRWM-001).

2.0 INSPECTION TEAM

A select panel of four or five individuals with relevant experience disciplines will be assembled to perform the cleanliness inspections on the fuel elements during the process validation campaign. The inspection team members will have individual expertise in process engineering, characterization, operations, safety, or modeling. The panel will have completed training to satisfy basic process engineering requirements, and will be required to be familiar with technical basis documents and bounding assumptions associated with fuel cleanliness.

In addition, a certified Quality Control Inspector will be present during cleanliness inspections to verify that recorded data is complete and correct. All personnel on the inspection team will be qualified to meet minimum requirements of the OCRWM QARD (DOE/RW/0333P).

3.0 INSPECTION CRITERIA

The inner and outer surfaces of each disassembled fuel element will be examined to determine whether residual canister sludge after fuel cleaning exceeds allowable limits. Specifically, a fuel assembly would fail the cleaning criteria should either of the following conditions be found to exist after cleaning (Shen 1999):

- Visual examinations identify a bore obstruction that cannot be attributed to features of the element (e.g., clad defects or clips) or coatings.
- When removing the inner element from the outer element, and/or during subsequent inspection of both elements, the total quantity of particulate matter (excluding coating material) observed is equivalent to or exceeds a cone that is 1-inch in diameter at the base and 1/3-inch high.

Figures 1 and 2 show nominal views of how such a cone-shaped pile would appear in relation to the size of a fuel assembly. The volume of this material is 1.4 cm^3. Figure 3 presents a close-up view of this conical pile, and Figures 4 and 5 show the same amount of material reconfigured into more prismatic shapes.

4.0 INSPECTION PROCESS

All inspection operations will be performed in conformance with approved procedures for conducting the FRS Phased Startup Hot Operations.

Cleanliness inspections of the fuel will be performed on a real time basis by the inspection team during conduct of the Hot Operations portion of the Phased Startup of the FRS. At least three team members must be present to form an inspection team quorum. All inspection operations will be videotaped to provide video records for subsequent evaluation if needed.

The preferred location for performing the inspection would be the Equipment Operating Center (EOC). This would allow for direct communication between the inspection team and operations personnel. This communication will be necessary to direct the positioning of fuel elements to achieve optimum viewing orientations, and to coordinate the collection of released sludge into an appropriate configuration for volume assessment. However, it is anticipated that Conduct of Operations will not permit such an assemblage of inspectors in the EOC. An alternative arrangement would be to set up a separate station receiving the same CCTV images as the EOC, and to establish verbal communication with the EOC via speakerphones or two-way radios. The inspection station should also be equipped with a computer connected to the HLAN. One member of the inspection team may be situated in the basin for overall observation of the cleaning and handling operations.

Room 4 of the 105KW Building has been identified as an acceptable location for the Inspection Station. This locale is within reasonable distance for extending signal feeds from the EOC. The signal feeds from the Inspection Station can also be readily extended to the lunchroom for general audience viewing.

Visual inspections of the fuel elements will commence once the fuel has been dumped from the canister onto the process table following cleaning in the PCM. Care should be exercised to maintain the assemblies intact during the dumping process; i.e., try to avoid separating the inner elements from the outer elements when dumping the canister contents on the table.

After dumping on the process table, the fuel assemblies will be individually transferred to the separation station for disassembly. Each separated fuel element will be visually examined for damage, consistent with damage categories previously employed in characterization assessments (Pitner 1998). The four damage categories are listed below. It is not anticipated that many (if any) fuel elements in the "Defected" category will be found after cleaning.

- Intact – No evidence of cladding rupture or end cap breach.
- Breached – Minor cladding rupture or end cap breach, but with no corroded fuel visible at the breach location.
- Defected – Definite evidence of cladding breach with reacted or corroded fuel present at the breach location. The amount of reacted fuel may be significant, but there is no gross cladding splitting, element dilation, or fuel voiding.
- Bad – Gross failure is evident with substantial element dilation, cladding splitting, breakage, or fuel voiding.

Bad assemblies will not be separated and inspected. During normal process operations, these assemblies will be placed directly in scrap baskets. During the phased startup stages, bad assemblies will be placed in a separate scrap canister.

During assembly separation, the inner fuel element will be pushed into a specially fabricated tray to facilitate collection of any canister sludge that may be dislodged during element separation (Figure 6). The collection tray shall be cleaned before each disassembly operation. The external surfaces of the separated elements will be visually examined for any residual canister particulate material. If possible, any such material should be physically dislodged and added to any inventory of particulate collected during element disassembly. The outer element shall be turned vertically to permit any retained internal sludge to drain into the collection tray. Care should be taken to preclude the inclusion of any aluminum hydroxide flakes in this inventory.

After removal of the inner assembly from the collection tray, the amount of sludge particulate present in the tray will be visually assessed. It is anticipated that in general, this assessment will suffice to determine whether the 1.4-cm^3 limit has been exceeded. If necessary, a quantitative measure of the particulate volume will be undertaken. This would involve attaching (slip fit) a special adapter to the tip of the secondary cleaning station vacuum wand (Figure 7). The particulate material in the tray would then be suctioned into the transparent calibrated chamber on the end of the adapter to determine whether the 1.4-cm^3 volume limit had been exceeded. This adapter will be developed in laboratory testing (Pitner 2000). Again, care should be taken to avoid suctioning up any aluminum hydroxide flakes in this collection process. The sludge collection adapter would be changed out for each new inspection operation.

The bore of each disassembled fuel element will be examined using the available back-lighted fixture at the inspection station, and the observations compared to the inspection criteria described above (Section 3.0).

Based on the results of the above inspections, the fuel assembly will be judged to either pass or fail the cleanliness criteria. The damage level and results of the cleanliness inspection for each fuel element examined will be recorded on data sheets (Shen 1999).

5.0 ACCEPTANCE VERIFICATION

Phase 3 of PSI process validation testing consists of equipment operability verification. It is anticipated that approximately six canisters of fuel will be processed during this phase of the testing to demonstrate satisfactory cleaning performance of the PCM. Some of the PCM operating parameters may be adjusted during this phase of the testing to improve or optimize PCM cleaning performance. This phase of testing will be considered complete when it has been demonstrated that the PCM satisfactorily cleans fuel from both stainless steel and aluminum canisters containing fuel with the full range of damage categories. All assemblies except "Bad" assemblies will be inspected during Phase 3 testing. The final PCM operating parameters established during Phase 3 testing will be applied to Phase 4 of the validation testing program.

Phase 4 of PSI constitutes the actual process validation testing for the PCM. It will involve a minimum of 29 canisters (both stainless steel and aluminum) of fuel selected on a random basis from the K West Basin fuel inventory. Fuel inspection will again be performed on all but the bad assemblies during Phase 4 testing. Fuel cleaning operations will be considered successful if no more than one of the fuel assemblies in the 29-canister batch fails the cleanliness criteria. If more than one fuel assembly fails the cleanliness criteria, Phase 4 testing will be terminated and testing will return to the Phase 3 mode. PCM operating parameters will be readjusted to demonstrate cleaning effectiveness, and a new batch of 29 canisters will be processed in the Phase 4 mode of FRS validation testing (Pajunen 1999). The allowable cleanliness criteria provide the required statistical confidence that bounding canister particulate mass limits in an MCO will not be exceeded (Sloughter 1998).

The cleanliness inspection team members are selected for their experience and expertise in various SNF disciplines, and as such form a select panel for the purpose of performing the fuel cleanliness assessments. A certified Quality Control Inspector will also be present during cleanliness inspections to verify that recorded data are complete and correct.

Upon completion of the FRS process validation testing, a final report will be prepared describing the PCM performance and validation testing results. This report will form the basis for validating the PCM performance and verifying that canister particulate loading levels in MCOs will not exceed safety basis limits. This FRS Process Validation report will be peer reviewed to satisfy OCRWM documentation requirements. Quality assurance review and signoff will be required to confirm that the inspection data has been appropriately documented. Nuclear Safety will also review and approve the final report to corroborate that the inspection results are within the safety basis for MCO fuel loading.

Once the FRS begins operation in the production mode, full-scale cleanliness inspections of fuel elements will be performed only on every tenth canister processed (Shen 1999). The level of cleanliness inspection on the fuel in every tenth canister will be the same as that performed on the fuel in Phases 3 and 4. Similar data sheets will be used to record damage levels and the results of the cleanliness inspections. These packages of data sheets constitute quality records for the MCO loading inventories, and will also be subjected to peer reviews to satisfy OCRWM documentation requirements. The peer reviews may entail the use of video records generated during the inspection processes.

6.0 REFERENCES

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Quality Assurance Program Plan for Implementation of the OCRWM QARD for the Spent Nuclear Fuel Project, QAPP-OCRWM-001, Rev. 4, Fluor Daniel Hanford, Richland, Washington.

DOE/RW/0333P, *Office of Civilian Radioactive Waste Management Quality Assurance Requirements and Description.*

Figure 1. Conical Particulate Pile in Relation to Fuel Assembly—Overall View

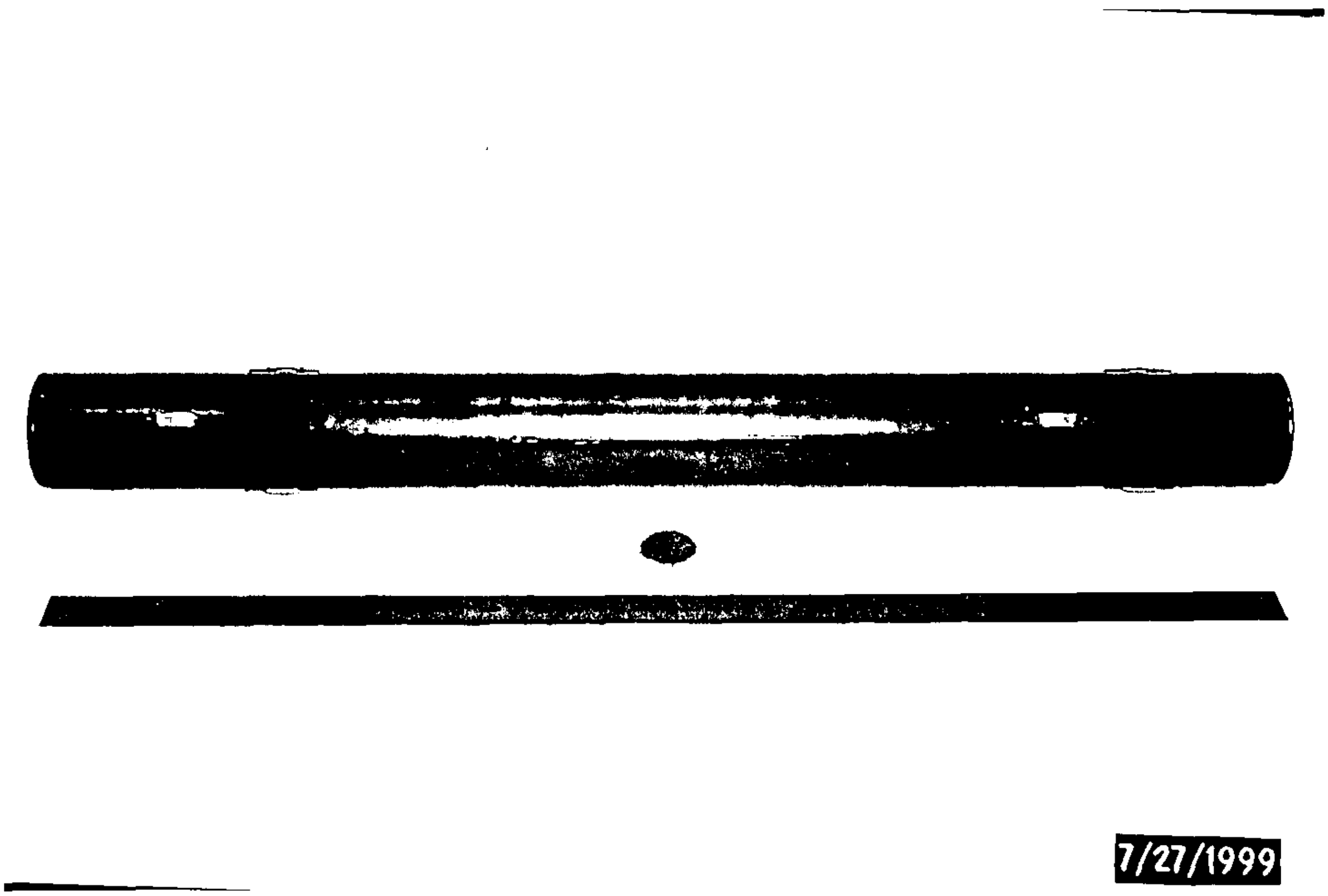


Figure 2. Conical Particulate Pile in Relation to Fuel Assembly—End View

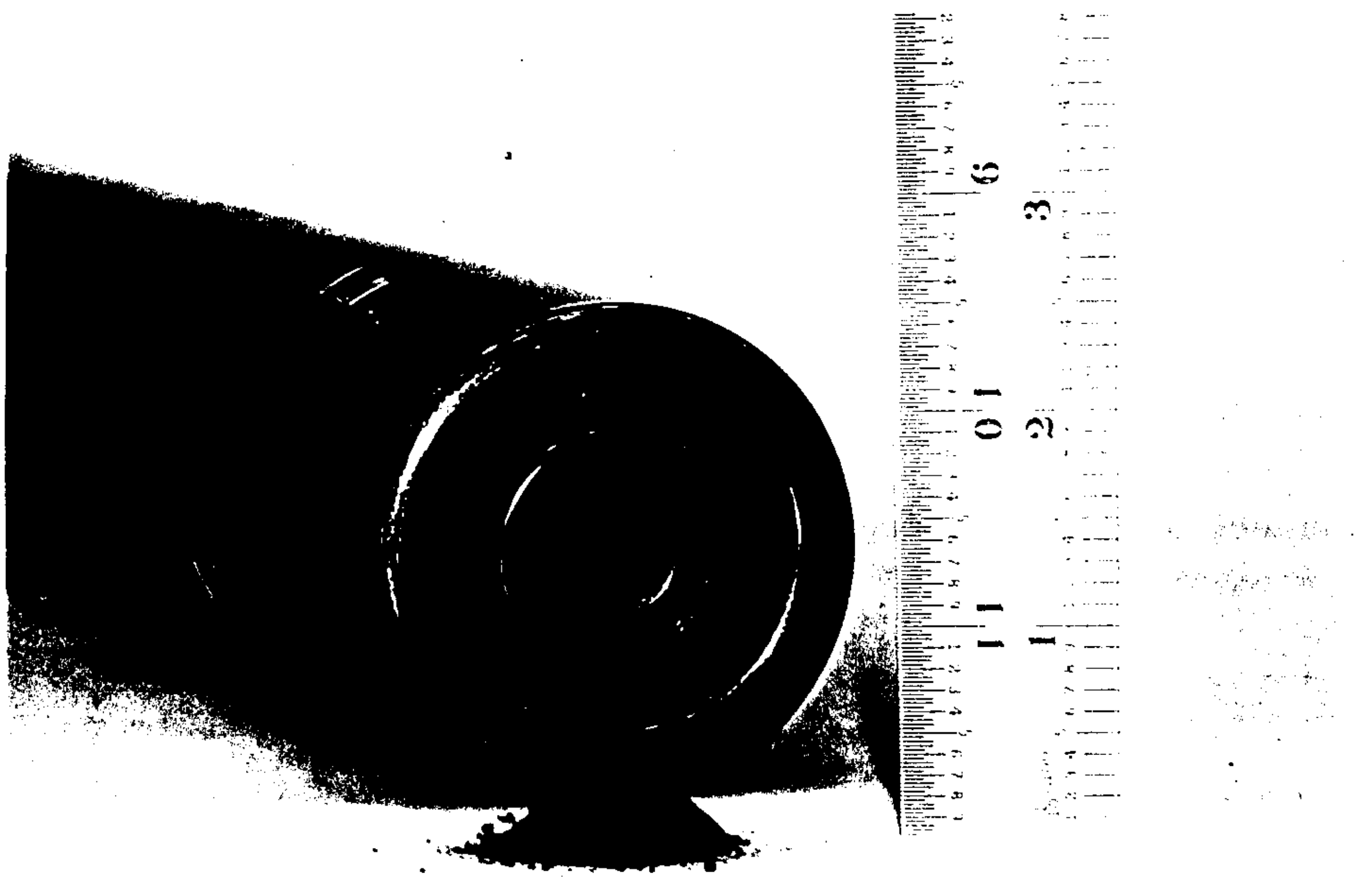


Figure 3. Conical Particulate Pile—Close-up

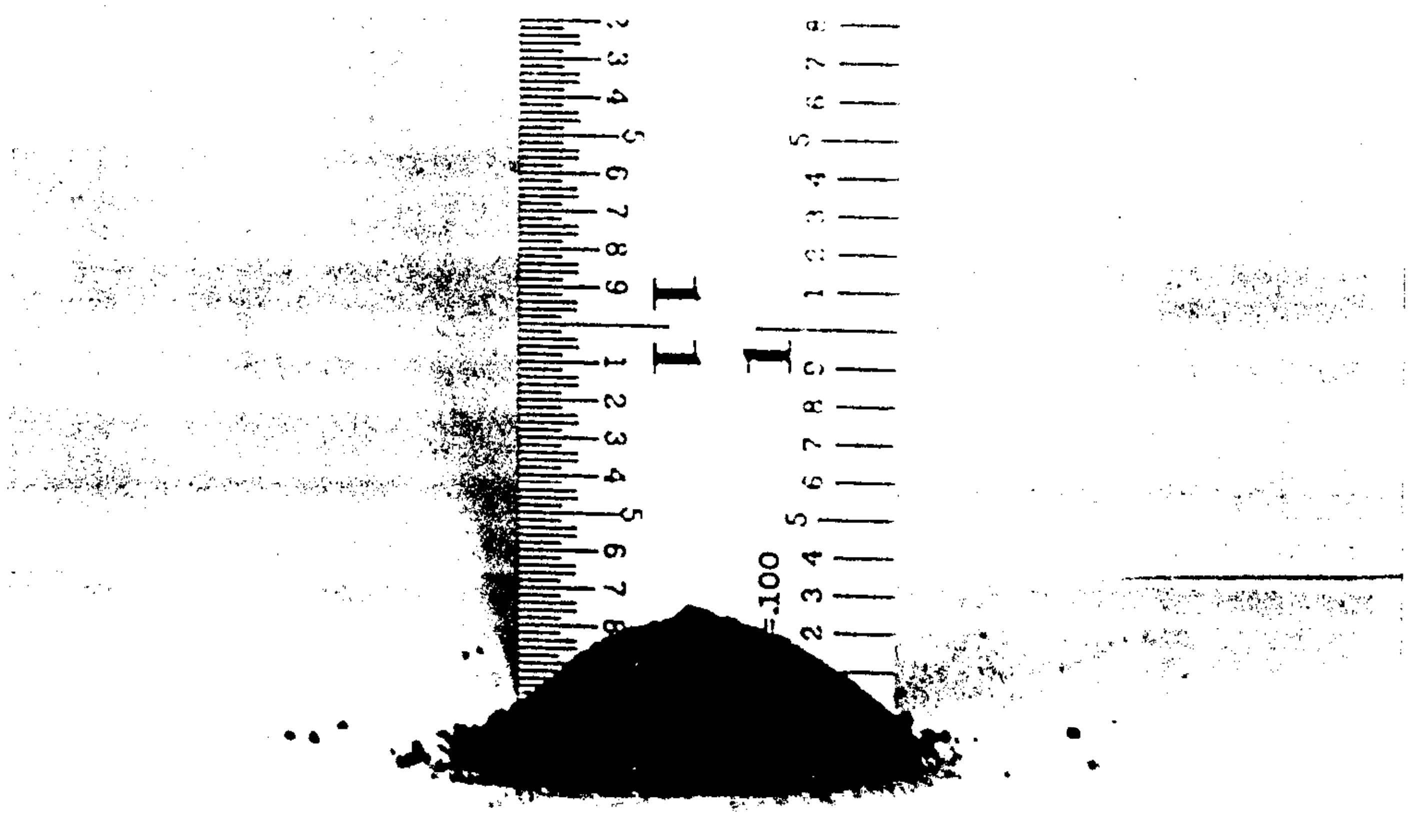


Figure 4. Particulate Pile in 1-inch Long Prismatic Configuration

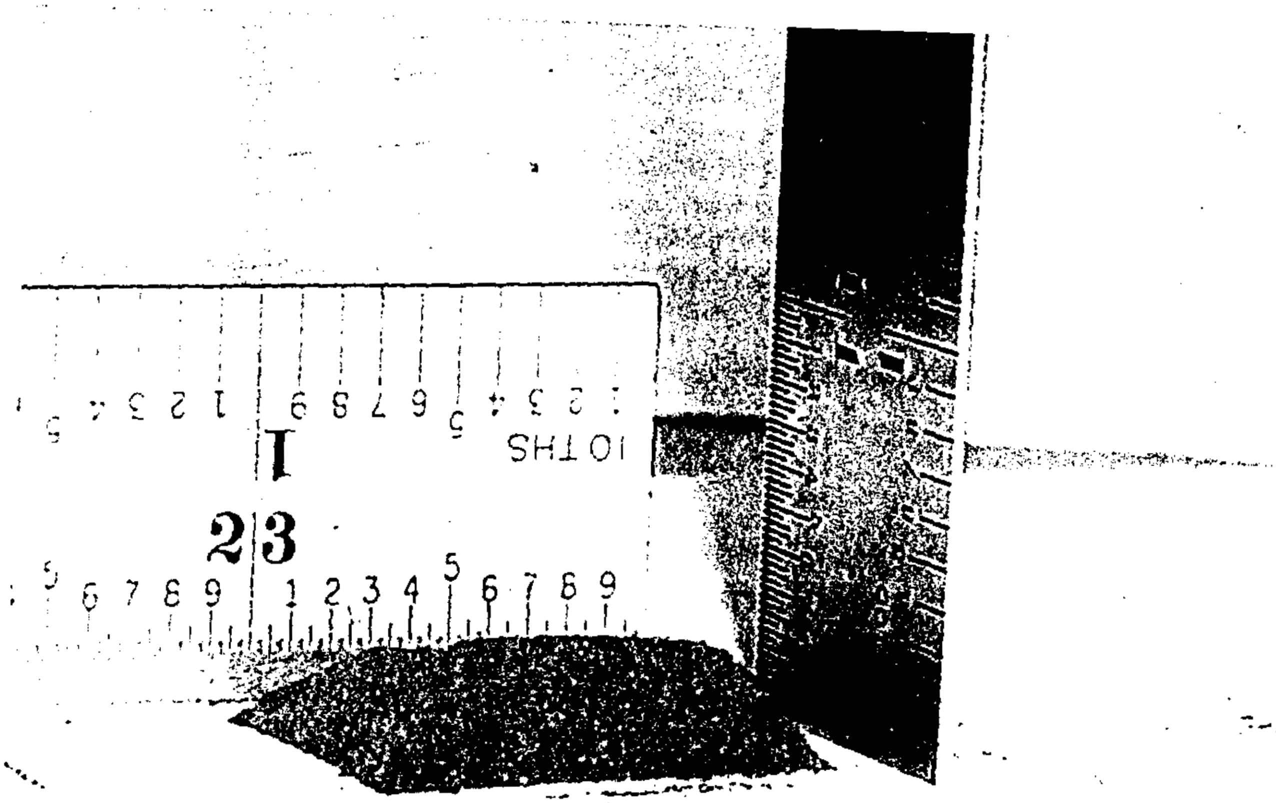


Figure 5. Particulate Pile in 2-inch Long Prismatic Configuration

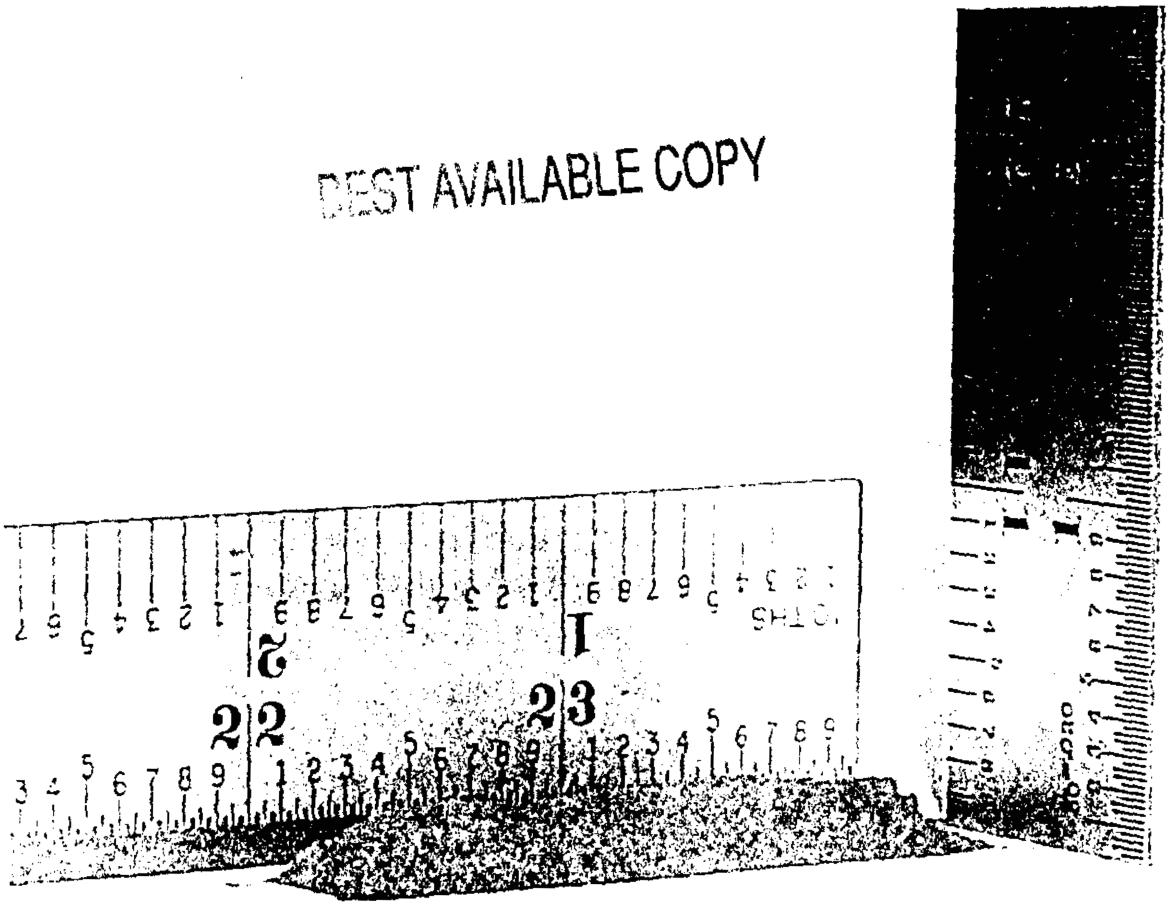


Figure 6. Schematic of Canister Sludge Collection Tray

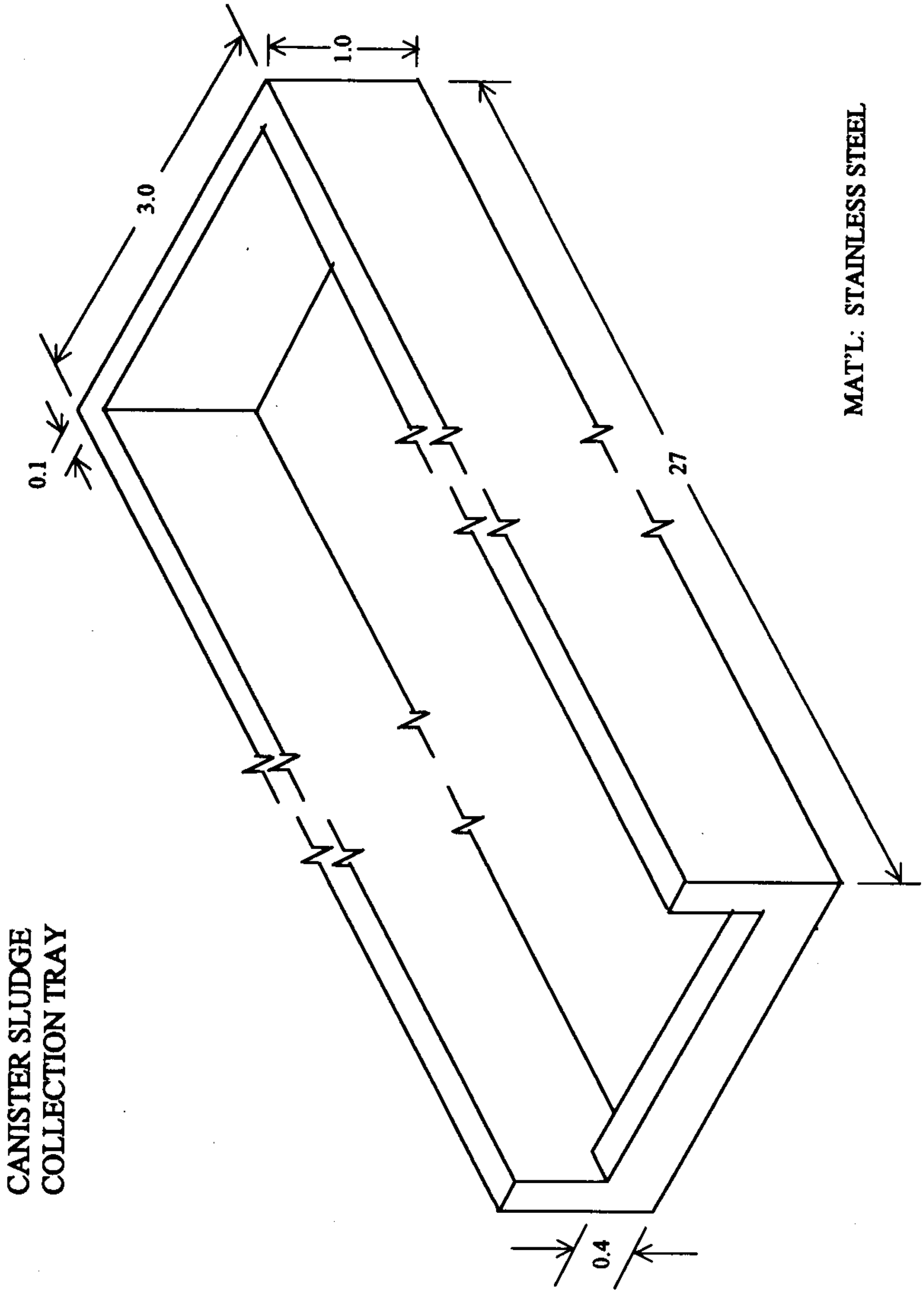
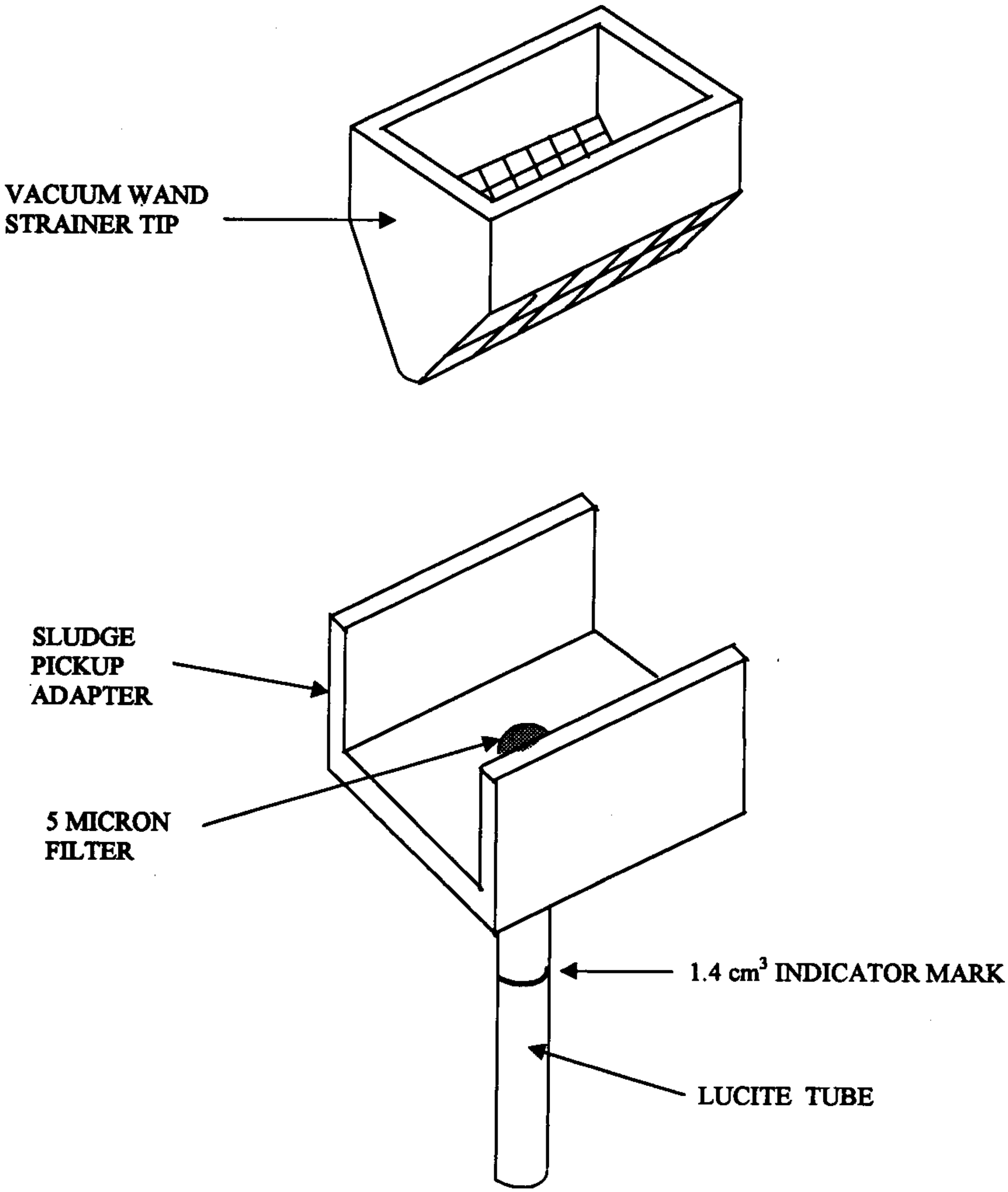


Figure 7. Sludge Pickup Adapter for Particulate Volume Assessment



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