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FIELD SAMPLING AND ANALYSIS PLAN

BUILDING 121 REMEDIATION
U.S. NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Prepared for:

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1.0 PURPOSE AND WORK DESCRIPTION

1.1 PURPOSE

OHM Remediation Services Corp. (OHM), a subsidiary of OHM Corporation, is contracted by the U.S. Department of the Navy (LANTDIV) to provide remediation of Building 121 at U.S. Naval Station Roosevelt Roads, Cieba, Puerto Rico.

The purpose of this Field Sampling and Analysis Plan (FSAP) is to present the procedures, organization, and responsibilities for collecting and handling field samples, sample and analytical documentation, performing field tests, and performing laboratory analytical testing. This FSAP is prepared in accordance with the requirements of NAVFAC Specification No. 05-93-3199 (as amended), Section 02225 - Part 3.3.

1.2 WORK DESCRIPTION

The scope of work for the remediation of Building 121 generally includes: preparation of various pre-construction, construction, and post-construction plans and submittals; attendance and participation at pre-construction and various other meetings; mobilization and demobilization; site preparation; cleaning the interior surfaces of Building 121; various sampling and analyses for air, soil, water, and concrete media; removing a portion of the concrete from the surface of the building floor; excavating contaminated soil outside the building; transportation and disposal of generated hazardous and non-hazardous wastes; erosion and sediment control; health and safety control; quality control; site restoration; and incidental work.

Further discussion of the work and its implementation can be found in the OHM Work Plan, Equipment Decontamination Plan, and Waste Transportation and Disposal Plan.

2.0 ORGANIZATION AND RESPONSIBILITIES

2.1 ORGANIZATION

The project is organized as shown in Figure 1.

2.2 RESPONSIBILITIES

The responsibilities of the program manager, project manager, project superintendent, QC manager, certified industrial hygienist, and site health and safety officer are as provided in the Basic Contract: Section C, Part 1.3.

The responsibilities of the Sample Technician include the proper collection of all non-health and safety related project samples, sample tracking, sample preservation and handling, sample shipping, proper care and maintenance of sampling equipment, sampling equipment decontamination, and all sampling related documentation. The Sample Technician is responsible for submitting the analytical data to the Navy Technical Representative following review and approval by the project superintendent. Basically, the Sample Technician is responsible for the implementation of this FSAP.

Sample Technicians are required by OHM to have a college degree or substantive technical experience and successfully complete a comprehensive in-house training course on hazardous waste sampling techniques and protocols prior to field assignments. The Sample Technician works under the direct supervision of the project superintendent. The Sample Technician may supervise the collection of samples by assistants in the field and is responsible for assuring the correct sampling procedures are followed.

3.0 BUILDING FLOOR WIPE SAMPLES

3.1 FIRST HIGH-PRESSURE WIPE SAMPLES

Initially, the building floor, ceiling, and walls will be cleaned by scrubbing with detergent to remove accumulated dust and dirt. No wipe samples are taken before or immediately after this initial scrubbing.

Following the initial scrubbing, the first high-pressure washing with detergent will be done. After this first high-pressure washing and the subsequent rinsing is completed, collect 8 wipe samples from the building floor at the locations shown in Figure 6. Collect the wipe samples as described in Section 3.5 and follow the sample handling procedures in Section 10.0, except:

- These samples will be retained on site or at the laboratory
- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

3.2 SECOND HIGH-PRESSURE WIPE SAMPLES

Following the first high-pressure washing and rinsing, the second high-pressure washing and rinsing will be done. After this second high-pressure washing and the subsequent rinsing is completed, collect 8 wipe samples from the building floor at the locations shown in Figure 6. Collect the wipe samples as described in Section 3.5 and follow the sample handling procedures in Section 10.0, except:

- These samples will be retained on site or at the laboratory
- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

3.3 THIRD HIGH-PRESSURE WIPE SAMPLES

Following the second high-pressure washing and rinsing, the third, and final, high-pressure washing and rinsing will be done. After this third high-pressure washing and the subsequent rinsing is completed, collect 8 wipe samples from the building floor at the locations shown in Figure 6. Collect the wipe samples as described in Section 3.5 and follow the sample handling procedures in Section 10.0 below.

Send these samples to the analytical laboratory to be tested for the parameters given in Table 1. These samples are Rapid-TAT-Urgent. They must be tested in the shortest turnaround time possible and the results are to be telephoned to the project superintendent (either at the project site or hotel) the as soon as they are available. Be sure to write these instructions and the site/hotel telephone numbers in the comments section of the Chain-of-Custody (COC) form. Contact the analytical laboratory when high-pressure washing operations begin and again the day before this sampling event to notify the laboratory of the required turnaround time. Notify the project superintendent if there are any anticipated problems with the laboratory meeting these schedule requirements.

3.4 POST-SCABBLING WIPE SAMPLES

After scabbling of the building floor is completed, collect 8 wipe samples from the building floor at the locations shown in Figure 6. Collect the wipe samples as described in Section 3.5 and follow the sample handling procedures in Section 10.0 below. Send these samples to the analytical laboratory to be tested for the parameters in Table 1. These samples are to be tested on a 7-day turnaround time. If the results will not be available prior to site demobilization, arrange for the results to be delivered to the OHM project manager.

3.5 WIPE SAMPLE COLLECTION METHOD

The Sample Technician will have the sample jars and other equipment ready for use upon completion of the rinsing work. Be prepared for four wipe sampling events (three high-pressure cleanings and post-scabbling) and allow extra materials for four QC samples, breakage or other losses. The required equipment for one sampling event (eight wipe samples) includes the following:

- Eight pair of new latex gloves
- Eight 1-liter, glass bottles with Teflon-lined caps, each containing 1 liter of laboratory grade, organic free deionized (OFDI) water
- Commercially available, untreated cotton gauze pads
- Eight pre-cleaned, 1-liter, amber glass bottles with Teflon-lined caps

- Photocopy of Figure 6 to record sample number by sampling location
- COC forms, labels, custody seals, shipping shuttle, ice, steel tape, markers.

Use a steel tape to locate each of the sample collection areas and **LIGHTLY** mark the boundaries on the floor with a wax crayon (e.g., Mean Streak). Put on a new pair of latex gloves. For each of the eight floor wipe samples, dip a cotton gauze pad into a new bottle of OFDI water and wipe the concrete with firm strokes inside the boundaries of the sampling area. Place the used pads into the second pre-cleaned amber glass sample collection bottle. Repeat the wiping process until all the OFDI water is used. Keep both glass bottles closed except when moistening or placing the pads. Dispose of used latex gloves as hazardous waste.

Label each of the eight floor wipe sample collection bottles with the sample number, project number, sample person's initials, date and time of sampling at a minimum. Place a custody seal over the cap of each sample collection bottle. For each sample collected, clearly and legibly document the dimensions of the area wiped and the sample number on the photocopy of Figure 6 and retain for inclusion in the sampling report. For each sampling event, prepare a brief sampling report (standard form or 1 page typed or less) describing the sampling event (number and type of samples, dates, who collected samples, reference procedures used and any deviations, sample handling and shipment, analytics required, QC samples, etc). Attach the Figure 6, a copy of the COC form, and other pertinent information and give the report to the project superintendent on or before the following work day.

3.6 CLEANING WIPE QUALITY CONTROL SAMPLES

All high-pressure cleaning wipe samples (3 events x 8 samples = 24 samples) will be shipped together at the same time to the analytical laboratory after collecting the floor wipe samples following the third high-pressure cleaning operations. They will be accompanied by one trip blank sample and one field blank sample. Both the trip blank and field blank will be tested for the parameters given in Table 1.

3.6.1 Cleaning Wipe Samples Trip Blank

Arrange for one bottle of OFDI water to be sent to the project site from the analytical laboratory to become the trip blank. It will be left sealed (unopened) from the laboratory, labeled as the Cleaning Wipe Samples Trip Blank, and returned unopened with the other wipe samples to the analytical laboratory. It is to be tested for the parameters in Table 1. The cleaning wipe sample testing results will be invalid without a valid trip blank. Include the Cleaning Wipe Samples Trip Blank on the COC form.

3.6.2 Cleaning Wipe Samples Field Blank

Prepare a field blank by obtaining a new bottle of OFDI water, put on the ninth pair of latex sample gloves, dip new gauze pads into the OFDI water, and place the wetted pads directly into a pre-cleaned amber glass sample collection bottle without contacting the floor or anything else. Continue until all of the OFDI water is transferred by gauze pads into the sample collection bottle. Label this sample bottle as the Cleaning Wipe Samples Field Blank and put a custody seal on it. Send it to the analytical laboratory with the Cleaning Wipe Samples Trip Blank and the 24 other wipe samples. It is to be tested for the parameters in Table 1. The cleaning sample testing results will be invalid without a valid field blank. Include the Cleaning Wipe Samples Field Blank on the COC form.

3.7 POST-SCABBLING WIPE QUALITY CONTROL SAMPLES

All post-scabbling wipe samples (1 event x 8 samples = 8 samples) will be shipped together at the same time to the analytical laboratory after being collected. They will be accompanied by one trip blank sample and one field blank sample. Both the trip blank and field blank will be tested for the parameters given in Table 1.

3.7.1 Post-Scabbling Wipe Samples Trip Blank

The Sample Technician will arrange for one bottle of OFDI water to be sent to the project site from the analytical laboratory to become the trip blank. It will be left sealed (unopened) from the laboratory, labeled as the Post-Scabbling Wipe Samples Trip Blank, and returned unopened with the other wipe samples to the analytical laboratory. It is to be tested for the parameters in Table 1. The post-scabbling wipe sample testing results will be invalid without a valid trip blank. Include the Post-Scabbling Wipe Samples Trip Blank on the COC form.

3.7.2 Post-Scabbling Wipe Samples Field Blank

Prepare a field blank by obtaining a new bottle of OFDI water, put on the ninth pair of latex sample gloves, dip new gauze pads into the OFDI water, and place the wetted pads directly into a pre-cleaned amber glass sample collection bottle without contacting the floor or anything else. Continue until all of the OFDI water is transferred by gauze pads into the sample collection bottle. Label this sample bottle as the Post-Scabbling Wipe Samples Field Blank and put a custody seal on it. Send it to the analytical laboratory with the Post-Scabbling Wipe Samples Trip Blank and the 8 other wipe samples. It is to be tested for the parameters in Table 1. The post-scabbling sample testing results will be invalid without a valid field blank. Include the Post-Scabbling Wipe Samples Field Blank on the COC form.

4.0 CLEANING WASH AND RINSE WATER SAMPLES

4.1 INITIAL SCRUB WASH WATER SAMPLE

The initial scrubbing wash waters will be collected into labeled drums. After all wash waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below, except:

- These samples will be retained on site or at the laboratory
- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

4.2 INITIAL SCRUB RINSE WATER SAMPLE

The rinse waters from the initial scrubbing will be collected into labeled drums. After all rinse waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below, except:

- These samples will be retained on site or at the laboratory
- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

4.3 FIRST HIGH-PRESSURE WASH WATER SAMPLE

Wash waters will be collected into labeled drums. After all wash waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below, except:

- These samples will be retained on site or at the laboratory

- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

4.4 FIRST HIGH-PRESSURE RINSE WATER SAMPLE

Rinse waters will be collected into labeled drums. After all rinse waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below, except:

- These samples will be retained on site or at the laboratory
- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

4.5 SECOND HIGH-PRESSURE WASH WATER SAMPLE

Wash waters will be collected into labeled drums. After all wash waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below, except:

- These samples will be retained on site or at the laboratory
- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

4.6 SECOND HIGH-PRESSURE RINSE WATER SAMPLE

Rinse waters will be collected into labeled drums. After all rinse waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below, except:

- These samples will be retained on site or at the laboratory
- These samples will be retained under the conditions given in Table 4
- Only upon instruction from the client will these samples will be analyzed
- If these samples are analyzed, they will be tested for the parameters of Table 1.

4.7 THIRD HIGH-PRESSURE WASH WATER SAMPLE

Wash waters will be collected into labeled drums. After all wash waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below. This sample will be sent to the analytical laboratory and tested for the parameters given in Table 1. These samples are to be tested on a 3-day rapid turnaround time and the results telephoned to the site as soon as they are available.

4.8 THIRD HIGH-PRESSURE RINSE WATER SAMPLE

Rinse waters will be collected into labeled drums. After all rinse waters have been drummed, collect one composite sample following the procedures described in Sections 4.9 and 10.0 below. This sample will be sent to the analytical laboratory and tested for the parameters given in Table 1. These samples are to be tested on a 3-day rapid turnaround time and the results telephoned to the site as soon as they are available.

4.9 DRUMMED CLEANING WATER SAMPLING METHOD

The Sample Technician will have the sample jars and other equipment ready for use upon completion of the rinse work. Be prepared for four cleaning water sampling events (two samples per event) and allow extra materials for two QC samples, breakage or other losses. The required equipment for one sampling event (one wash water sample, one rinse water sample) includes the following:

- Two pair of latex sample gloves
- Two glass dip tubes
- Two 1-liter, pre-cleaned, amber glass bottles with Teflon-lined lids
- COC forms, labels, custody seals, drum log, shipping shuttle, ice.

Identify the drums to be sampled and put on one pair of latex sample gloves. Insert one dip tube into a wash water drum, firmly place a finger over the upper end of the dip tube and withdraw the dip tube from the drum. While maintaining firm finger pressure, place the lower end of the dip tube into the amber sample collection bottle and release finger pressure allowing the sample to flow into the sample collection bottle. Repeat the process for each wash water drum to form a composite sample until the sample collection bottle is completely full (no air bubble). Put on a new pair of latex gloves and repeat this procedure using a new dip tube to collect one composite sample from the rinse water drums. Discard the used dip tubes and latex gloves as hazardous wastes.

Label each of the sample collection bottles with the sample number, project number, sample person's initials, date and time of sampling at a minimum. Place a custody seal over the cap of each sample collection bottle. For each sampling event, prepare a brief sampling report (standard form or 1 page typed or less) describing the sampling event (number and type of samples, dates, who collected samples, reference procedures used and any deviations, sample handling and shipment, analytics required, QC samples, etc). Attach a copy of the COC form, drum log, and other pertinent information and give the report to the project superintendent on or before the following work day.

4.10 CLEANING WATER QUALITY CONTROL SAMPLES

All cleaning water samples (4 wash samples + 4 rinse samples = 8 samples) will be shipped to the analytical laboratory together at the same time following sample collections from the third high-pressure cleaning operations. They will be accompanied by one trip blank sample and one field blank sample. Both the trip blank and field blank will be tested for the parameters given in Table 1.

4.10.1 Cleaning Water Samples Field Blank

Prepare one field blank sample using a new dip tube and latex sampling gloves by following the procedure given in Section 4.9 above to sample a drum containing only potable water. Label this bottle as the Cleaning Water Samples Field Blank and place a custody seal on it. It will be sent to the analytical laboratory with the Cleaning Water Samples Trip Blank and other cleaning water samples. It will be tested for the parameters given in Table 1. The cleaning water testing results are invalid without a valid field blank. Include the Cleaning Water Samples Field Blank on the COC form.

4.10.2 Cleaning Water Samples Trip Blank

The Sample Technician will arrange for the analytical laboratory to ship to the project site a sealed amber glass bottle containing 1 liter of OFDI water to be used as a trip blank. Label this bottle as the Cleaning Water Samples Trip Blank and leave it unopened. It will be shipped with the Cleaning Water Samples Field Blank and other cleaning water samples to the analytical laboratory. It will be tested for the parameters given in Table 1. The cleaning water testing results will be invalid without a valid trip blank. Include the Cleaning Water Samples Trip Blank on the COC form.

5.0 CHIP SAMPLES

5.1 FLOOR CHIP SAMPLES

Upon completion of all floor, ceiling, and wall cleaning events, perform chip sample collection. Collect 13 chip samples from the building floor as described in Section 5.7 and at the locations shown on Figure 3. Send the sample to the analytical laboratory and test it for the parameters given in Table 2.

5.2 CEILING CHIP SAMPLE

Upon completion of all floor, ceiling, and wall cleaning events, perform chip sample collection. Collect one chip sample from the building ceiling as described in Section 5.7 and at the locations shown on Figure 3. Send the sample to the analytical laboratory and test it for the parameters given in Table 2.

5.3 NORTH WALL CHIP SAMPLE

Upon completion of all floor, ceiling, and wall cleaning events, perform chip sample collection. Collect one chip sample from the building north wall as described in Section 5.7 and at the locations shown on Figure 4. Send the sample to the analytical laboratory and test it for the parameters given in Table 2.

5.4 SOUTH WALL CHIP SAMPLE

Upon completion of all floor, ceiling, and wall cleaning events, perform chip sample collection. Collect one chip sample from the building south wall as described in Section 5.7 and at the locations shown on Figure 4. Send the sample to the analytical laboratory and test it for the parameters given in Table 2.

5.5 EAST WALL CHIP SAMPLE

Upon completion of all floor, ceiling, and wall cleaning events, perform chip sample collection. Collect one chip sample from the building east wall as described in Section 5.7 and at the locations shown on Figure 5. Send the sample to the analytical laboratory and test it for the parameters given in Table 2.

5.6 WEST WALL CHIP SAMPLE

Upon completion of all floor, ceiling, and wall cleaning events, perform chip sample collection. Collect one chip sample from the building west wall as described in Section 5.7 and at the locations shown on Figure 5. Send the sample to the analytical laboratory and test it for the parameters given in Table 2.

5.7 CHIP SAMPLING METHOD

The Sample Technician will have the sample jars and other equipment ready for use upon completion of all cleaning events. Be prepared for 18 chip samples and allow extra materials for breakage or other losses. The required equipment for one chip sample event includes the following:

- Steel chisel and hammer, or power chisel tool
- Plastic sheet (e.g., Visqueen)
- Face shield and safety glasses or goggles
- Heavy canvas or leather work gloves
- Eighteen pre-cleaned, 8-ounce, glass bottles with Teflon-lined caps
- Photocopies of Figures 3, 4, and 5 to record sample number and locations
- COC forms, labels, custody seals, shipping shuttle, ice, steel tape, markers.

Use a steel tape to locate each of the sample collection areas and mark corners of the grid location with a wax crayon (e.g., Mean Streak). Place plastic sheet on floor so that the concrete chips will be collected. Put on a work gloves and face shield. Place the chisel at the approximate center of the sample location and knock out chips of concrete. Collect chips from the plastic sheet and place into the bottle. Continue work around the center area until the 1/2-liter bottle is full of chips. Decontaminate, or use a new chisel, between samples as described in the Decontamination Plan.

Label each of the eighteen chip sample collection bottles with the sample number, project number, sample person's initials, date and time of sampling at a minimum. Place a custody seal over the cap of each sample collection bottle. For each sample collected, clearly and legibly document the location of the area sampled and the sample number on the photocopies of Figures 3, 4, or 5 and retain for inclusion in the sampling report. For each sampling event, prepare a brief sampling report (standard form or 1 page typed or less) describing the sampling event (number and type of samples, dates, who collected samples, reference procedures used and any deviations, sample handling and shipment, analytics required, QC samples, etc). Attach the figures, a copy of the COC, and other pertinent information and give the report to the project superintendent on or before the following work day.

6.0 SOIL CHEMICAL SAMPLES

6.1 INITIAL SITE SOIL CHEMICAL SAMPLES

Collect seven soil samples to a depth of 12 inches following the procedures of Sections 6.5.1 and 10.0 below at the locations shown on Figure 7. Ship each sample to the analytical laboratory for testing of the parameters given in Table 1.

6.2 CONTAINERIZED SITE SOIL CHEMICAL SAMPLE

Collect one composite soil sample of the excavated soil from the soil containers (intermodal box) following the procedures of Sections 6.5.2 and 10.0 below. Ship the sample to the analytical laboratory for testing of the parameters given in Table 2.

6.3 VERIFICATION SITE SOIL CHEMICAL SAMPLES

After soil excavation and prior to placement of backfill, collect seven soil samples to a depth of 12 inches following the procedures of Section 6.5.1 and 10.0 below at the locations shown on Figure 7. Ship each sample to the analytical laboratory for testing of the parameters given in Table 1.

6.4 BACKFILL SOIL CHEMICAL SAMPLE

Collect one composite soil sample from the source of soil backfill material using the procedures of Sections 10.0 and 6.5.1 or 6.5.2 as appropriate. Send the sample to the analytical laboratory for testing of the parameters given in both Tables 1 and 2. This sample is a Rapid Turnaround-Time and must be tested in the shortest time possible with the results delivered as soon as they are available. The Sample Technician will contact the laboratory to make these schedule arrangements and will notify the project superintendent if there are any anticipated problems.

6.5 SOIL CHEMICAL SAMPLING METHODS

Soil samples may be collected from either an in-situ (i.e., "bank") condition or from an ex-situ (i.e., "pile") condition. Refer to Appendix E for copies of field-related ASTM methods.

6.5.1 Bank Soil Sampling Method

Use a steel tape to grid the area to be sampled and place a pin-flag or other marker at the center of each individual sampling location. Use a hand auger technique from ASTM-D1452 "Standard Practice for Soil Investigation and Sampling by Auger Borings" to collect soil cores to the required depth. Place the soil cores into a stainless steel mixing bowl and thoroughly mix with stainless steel tools to break-up clods and provide a homogeneous mix. Collect sufficient soil to provide a 1-liter soil sample from the

homogeneous mix. Place the soil sample in a 1-liter glass bottle with Teflon-lined lid packing the soil to completely fill the bottle to the extent possible. Decontaminate the sampling auger, mixing bowl, and mixing tools between collection of each new sample following the procedures given in the Decontamination Plan.

Label each sample collection bottle with the sample number, project number, sample person's initials, date and time of sampling at a minimum. Place a custody seal over the cap of each sample collection bottle. For each sample collected, clearly and legibly document the location of the area sampled and the sample number on a photocopy of Figure 7, or a hand sketch of the location if it is off of the project site, and retain for inclusion in the sampling report. For each sampling event, prepare a brief sampling report (standard form or 1 page typed or less) describing the sampling event (number and type of samples, dates, who collected samples, reference procedures used and any deviations, sample handling and shipment, analytics required, etc). Attach the figures, a copy of the COC, and other pertinent information and give the report to the project superintendent on or before the following work day.

6.5.2 Pile Soil Sampling Method

Use a small hand shovel (or a hand auger technique from ASTM-D1452 "Standard Practice for Soil Investigation and Sampling by Auger Borings") to collect soil sub-samples to the specified depth or otherwise to a depth of 1 foot. Collect soil sub-samples from a minimum of five different locations around the circumference of the pile or as is sufficient to provide a representative soil sample. Place the soil sub-samples into a large stainless steel mixing bowl and thoroughly mix with stainless steel tools to break up clods and provide a homogeneous mix. Collect sufficient soil to provide a 1-liter soil sample from the homogeneous mix. Place the soil sample in a 1-liter glass bottle with Teflon-lined lid packing the soil to completely fill the bottle to the extent possible. Decontaminate the sampling auger, mixing bowl, and mixing tools between collection of each new sample following the procedures given in the Decontamination Plan.

Label each sample collection bottle with the sample number, project number, sample person's initials, date and time of sampling at a minimum. Place a custody seal over the cap of each sample collection bottle. For each sample collected, clearly and legibly document the location of the area sampled and the sample number on a photocopy of Figure 7, or a hand sketch of the location if it is off of the project site, and retain for inclusion in the sampling report. For each sampling event, prepare a brief sampling report (standard form or 1 page typed or less) describing the sampling event (number and type of samples, dates, who collected samples, reference procedures used and any deviations, sample handling and shipment, analytics required, etc). Attach the figures, a copy of the COC, and other pertinent information and give the report to the project superintendent on or before the following work day.

7.0 SOIL GEOTECHNICAL SAMPLES

7.1 BACKFILL SOIL GEOTECHNICAL SAMPLE

After an off-site backfill borrow source has been identified, collect a geotechnical bulk soil sample of the soil to be used as backfill following the procedures of Section 7.3 and 10.0, except:

- All geotechnical bulk soil samples will be preserved and transportation provided according to ASTM-D4220 "Standard Practices for Preserving and Transporting Soil Samples" - Group B samples

- If it is shipped to a laboratory off of Puerto Rico, the shipping container must have a U.S. Department of Agriculture shipping permit label affixed to the outside in order to pass through customs. Obtain this label from the geotechnical laboratory prior to sampling.

Send the sample to the geotechnical laboratory and have it tested for the following listed parameters on a rapid turnaround basis of 3 days or less from receipt. Have the results telephoned to the project site as soon as they are available.

- ASTM-D2487 "Classification of Soils for Engineering Purposes (USCS)"

- ASTM-D4318 "Liquid Limit, Plastic Limit, and Plasticity Index of Soils"

- ASTM-D1140 "Amount of Material in Soils Finer Than the No. 200 Sieve"

- ASTM-D698 "Laboratory Compaction Characteristics of Soils Using Standard Effort" with five points

- ASTM-D2216 "Laboratory Determination of Water (Moisture) Content of Soil and Rock" on the sample in the glass bottle or plastic bag.

7.2 EXISTING SUBGRADE SOIL SAMPLE

After the on-site contaminated soil has been completely excavated from the 30-foot-square area east of Building 121 including re-excavation if necessary and passing chemical verification analytical results, collect a geotechnical bulk soil sample.

Collect this sample by compositing auger cores collected near each corner and the center of the excavation. Otherwise, follow the procedures given in Sections 7.3, 6.5.1, and 10.0 as applicable. Ship this sample to the geotechnical laboratory and have it tested for the following listed parameters on a rapid turnaround basis of 3 days or less from receipt. Have the results telephoned to the project site as soon as they are available.

- ASTM-D698 "Laboratory Compaction Characteristics of Soils Using Standard Effort" with five points
- ASTM-D2216 "Laboratory Determination of Water (Moisture) Content of Soil and Rock" on the sample in the glass bottle or plastic bag.

7.3 GEOTECHNICAL BULK SOIL SAMPLING METHOD

Geotechnical soil samples are intended only for testing the physical engineering properties of the soil and are specifically not to be tested for any chemical parameters related to the remediation cleanup requirements for this project. The sample handling and collection procedures for geotechnical soil samples are insufficient for valid remediation chemical analyses.

Geotechnical bulk soil samples may be collected from either an in-situ (i.e., "bank") condition or from an ex-situ (i.e., "pile") condition. Follow the applicable procedures given in Section 6.5.1 or 6.5.2, except that decontamination of the sampling equipment will not be necessary. The equipment and materials required to obtain one geotechnical bulk sample include the following:

- Hand auger (Section 6.5.1) or small shovel (Section 6.5.2)
- Stainless steel mixing bowl (approximately 1-gallon capacity)
- Stainless steel mixing tools (e.g., trowel)
- Cardboard shipping box (1 cubic foot) with plastic liner
- One 8-ounce glass bottle with Teflon-lined lid
- COC form, labels, steel tape, pin-flags or markers, location map or Figure 7.

All geotechnical soil samples will be preserved and transportation provided according to ASTM-D4220 "Standard Practices for Preserving and Transporting Soil Samples" - Group B samples. Any soil sample shipped to a laboratory off of Puerto Rico, the shipping container must have a U.S. Department of Agriculture shipping permit label affixed to the outside in order to pass through customs. Obtain this label from the geotechnical laboratory prior to sampling.

Geotechnical bulk soil samples for ASTM-D698 testing require approximately 1/2 cubic foot of sample in a plastic lined box or glass or plastic jars. Soil samples for ASTM-2216 testing require an 8-ounce glass or plastic jar with Teflon-lined lid, or a similar soil sample volume in a sealed plastic bag, to preserve the existing moisture content. All other required geotechnical tests can be performed from these sample materials and additional sample quantities are not necessary.

Label each sample collection container with the sample number, project number, sample person's initials, date and time of sampling at a minimum. For each sample collected, clearly and legibly document the location of the area sampled and the sample number on a published map or hand sketch of the location if it is off of the project site, or on a photocopy of Figure 7 if it is on the project site, and retain for inclusion in the sampling report. For each sampling event, prepare a brief sampling report (standard form or 1 page typed or less) describing the sampling event (number and type of samples, dates, who collected samples, reference procedures used and any deviations, sample handling and shipment, analytics required, etc). Attach the figures, a copy of the COC, and other pertinent information and give the report to the project superintendent on or before the following work day.

8.0 EQUIPMENT DECONTAMINATION WATER SAMPLE

8.1 EQUIPMENT DECONTAMINATION RINSE WATER SAMPLE

Equipment wash waters and rinse waters will be collected into separate labeled drums. After all decontamination waters have been drummed, collect one composite sample from the FINAL DECON RINSE WATER DRUMS ONLY following the procedures described in Sections 8.2 and 10.0 below. This sample will be sent to the analytical laboratory and tested for the parameters given in Table 1. These samples are to be tested on a 3-day rapid turnaround time and the results telephoned to the site as soon as they are available. Refer to the Equipment Decontamination Plan for further information.

8.2 EQUIPMENT DECONTAMINATION RINSE WATER SAMPLING METHOD

The Sample Technician will have the sample jars and other equipment ready for use upon completion of the rinse work. Be prepared for one equipment decontamination rinse water sample and allow extra materials for two QC samples, breakage or other losses. The required equipment for one sampling event (one rinse water sample) includes the following:

- One pair of latex sample gloves
- One glass dip tube
- One 1-liter, pre-cleaned, amber glass bottles with Teflon-lined lid
- COC form, label, custody seal, drum log, shipping shuttle, ice.

Identify the drum(s) to be sampled and put on one pair of latex sample gloves. Insert one dip tube into a wash water drum, firmly place a finger over the upper end of the dip tube and withdraw the dip tube from the drum. While maintaining firm finger pressure, place the lower end of the dip tube into the amber sample collection bottle and release finger pressure allowing the sample to flow into the sample collection bottle. Repeat the process for each equipment decontamination rinse water drum to form a composite sample until the sample collection bottle is completely full (no air bubble). Discard the used dip tube and latex gloves as hazardous wastes.

Label the sample collection bottle with the sample number, project number, sample person's initials, date and time of sampling at a minimum. Place a custody seal over the cap of the sample collection bottle. Prepare a brief sampling report (standard form or 1 page typed or less) describing the sampling event (number and type of sample, date, who collected sample, reference procedure used and any deviations, sample handling and shipment, analytics required, QC samples, etc). Attach a copy of the COC, drum log, and other pertinent information and give the report to the project superintendent on or before the following work day.

8.3 EQUIPMENT DECONTAMINATION WATER QUALITY CONTROL SAMPLES

If possible, the equipment decontamination water sample will be shipped to the analytical laboratory together at the same time as the drummed cleaning water samples (Section 4.0 above) to minimize the need for additional QC samples. If this is not feasible, the equipment decontamination water sample must be accompanied by one new trip blank sample and one new field blank sample. Both the trip blank and field blank will be tested for the parameters given in Table 1.

8.3.1 Equipment Decontamination Water Sample Field Blank

If necessary, prepare one field blank sample using a new dip tube and latex sampling gloves by following the procedure given in Section 4.9 above to sample a drum containing only potable water. Label this bottle as the Equipment Decontamination Water Sample Field Blank and place a custody seal on it. It will be sent to the analytical laboratory with the Equipment Decontamination Water Sample Trip Blank and equipment decontamination water sample. It will be tested for the parameters given in Table 1. The equipment decontamination water testing results are invalid without a valid field blank. Include the Equipment Decontamination Water Sample Field Blank on the COC form.

8.3.2 Equipment Decontamination Water Sample Trip Blank

If necessary, the Sample Technician will arrange for the analytical laboratory to ship to the project site a sealed amber glass bottle containing 1 liter of OFDI water to be used as a trip blank. Label this bottle as the Equipment Decontamination Water Sample Trip Blank and leave it unopened. It will be shipped with the Equipment Decontamination Water Sample Field Blank and the equipment decontamination water sample to the analytical laboratory. It will be tested for the parameters given in Table 1. The equipment decontamination water sample testing results will be invalid without a valid trip blank. Include the Equipment Decontamination Water Sample Trip Blank on the COC form.

9.0 HEALTH AND SAFETY SAMPLES

Various personnel and perimeter air sample collection and laboratory analyses will be performed as described in the Health and Safety Plan. These samples will be collected by the site health and safety officer and are not the responsibility of the Sample Technician. Refer to the Health and Safety Plan for further information on air monitoring samples. The health and safety laboratory is identified in Section 12.3 and their Statement of Qualifications is provided in Appendix D.

10.0 SAMPLE HANDLING PROCEDURES

The purpose of this section is to establish the procedures to be implemented for sample shipment. The basis for all procedures is understood to follow the Quality Control Plan. The following sections describe:

- Sample containers
- Sample preservation
- Sample chain-of-custody procedures.

10.1 SAMPLE CONTAINERS

Different types of containers will be used to collect samples for the sampling media including:

- Glass 8-ounce bottles with Teflon-lined caps (soil and chip samples)
- Glass 1-liter bottles with Teflon-lined cap (water, wipe, and soil samples)
- Polyethylene 1-liter and 500-ml bottles with plastic lids (soil samples)
- Plastic-lined cardboard boxes (soil samples).

The laboratory will provide cleaned containers prior to shipment to the field. Sample preservation, containers, and sample holding times are summarized in Table 4.

10.2 SAMPLE PRESERVATION

The purpose of sample preservation is to prevent or retard the degradation/transformation of chemicals in the sample during transport and storage. The samples will be preserved in the field at the time they are taken. Table 4 lists preservation requirements for the samples.

All sample containers will be filled as completely as possible to minimize headspace. Except for bulk geotechnical soil samples, samples will be stored and shipped to the laboratory at 4 degrees Celsius.

10.3 SAMPLE SHIPMENT

All samples will be shipped to the laboratory either by hand delivery or express overnight air service so that the sample is received at the laboratory within 24 hours from the close of business of the date the sample was collected. Sample shipment will comply with 49 CFR 100-199 as applicable for the transport of hazardous material/wastes.

10.4 SAMPLE TRACKING

The following will be used in the chain-of-custody process for sample tracking and field activities:

- Sample identification and labeling
- Sample chain-of-custody form
- Sample collection log.

10.4.1 Sample Identification and Labeling

All samples will be adequately marked for identification from the time of collection and packaging through shipping and storage. Marking will generally be made on the sample container (jar, bottle, etc.) but may be applied directly to the sample or on a tag or label attached to the sample or container, depending on the type of sample and its intended use. Sample identification will include, as appropriate:

- Project name and number: Building 121 Remediation No. 15591
- Sample number: 15591 - (unique number per sample)
- Sample location (e.g., depth or sample interval, and field coordinates)
- Sampling date and time
- The initials of the individual(s) performing the sampling
- Sample preservation used, if any.

10.4.2 Chain-of-Custody Record

Documentation of the sample chain-of-custody is provided by the use of a chain-of-custody record that includes the sampling location, the type and amount of samples collected, the date and time of sample collection, the name(s) of the person(s) responsible for sample collection, the date and time of all custody transfers, the signature of the persons relinquishing and accepting sample custody, laboratory request for analysis, and other pertinent information.

Chain-of-custody procedures document sample possession from the time of collection to disposal. A sample is considered in custody if it is:

- In one's physical possession
- In view, after being in physical possession
- In a locked area so that no one can tamper with it, after having been in physical custody
- In a secured area, restricted to unauthorized personnel.

A chain-of-custody record will be initiated in the field by the sample technician and will accompany each group of samples during shipment to the laboratory. Each time custody of the sample changes, the new custodian will sign the record and indicate the dates of transfer. An example of an OHM chain-of-custody record is included in Appendix A.

If the samples are shipped to the laboratory by commercial carrier, the original chain-of-custody form will be sealed in a water-tight container, placed in the shipping container, and the shipping container sealed prior to giving it to the carrier.

If the samples are directly transported to the laboratory, the original chain-of-custody form will be kept in possession of the person delivering the samples.

For samples shipped by commercial carrier, the waybill will serve as an extension of the chain-of-custody record between the final field custodian and receipt in the laboratory. (The carrier waybill number will be written on the chain-of-custody form. If the original chain-of-custody form is sealed in the shipping container before the waybill number is received, then this number will be written on the copy of the chain-of-custody form.)

Upon receipt in the laboratory, the receiving technician or representative will open the shipping containers, compare the contents with the chain-of-custody record, and sign and date the record. The receiving technician will also record the carrier and waybill number of the original chain-of-custody form, if it is not already present.

All original chain-of-custody records, analytical data, and other project documentation will be maintained in a project file. Project files will be stored in a central filing system pending disposition by the Navy.

A legible copy of the field chain-of-custody record will be maintained in the field office on site. Once samples are received in the laboratory, chain-of-custody records will be signed by a designated representative of the laboratory and copies of the signed chain-of-custody records will be submitted to the field office or other designated representative.

10.4.3 Sample Collection Log

A sample collection log is prepared for each sample to record information pertaining to the location and collection of a sample. The following information is required on the sample collection log, as appropriate:

- Unique sample number
- Sample location
- Collector's initials

- Date and time of sample collection
- Sample coordinates
- Sample identification (type, media, sequence, blank, spike, duplicate, split).

An example of a sample collection log is provided in Appendix A.

10.4.4 Laboratory Receipt

Upon sample receipt, the receiving technician or designee will:

- Examine all samples and determine if proper temperature has been maintained during shipment. The receiving temperature will be recorded on the chain-of-custody record. If samples have been damaged during shipment, the remaining samples will be carefully examined to determine whether they were affected. Any samples suspected of being affected will also be considered damaged. It will be noted on the chain-of-custody record what specific samples were damaged and that the samples were removed from the sampling program. Field personnel will be notified in writing as soon as possible of an estimate of the cause of damage, the samples that were damaged, and whether they must be resampled or the testing program revised.
- Compare samples received against those listed on the chain-of-custody record.
- Verify that sample holding times have not been exceeded. If the sample holding time has been exceeded, the receiving technician or designee will notify the field personnel by telephone that this has occurred and will follow up with a Nonconformance Report.
- Sign and date the chain-of-custody record and attach the waybill to the chain-of-custody record.
- Place the samples in adequate laboratory storage.
- Enter the samples in the laboratory sample log-in book which contains the following information:

  - Project identification number
  - Sample numbers
  - Type of samples
  - Date received in laboratory.

- Notify the analytical manager or group leaders of sample arrival.

- Place the completed chain-of-custody records in the project file.

If samples collected arrive without chain-of-custody or with incorrect chain-of-custody records, the following actions will be undertaken by the receiving technician:

- If the chain-of-custody record is incorrect, a memorandum to the project manager, site supervisor, manager of the laboratory, and appropriate field personnel is prepared stating the deviations. The memorandum must be signed and dated by the person originating the chain-of-custody and by the receiving technician. The memorandum will serve as an amendment to the chain-of-custody. If the information on the chain-of-custody record cannot be corrected by the receiving technician, the samples affected will be removed from the sampling program.

- If the chain-of-custody record is not shipped with the samples, the field personnel will be contacted and a memorandum prepared which lists the persons involved in collecting, shipping, and receiving the samples and the times, dates, and events. Each person involved must sign and date this memorandum. The completed memorandum will be maintained in lieu of the chain-of-custody record.

11.0 ON-SITE FIELD TESTING

11.1 EXISTING SUBGRADE COMPACTION TESTING

After the on-site contaminated soil has been completely excavated from the 30-foot-square area east of Building 121 including re-excavation if necessary and passing chemical verification analytical results (Section 6.3), perform a minimum of two tests to determine the existing in-place density of the subgrade.

This testing may be performed by the Sample Technician if qualified, otherwise it will be performed by a qualified geotechnical testing subcontractor. Perform the testing using one of the following methods:

- ASTM-D1556 "Density and Unit Weight of Soil In-Place by the Sand-Cone Method"
- ASTM-D2922 "Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)" including mandatory calibration by ASTM-D1556.

11.2 BACKFILL SOIL COMPACTION TESTING

Following placement of the backfill soil into the excavation, perform a minimum of two tests to determine the in-place density of the placed backfill.

This testing may be performed by the Sample Technician if qualified, otherwise it will be performed by a qualified geotechnical testing subcontractor. Perform the testing using one of the following methods:

- ASTM-D1556 "Density and Unit Weight of Soil In-Place by the Sand-Cone Method"
- ASTM-D2922 "Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)" including mandatory calibration by ASTM-D1556.

12.0 LABORATORIES

12.1 GEOTECHNICAL LABORATORY

The geotechnical laboratory for this project is Geotechnics, Inc., and their address is:

Geotechnics
P.O. Box 10623
11628 Frankstown Road
Pittsburgh, PA 15235
(412) 243-0333
Point of Contact: Dave Backstrom

Geotechnics is accredited by the American Association of State Highway and Transportation Officials (AASHTO) and is permitted by the U.S. Department of Agriculture (USDA) to receive overseas shipments of soil samples. Their statement of qualifications is provided in Appendix B.

12.2 ANALYTICAL LABORATORY

The analytical laboratory for testing contaminated media samples on this project is Beckton Environmental Laboratories, Inc., and their address is:

Beckton Environmental Laboratories, Inc.
192 Villa Street
Ponce, Puerto Rico 00731
(809) 841-7373
Point of Contact: Rafael Infante

Their Statement of Qualifications is provided in Appendix C.

12.3 HEALTH AND SAFETY LABORATORY

The laboratory providing testing of samples required by the Health and Safety Plan is MDS Laboratories, and their address is:

MDS Laboratories
4418 Pottsville Pike
Reading, PA 19605
(215) 921-8833
Point of Contact: Dave Shirey

Their Statement of Qualifications is provided in Appendix D.

TABLES

TABLE 1

PARAMETERS FOR ANALYSIS
BUILDING 121 REMEDIATION

Parameter	*SW-846 Method*	*Water Action Level (mg/l)*	*Water PQL (mg/l)*	*Soil Action Level (mg/kg)*	*Soil PQL (mg/kg)*	*Wipe Action Level (mg/100 cm²)*	*Wipe PQL (mg/100 cm²)*
2,4-D	8150	0.1	(1)	800	(1)	(2)	(1)
Copper Arsenite (3)	7061	0.05	(1)	80	(1)	(2)	(1)
Ethylene Bromide (3)	8010	4×10^{-7} (4)	(1)	0.008	(1)	(2)	(1)
Calcium Cyanide (3)	9010	1.0	(1)	300	(1)	(2)	(1)
Chlordane (5%)	8080	3×10^{-5} (4)	(1)	0.5	(1)	(2)	(1)
Zinc Phosphide (3)	6010	0.01	(1)	20	(1)	(2)	(1)

Notes:

(1)PQL - Practical Quantification Limit, to be provided by the analytical laboratory,

(2)To be provided by LANTDIV.

(3)Analytical laboratory reporting for this parameter will be in terms of elemental constituents.

(4)These values to be revised by LANTDIV.

TABLE 2

PARAMETERS FOR TCLP ANALYSIS
BUILDING 121 REMEDIATION

Parameter	*SW-846 Method*	*PQL (mg/l)*	*Regulatory Level (mg/l)*
Arsenic	6010	(1)	5.0
Barium	6010	(1)	100.0
Cadmium	6010	(1)	1.0
Chromium	6010	(1)	5.0
Lead	6010	(1)	5.0
Mercury	7470	(1)	0.2
Selenium	6010	(1)	1.0
Silver	6010	(1)	5.0
Endrin	8080	(1)	0.02
Lindane	8080	(1)	0.4
Methoxychlor	8080	(1)	10.0
Heptachlor	8080	(1)	0.008
2,4-D	8080	(1)	10.0
2,4,5-TP (Silvex)	8080	(1)	1.0
Chlordane	8080	(1)	0.03

Note:

(1)PQL - Practical Quantification Limit, to be provided by the analytical laboratory.

TABLE 3

SUMMARY OF PROJECT SAMPLES AND ANALYSES
BUILDING 121 REMEDIATION

Media Sampled	*Type of Sample*	*Number of Samples*	*Testing Laboratory and TAT*	*Tests Required*	*Sampling Location*
Building Concrete Floor	Wipe	26 total (8 wipes after each of 4 washings plus trip blank and field blank)	Analytical laboratory	Table 1	Figure 6 (building floor only)
			RTAT-Urgent on third high-pressure wipes only--store other samples		
Scabbled Concrete Floor	Wipe	8 or 10 total (8 wipes after scabbling plus trip blank and field blank if needed)	Analytical laboratory	Table 1	Figure 6 (building floor only)
			7-day TAT or less		
Cleaning Wash Waters	Water (composite)	6 total (4 samples from drums for each wash event plus trip blank and field blank)	Analytical laboratory	Table 1	Storage drums
			3-day RTAT on third high-pressure wash water sample only--store other samples		
Cleaning Rinse Waters	Water (composite)	4 total (4 samples from drums of each rinse event; QC samples included in cleaning wash water samples)	Analytical laboratory	Table 1	Storage drums
			3-day RTAT on third high-pressure rinse water sample only--store other samples		

TABLE 3
(CONTINUED)

Media Sampled	*Type of Sample*	*Number of Samples*	*Testing Laboratory and TAT*	*Tests Required*	*Sampling Location*
Building Concrete Floor, Ceiling, and Walls	Concrete chip samples	18 total	Analytical laboratory 7-day TAT or less	Table 2	Figures 3, 4, and 5
Soil Exterior to Building 121	Soil chemical (grab)	7 total	Analytical laboratory 3-day RTAT	Table 1	Figure 7
Excavated Soil	Soil chemical (composite)	1 total	Analytical laboratory 7-day TAT or less	Table 2	Intermodal box containers
Verification - Soil Exterior to Building 121	Soil chemical (grab)	7 total	Analytical laboratory 3-day RTAT	Table 1	Figure 7
Backfill Soil	Soil chemical (composite)	1 total per source	Analytical laboratory 7-day RTAT or less	RCRA Characteristics, TCL/TAL	Each source of backfill borrow
Backfill Soil	Soil geotechnical (bulk)	1 total per source	Geotechnical laboratory ASAP - RTAT	ASTM-D2487 ASTM-D4318 ASTM-D1140 ASTM-D698 ASTM-D2216	Each source of backfill borrow
Soil Subgrade	Soil geotechnical (bulk)	1 total	Geotechnical laboratory ASAP - RTAT	ASTM-D698 ASTM-D2216	Subgrade exposed after excavating soil

TABLE 3
(CONTINUED)

Media Sampled	*Type of Sample*	*Number of Samples*	*Testing Laboratory and TAT*	*Tests Required*	*Sampling Location*
Equipment Decontamination Final Rinse Water	Water (composite)	1 or 3 total (1 drum composite plus trip blank and field blank, if needed)	Analytical laboratory 3-day RTAT	Table 1	Storage drums
Soil Subgrade	Field test (in-situ soil)	2 total	Field test Before backfilling	ASTM-D1556 or ASTM-D2922	Subgrade exposed after excavating soil
Backfill Soil	Field test (in-situ soil)	2 total	Field test After backfilling	ASTM-D1556 or ASTM-D2922	Backfill soil after placement in excavation

TABLE 4

SUMMARY OF SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES
BUILDING 121 REMEDIATION

Sample Type	*Container Requirements*	*Preservation Requirements*	*Holding Time*	*Container Volume*
Wipe	Amber glass bottle, Teflon-lined cap	Cool to 4°C	Extraction within 7 days; analyze 40 days	1 x 1 liter
Water (drum composites)	• Organics - Amber glass bottle, Teflon-lined cap • Inorganics - Plastic bottle	Cool to 4°C	14 days	1 x ½ liter or 1 x 8 ounce
Concrete Chip	Glass bottle, Teflon-lined cap	Cool to 4°C	Extraction within 7 days; analyze 40 days	1 x 1 liter
Soil Chemical (grab or composite)	Glass bottle, Teflon-lined cap	Cool to 4°C	Table 1 - 14 days Table 2 - Extraction within 7 days; analyze 40 days	
Soil Geotechnical (bulk)	Plastic-lined box or bag; plus glass bottle with Teflon-lined cap	None required	120 days	Box - 1 x ½ cubic foot Bottle - 1 x 8 ounce or 1 x ½ liter

FIGURES

PLOT SCALE: 1" = 1"	OHM CORPORATION PITTSBURGH, PA	DRAWN BY B.O'Connor 1-17-94	CHECKED BY	APPROVED BY	DRAWING NUMBER 15591-A1

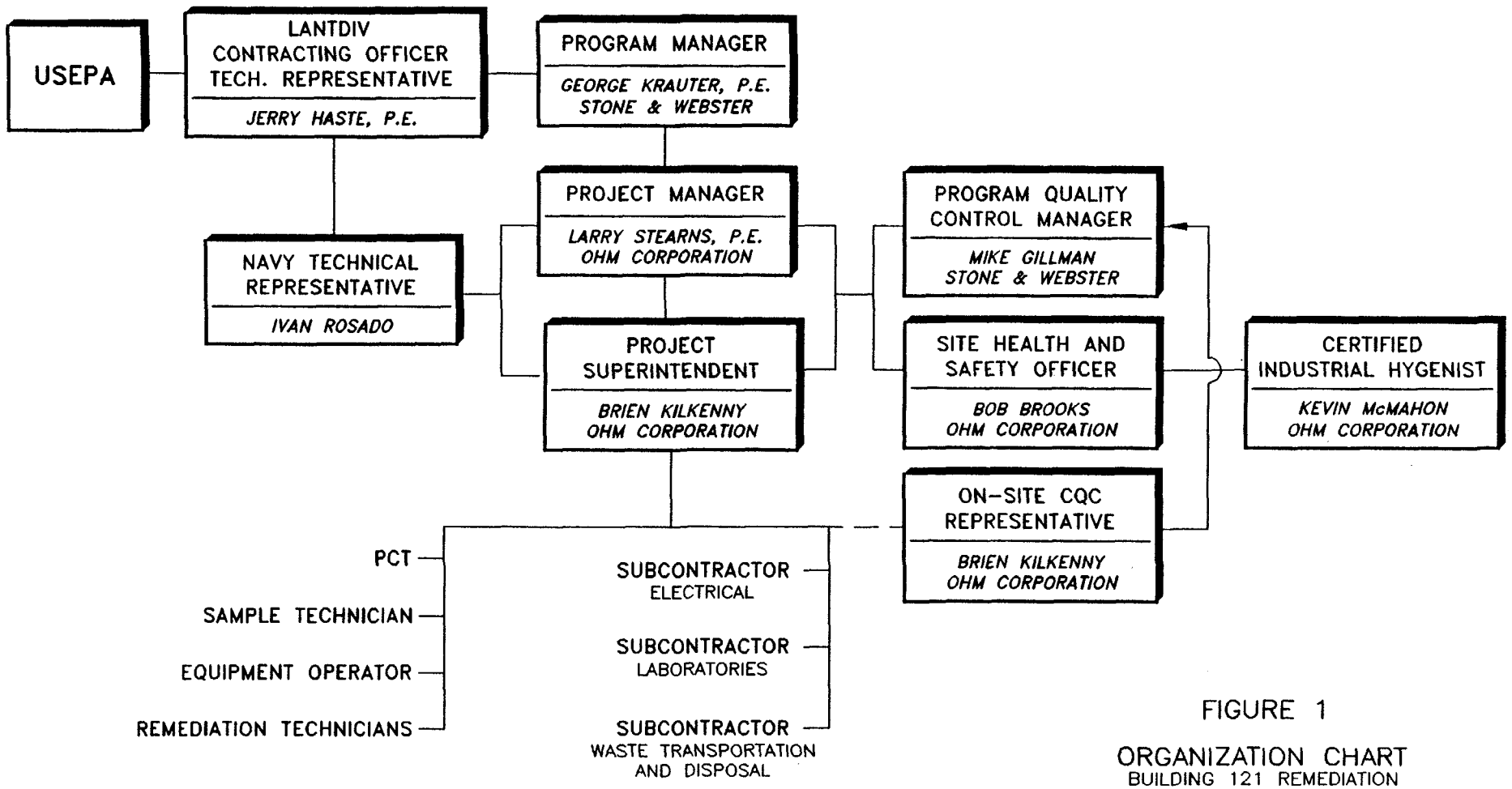


FIGURE 1

ORGANIZATION CHART
BUILDING 121 REMEDIATION
U.S. NAVAL STATION – ROOSEVELT ROADS

PREPARED FOR

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION – NAVFAC
NORFOLK, VIRGINIA

OHM Corporation

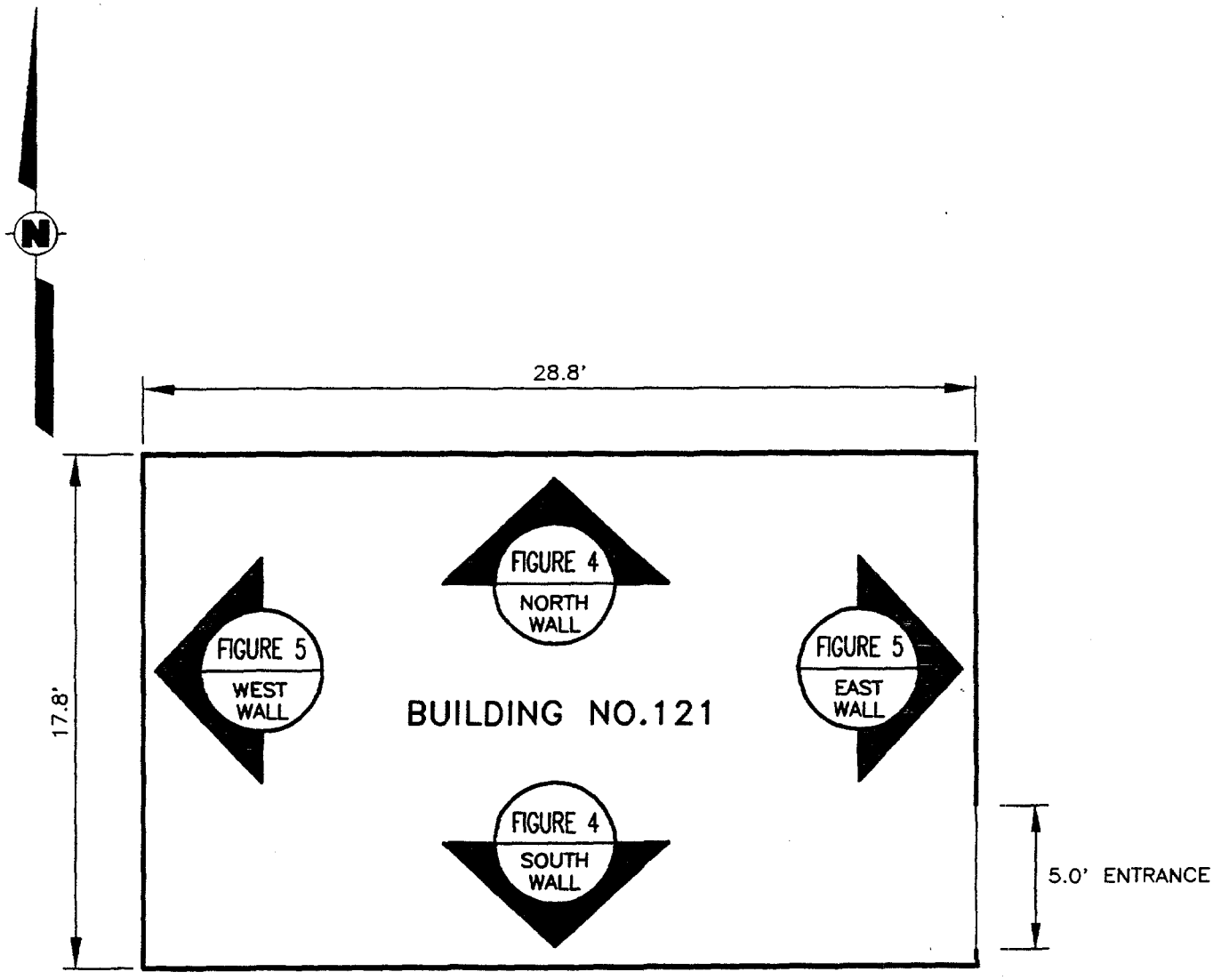


FIGURE 2

BUILDING 121
SAMPLE LOCATION KEY
BUILDING 121 REMEDIATION
U.S. NAVAL STATION – ROOSEVELT ROADS

PREPARED FOR

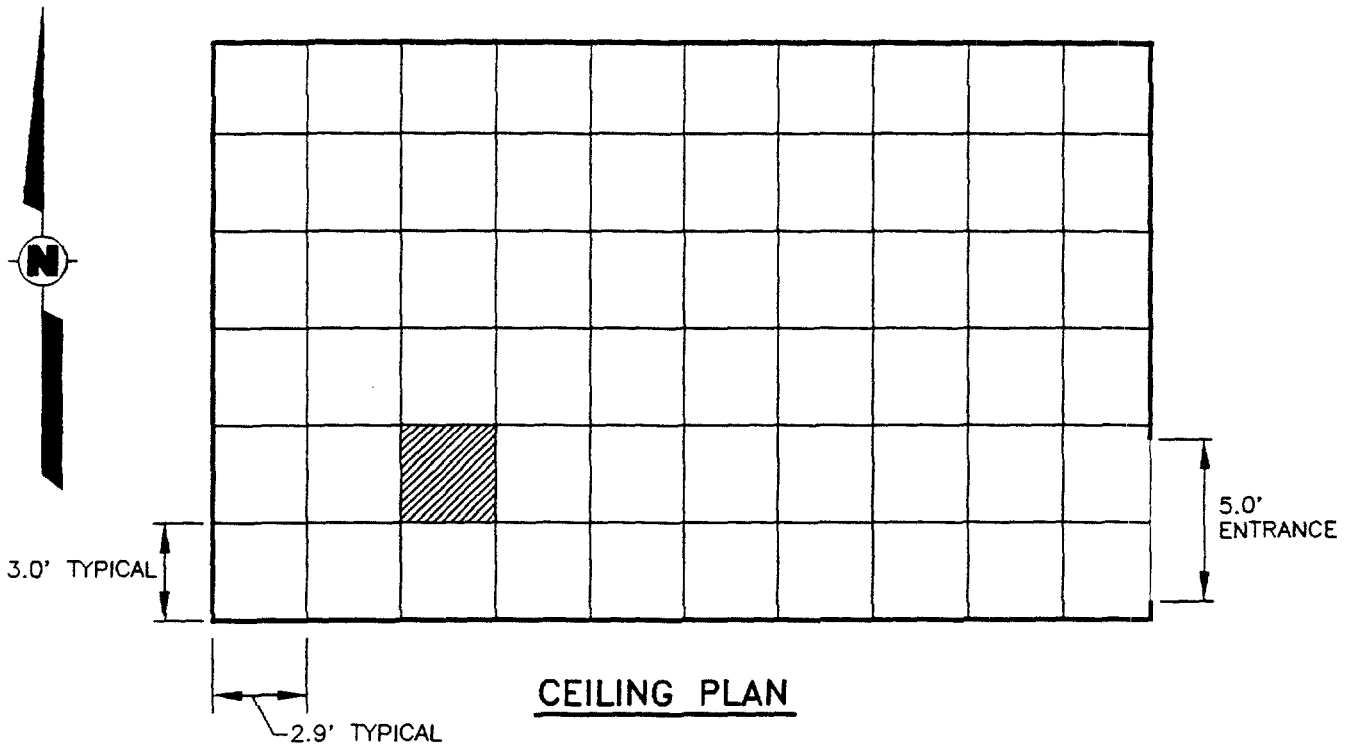
DEPARTMENT OF THE NAVY
ATLANTIC DIVISION – NAVFAC
NORFOLK, VIRGINIA

SCALE
0 6 12 FEET

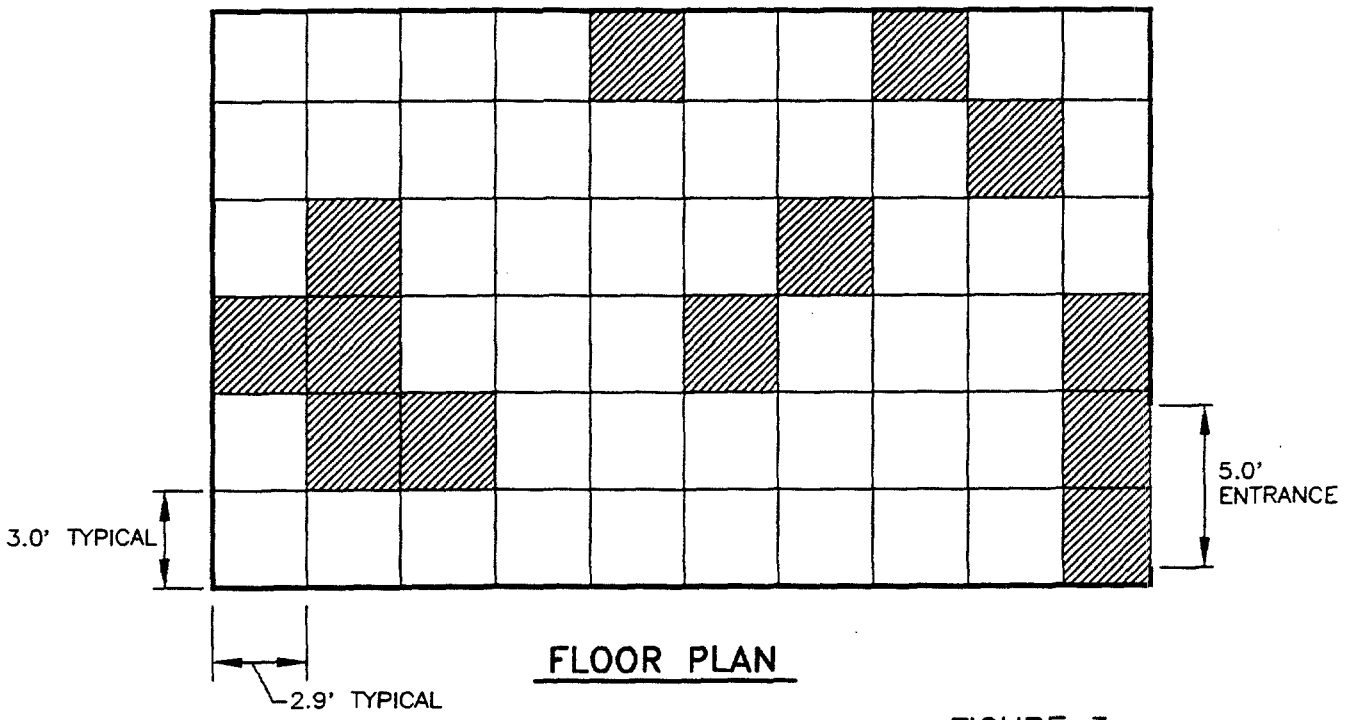
OHM Corporation

DRAWING NUMBER	15591-A3
APPROVED BY	
CHECKED BY	
DRAWN BY	A.C.Smith 1/17/94
OHM CORPORATION PITTSBURGH, PA	

PLOT SCALE: 1" = 1"



CEILING PLAN



FLOOR PLAN

LEGEND:

CHIP SAMPLE LOCATION

SCALE

0 6 12 FEET

FIGURE 3

CHIP SAMPLE LOCATIONS
FLOOR AND CEILING
BUILDING 121 REMEDIATION
U.S. NAVAL STATION – ROOSEVELT ROADS

PREPARED FOR

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION – NAVFAC
NORFOLK, VIRGINIA

OHM Corporation

OHM CORPORATION
PITTSBURGH, PA

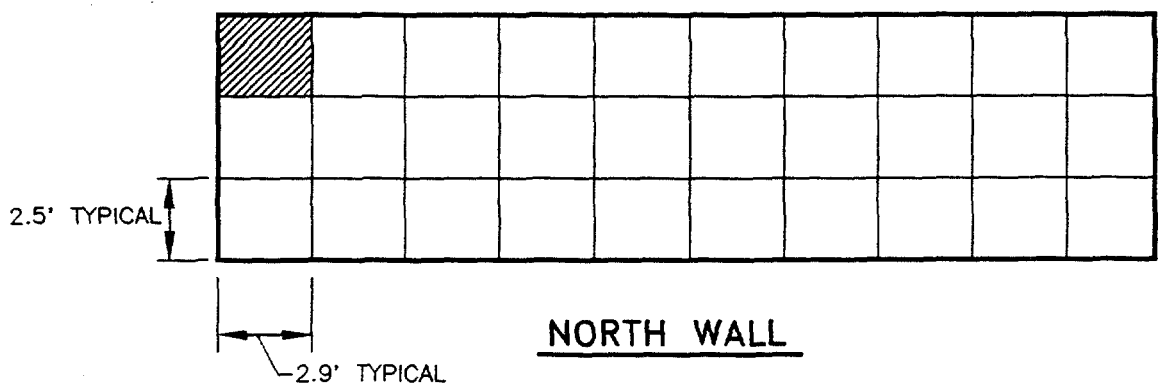
DRAWN BY A.C.Smith 1/17/94

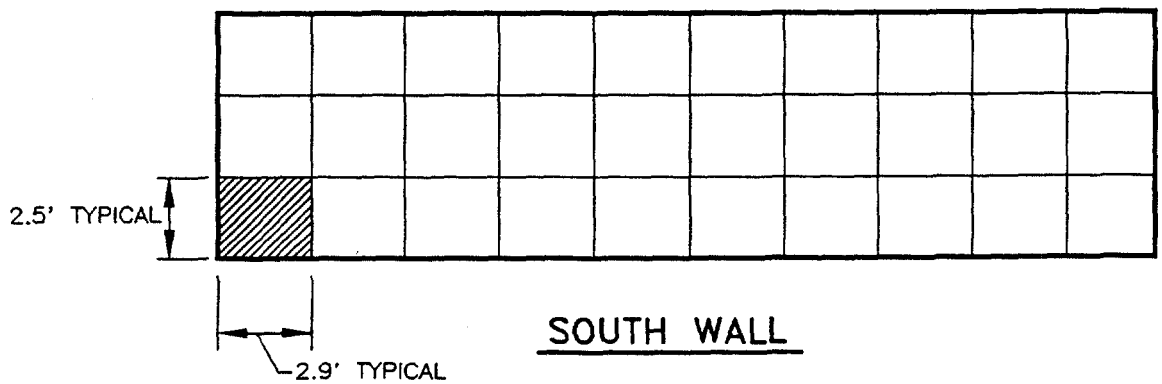
CHECKED BY

APPROVED BY

DRAWING NUMBER 15591-A4

PLOT SCALE: 1" = 1"





LEGEND:

CHIP SAMPLE LOCATION

SCALE

0 6 12 FEET

FIGURE 4

CHIP SAMPLE LOCATIONS
NORTH AND SOUTH WALLS
BUILDING 121 REMEDIATION
U.S. NAVAL STATION – ROOSEVELT ROADS

PREPARED FOR

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ATLANTIC DIVISION – NAVFAC
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DRAWING NUMBER 15591-A5

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OHM CORPORATION PITTSBURGH, PA

PLOT SCALE: 1" = 1'

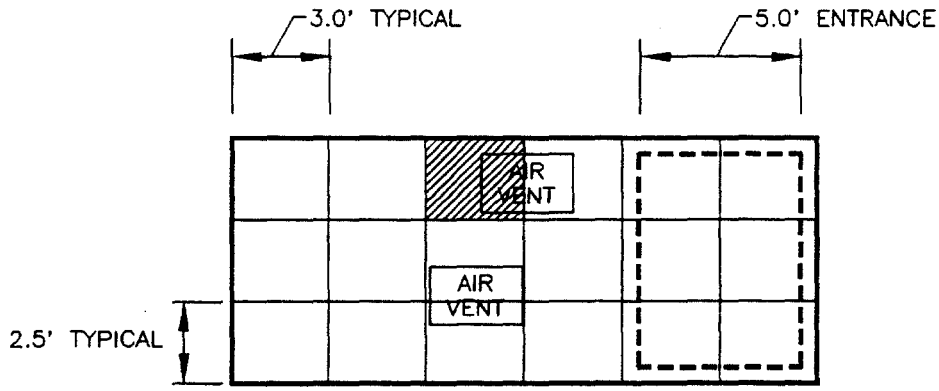
DRAWING NUMBER 15591-A6

APPROVED BY

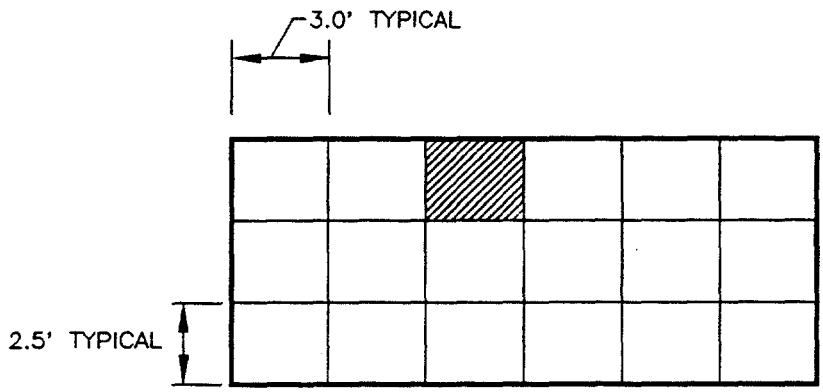
CHECKED BY

DRAWN BY A.C.Smith 1/17/94

OHM CORPORATION PITTSBURGH, PA



EAST WALL



WEST WALL

LEGEND:

CHIP SAMPLE LOCATION

SCALE

0 6 12 FEET

PLOT SCALE: 1" = 1"

FIGURE 5

CHIP SAMPLE LOCATIONS
EAST AND WEST WALLS
BUILDING 121 REMEDIATION
U.S. NAVAL STATION – ROOSEVELT ROADS

PREPARED FOR

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION – NAVFAC
NORFOLK, VIRGINIA

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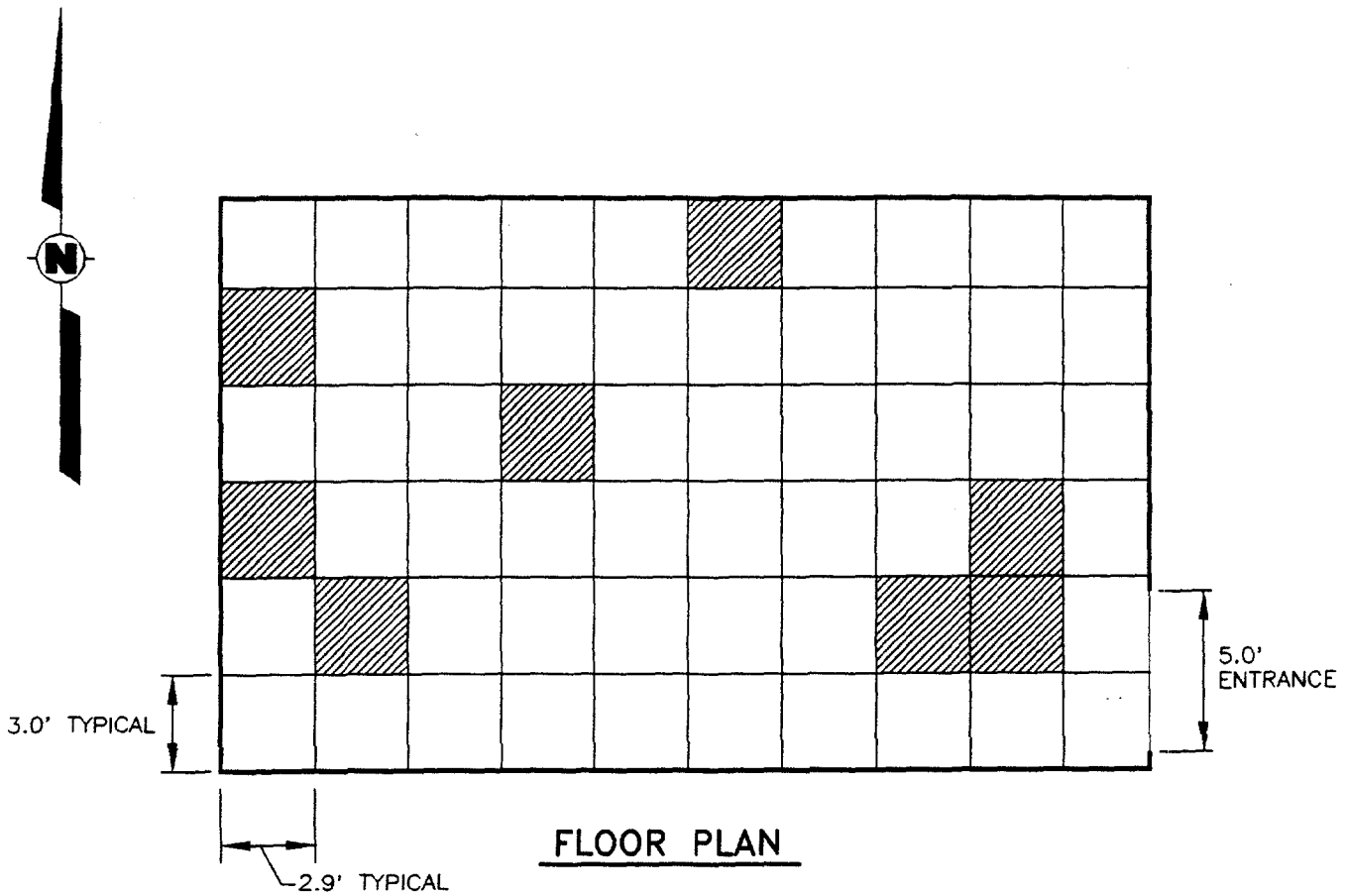

LEGEND:

WIPE SAMPLE LOCATION

SCALE

0 6 12 FEET

FIGURE 6

WIPE SAMPLE LOACTIONS
FLOOR

BUILDING 121 REMEDIATION
U.S. NAVAL STATION – ROOSEVELT ROADS

PREPARED FOR

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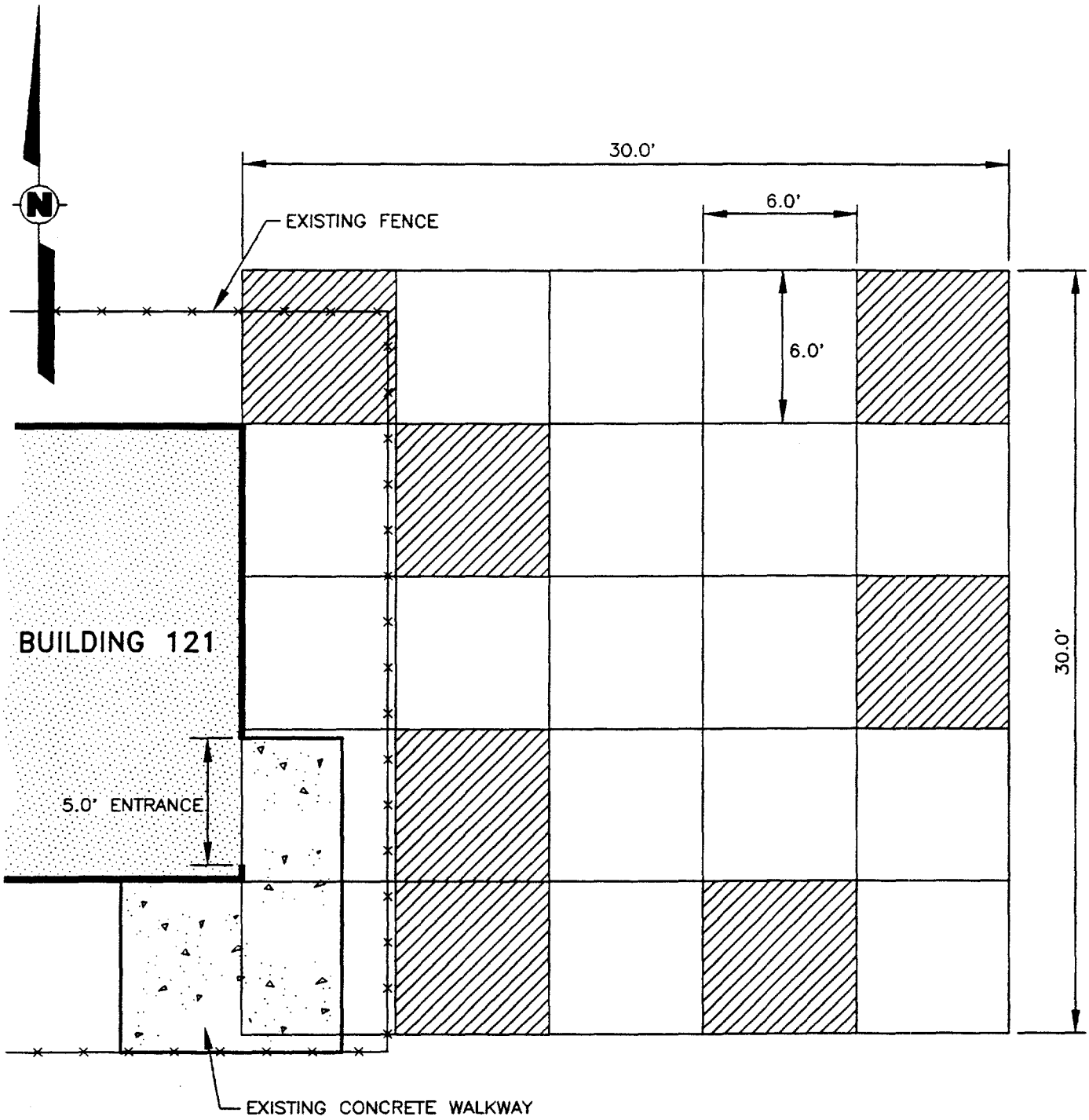
DRAWN BY	A.C.Smith 1/17/94
OHM CORPORATION PITTSBURGH, PA	

PLOT SCALE: 1" = 1"



LEGEND:

SOIL SAMPLE LOCATION

SCALE

0 6 12 FEET

FIGURE 7

SITE SOIL CHEMICAL SAMPLING LOCATIONS
BUILDING 121 REMEDIATION
U.S. NAVAL STATION – ROOSEVELT ROADS

PREPARED FOR

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION – NAVFAC
NORFOLK, VIRGINIA

OHM Corporation

DRAWING NUMBER 15591-A8

APPROVED BY

CHECKED BY

DRAWN BY A.C.Smith 1/17/94

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PLOT SCALE: 1" = 1'

APPENDIX A

CHAIN-OF-CUSTODY AND SAMPLE COLLECTION FORMS

OHM Corporation

CHAIN OF CUSTODY RECORD

Project Number _____ Page _____ of _____

Project Name _____

Site Location _____

SAMPLE IDENTIFICATION	DATE	TIME	SAMPLE TYPE	SAMPLE LOCATION	VOLUME COLLECTED	NUMBER OF CONTAINERS							COMMENTS

RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):	REMARKS:		

Distribution—Original accompanies shipment, copy to project files.

SAMPLE TYPE:
W—WATER, S—SOLID, A—AIR, O—OTHER

LABORATORY:

NOTE: ALL SAMPLES ARE TO BE INSPECTED FOR PHYSICAL INTEGRITY UPON RECEIPT BY THE ANALYTICAL LABORATORY.

F—129 10/2/89

OHM Corporation

ect No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
ect Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
ple No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

OHM Corporation

Project No. _____ Bottle ____ of ____
Project Name _____
Sample No. _____ Depth _____
Sample Type _____ Collected By _____
Analyze for _____ Date _____

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OHM Corporation

DRUM INVENTORY LOG

Project No. _____ Drum No. _____
Project Name _____
Site Location _____

Logger _____ Sampler _____ Date _____ Time _____
Client _____ Client Contact _____
Phone _____ Weather _____

Drum Type: ☐ Fiber ☐ Poly-Liner ☐ Steel ☐ Ringtop ☐ Poly ☐ Closed Top ☐ Stainless Steel ☐ Overpacked ☐ Nickel

Drum Condition: ☐ Meet DOT Spec. ☐ Good ☐ Fair ☐ Poor

Drum Size: ☐ 85 ☐ 55 ☐ 42 ☐ 30 ☐ 16 ☐ 10 ☐ 5 ☐ Other

Drum Contents: Amount ☐ Full ☐ 3/4 ☐ 1/2 ☐ 1/4 ☐ <1/4 ☐ MT

Layers	Physical State: LIQUID	SOLID	GEL	SLUDGE	Color	Clarity: CLEAR	CLOUDY	OPAQUE	Layer Thickness
					Use STD Colors				Inches
T									
M									
B									

Field Analysis

pH _____ SU PID _____ ppm
Dosimeter _____
Other _____

Drum Labels/Markings

DOT Haz. _____ UN/NA _____

MFG Name _____
Chemical Name _____
Additional Information _____

Laboratory Compatability Data

☐ Mark if physical state and color matches the above information. If not, stop analysis and notify project contact. Further work will not be paid for.

Radiation: ☐ Positive ☐ Negative _____ MREM/HR

Compatability Cat _____
Analysts _____
Date Performed _____

Layers	Physical State: LIQUID	SOLID	GEL	SLUDGE	Color	Clarity: CLEAR	CLOUDY	OPAQUE	Water Solubility	React	pH	Hex. Sol.	Per	Oxid	CN	Sul	Biel-stein	Flash Point	PCB's (25ppm)	PCB Test Comp.
					Use STD Colors				Solubility SPSI Density H or L	A=Air W=Water	Std. Unit	S or I	+ or −	+ or −	+ or −	+ or −	+ or −	<60°C + or −	+ or −	NUMBER
T																				
M																				
B																				

Comments _____
PCB Conc. _____ ppm Flash Point _____ °C Campatability Comp. Bulk No. _____
Data Reviewer: _____ Data Review Date: _____
Field Reviewer: _____ Field Review Date: _____

Transfer Number	Transfers Relinquished By	Transfers Accepted By	Date	Time
1				

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OHM Corporation

WATER SAMPLE FIELD COLLECTION REPORT

Project Number _____
Project Name _____
Site Location _____

Sample ID Number _____ Date Collected _____
Sample Location _____ Time Collected _____
Diameter of Well _____ (in.) Collected By _____
Depth to Bottom of Well _____ (ft.) Casing Stick Up _____ (ft.)
Static Water Level _____ (ft.), Measured From (1) _____
Well Volumes Purged _____, Purging Method (2) _____
Type of Sample (3) _____, Sampling Method (4) _____
Depth of Sample _____ (ft.), Measured From (1) _____
Sample Collection Order _____

FIELD MEASUREMENTS

Water Temperature _____ pH _____
Specific Conductance _____ umho/cm at _____ (Temperature)
Other _____

METER CALIBRATION

pH STD	METER READING	SP. COND. STD	METER READING	_____ /STD	METER READING

SAMPLE TYPES COLLECTED

TYPE (5)	VOLUME	FILTERED	PRESERVATION (6)
_____	_____	Y ☐ N ☐	Y _____ N ☐
_____	_____	Y ☐ N ☐	Y _____ N ☐
_____	_____	Y ☐ N ☐	Y _____ N ☐
_____	_____	Y ☐ N ☐	Y _____ N ☐
_____	_____	Y ☐ N ☐	Y _____ N ☐

Number of Containers _____
Date Received by Lab _____ Laboratory _____
Remarks: _____

(1) T.O.C.=Top of Protective Casing; T.O.W.=Top of OF Well Casing; G.S.=Ground Surface
(2) Bailed, Pumped, Air Lift, Etc.
(3) Stream, Pond, Spring, Well, Seep, Supply, Etc.
(4) Bailer, Kemmerer, Grab, Pump, Etc.
(5) General Chem., Metal, VOA, Organics, Etc.
(6) HNO^3, NaOH, H^2SO^4, $Na^2O^3S^2$, Etc.

OHM Corporation

SOIL SAMPLE FIELD COLLECTION REPORT

Project Number _____

Project Name _____

Site Location _____

Collected By _____ Date and Time Collected _____

Sample Location _____

SAMPLE(S) LOCATION SKETCH (use back side if necessary)

SAMPLE ID NUMBER	DEPTH OF SAMPLE	SOIL DESCRIPTION (color, composition, staining, odor, field measurements[1])

Sampling Method _____

Composite Sample ? Y ☐ N ☐ Composite Sample ID Number _____

Describe Compositing _____

SAMPLE TYPES COLLECTED

TYPE[2]	VOLUME	PER SAMPLE ?	PER COMPOSITE ?
		Y ☐ N ☐	Y ☐ N ☐
		Y ☐ N ☐	Y ☐ N ☐
		Y ☐ N ☐	Y ☐ N ☐
		Y ☐ N ☐	Y ☐ N ☐

Number of Containers _____

Date Received By Lab _____ Laboratory _____

Remarks: _____

(1) For Example, Organic Vapor Analysis, Pocket Penetrometer, Etc.
(2) For Example, Metals, VOA, Organics, Etc.

OHM Corporation

NATURAL WATER CONTENT

Project Number _____
Project Name _____
Site Location _____

Tested By _____ Calculated By _____ Checked By _____
Date _____ Date _____ Date _____

SAMPLE NUMBER						
Container Number						
Wt. Container + Wet Soil, Grams (W)						
Wt. Container + Dry Soil, Grams (W')						
Wt. Moisture, Grams (W_W = W−W')						
Wt. Container + Dry Soil, Grams (W')						
Wt. Container, Grams (W")						
Wt. Dry Soil, Grams (W_S = W'−W")						
% Moisture, ($W_P = W_W / W_S$ x100)						

SAMPLE NUMBER						
Container Number						
Wt. Container + Wet Soil, Grams (W)						
Wt. Container + Dry Soil, Grams (W')						
Wt. Moisture, Grams (W_W = W−W')						
Wt. Container + Dry Soil, Grams (W')						
Wt. Container, Grams (W")						
Wt. Dry Soil, Grams (W_S = W'−W")						
% Moisture, ($W_P = W_W / W_S$ x100)						

SAMPLE NUMBER						
Container Number						
Wt. Container + Wet Soil, Grams (W)						
Wt. Container + Dry Soil, Grams (W')						
Wt. Moisture, Grams (W_W = W−W')						
Wt. Container + Dry Soil, Grams (W')						
Wt. Container, Grams (W")						
Wt. Dry Soil, Grams (W_S = W'−W")						
% Moisture, ($W_P = W_W / W_S$ x100)						

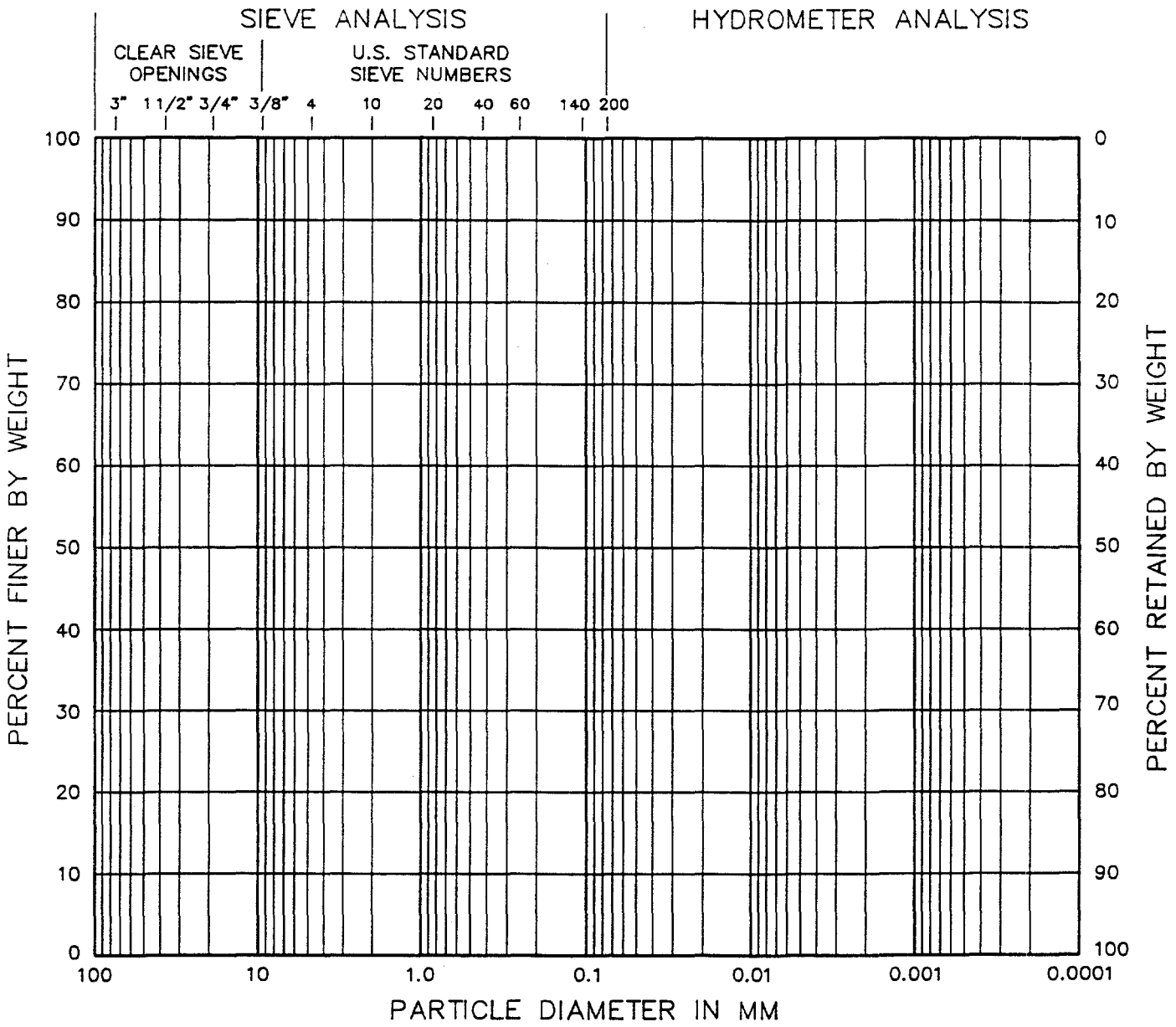
OHM Corporation

GRAIN SIZE ANALYSIS

Project Number_____ Date_____

Project Name_____

Site Location_____



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

SYMBOL	BORING	SAMPLE	DEPTH	SOIL DESCRIPTION	U.S.C.S.	LL	PI	W,%

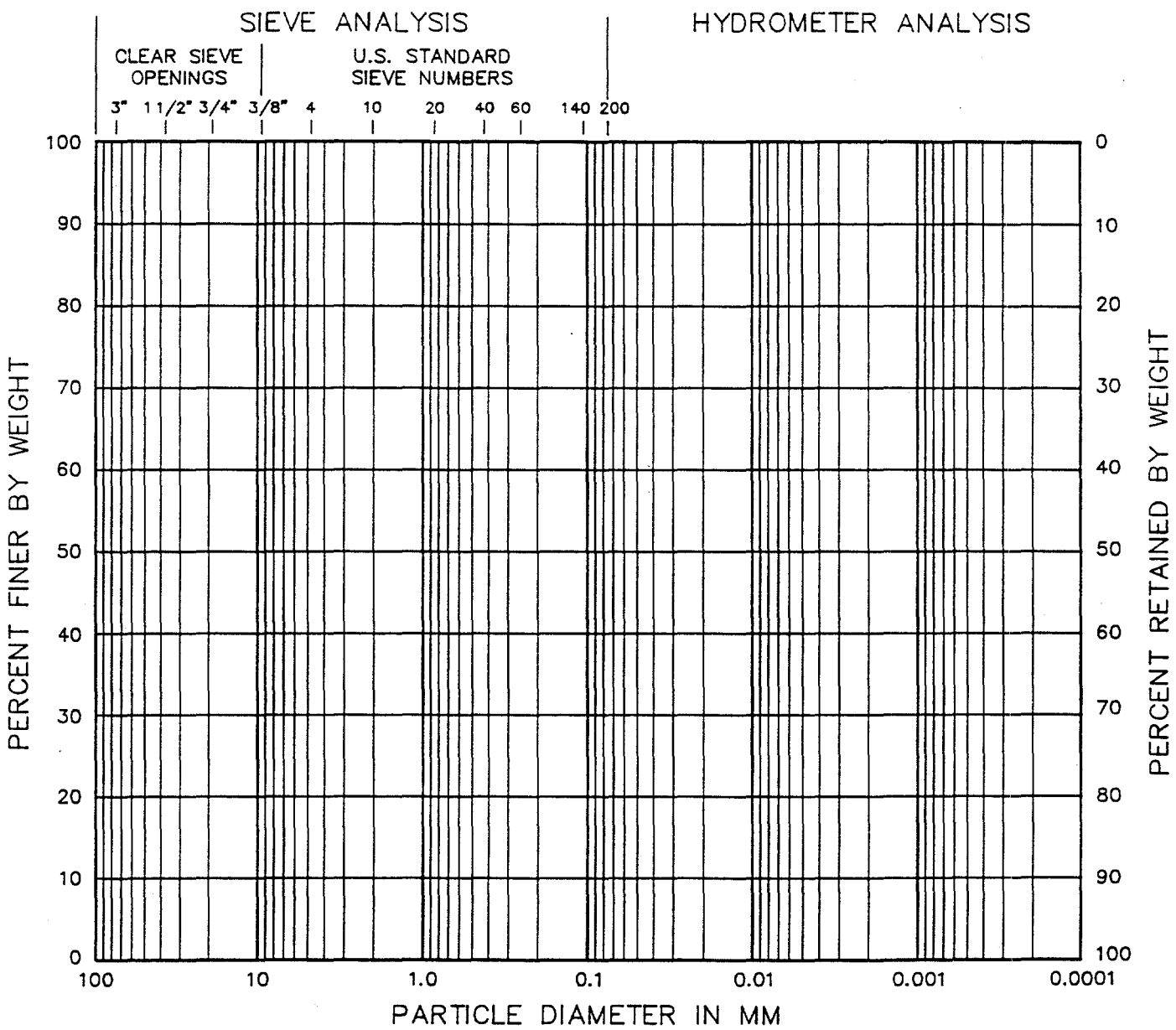
OHM Corporation

GRAIN SIZE ANALYSIS

Project Number _____ Date _____

Project Name _____

Site Location _____



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

SYMBOL	BORING	SAMPLE	DEPTH	SOIL DESCRIPTION	U.S.C.S.	D_{10}	C_U	W,%

OHM Corporation

GRAIN SIZE ANALYSIS

Project Number _____ Date _____
Project Name _____
Site Location _____

Boring Number _____ Soil Type: ☐ any(0) ☐ cohesionle(1) ☐ cohesive(2)
Sample Number _____ Specific Gravity: ☐ measure(M) ☐ assume(A)
Depth of Sample _____ Liquid Limit _____
USCS Symbol _____ Plasticity Index _____ Water Content _____ %
Soil Description _____

SIEVE ANALYSIS

Tare No. _____ Weight of Tare _____ gm Weight of dry Soil + Tare _____ gm

SIEVE OPENING (mm)	SIEVE NUMBER	WEIGHT OF SOIL RETAINED (gm)	% SOIL RETAINED	ACCUMULATIVE % RETAINED	% PASSING
75.000	3.0 in.				
37.500	1.5 in.				
19.000	0.75 in.				
9.500	0.375 in.				
4.750	No. 4				
2.000	No. 10				
0.850	No. 20				
0.425	No. 40				
0.250	No. 60				
0.106	No. 140				
0.075	No. 200				

HYDROMETER ANALYSIS

Volume of Soil/Water Suspension _____ L
Weight of Tare _____ gm
Weight of Deflocculating Agent _____ gm
Weight of Dry Soil + Tare + Defloc. _____ gm
Hyd. Portion of Total Sample _____
(Reading in Water −1) x 1000 _____

Meniscus Correction _____
Y−Intercept No Immer. _____
Y−Intercept with Immer. _____
Temperature _____ deg C
Slope of Cal. Curve _____ (abs value)
_____

ELAPSED TIME (MIN)	(READING −1) x 1000	ELAPSED TIME (MIN)	(READING −1) x 1000
0.25			
0.50			
1.0			
2.0			

OHM Corporation

ATTERBERG LIMITS TEST

Project Number _____
Project Name _____
Site Location _____

Boring Number _____ Tested By _____ Date _____
Sample Number _____ Depth _____ Calculated By _____ Date _____
Soil Description _____ Checked By _____ Date _____

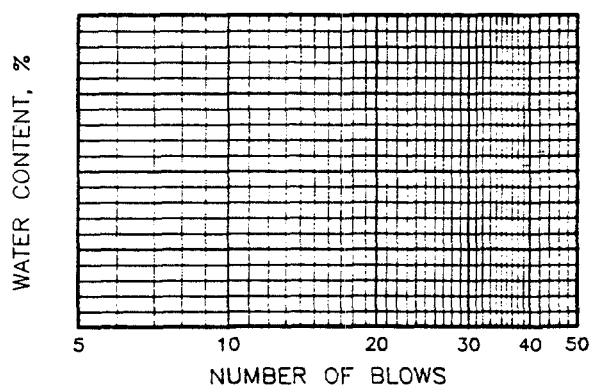
LIQUID LIMIT

DETERMINATION NUMBER	1	2	3	4	5
Container Number					
Wt. of Container + Wet Soil (gm)					
Wt. of Container + Dry Soil (gm)					
Wt. of Water, W_w(gm)					
Wt. of Container (gm)					
Wt. of Dry Soil, W_s(gm)					
Water Content, %					
Number of Blows					

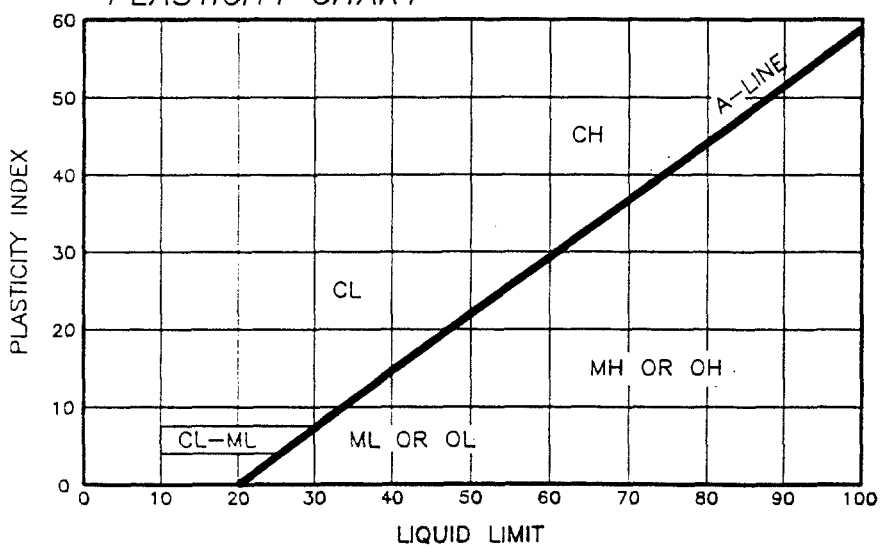
PLASTIC LIMIT

DETERMINATION NUMBER	1	2	3
Container Number			
Wt. of Container + Wet Soil (gm)			
Wt. of Container + Dry Soil (gm)			
Wt. of Water, W_w(gm)			
Wt. of Container (gm)			
Wt. of Dry Soil, W_s(gm)			
Water Content, %			

FLOW CURVE



PLASTICITY CHART



SUMMARY OF RESULTS

Liquid Limit	
Plastic Limit	
Plasticity Index	
Natural Water Content	
U.S.C.S. Symbol	

OHM Corporation

MOISTURE-DENSITY RELATIONSHIP

Project Number _____
Project Name _____
Site Location _____

Test Method _____ Tested By _____ Date _____
Soil Description _____ Calculated By _____ Date _____
_____ Checked By _____ Date _____

POINT NUMBER	1	2	3	4	5
Wt. Mold + WS (gm)					
Wt. Mold (gm)					
Wt. WS (gm)					
Vol. Mold (cc)					
W_S Dry (gm)					
γ Wet (pcf)					
Tare Number					
Wt. Tare + WS (gm)					
Wt. Tare + DS (gm)					
Wt. Tare (gm)					
Wt. DS (gm)					
Wt. Water (gm)					
W (Percent)					
$\gamma_d = \gamma/(1 + w)$ pcf					

DRY DENSITY γ_d (PCF)

WATER CONTENT , W%

METHOD	MATERIAL SIZE	MOLD SIZE	BLOWS/ LAYER
A	All Passing #4	4" Dia.	25
B	All Passing #4	6" Dia.	56
C	All Passing 3/4"	4" Dia.	25
D	All Passing 3/4"	6" Dia.	56

DESIGNATION	HAM/DROP	LAYERS
STANDARD	5.5#/12"	3
MODIFIED	10#/18"	5

OHM Corporation

COMPACTION TEST

Project Number _____

Project Name _____

Site Location _____

Test Method _____ Maximum Density _____

Sample No. _____ Optimum Moisture Content _____

Tested By _____ Date _____ Natural Moisture Content _____

Checked By _____ Date _____ Specific Gravity _____
(assumed or measured)

Sample Description _____

DRY DENSITY, LBS./FT.^{3}

WATER CONTENT, W%

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SAND-CONE CALIBRATION

EQUIPMENT NUMBER _____

EQUIPMENT NAME _____

DATE _____ DATE LAST CALIBRATED _____

CALIBRATION PERIOD _____

I. DETERMINE THE VOLUME OF THE JAR AND ATTACHMENT

WT. OF JAR & ATTACHMENT (gm.)	A				
WT. OF "A" PLUS WATER (gm.)	B				
TEMPERATURE (°C)	t				
WT. OF WATER (gm.) B-A = C	C				
VOLUME (ml) V_1 = C x T *	V_1				
AVE. VOL. OF JAR & ATTACHMENT (ml.)	V				

* TEMP. (°C)	UNIT VOL. (ml/g)
16.0	1.00103
17.0	1.00120
18.0	1.00138
19.0	1.00157
20.0	1.00177
21.0	1.00198

* TEMP. (°C)	UNIT VOL. (ml/g)
22.0	1.00220
23.0	1.00245
24.0	1.00269
25.0	1.00294
26.0	1.00320
27.0	1.00347

II. DETERMINE THE BULK DENSITY OF THE SAND TO BE USED IN THE FIELD TEST

WT. OF JAR & ATTACHMENT (gm.)	A				
WT. OF "A" PLUS SAND (gm.)	D				
WT. OF SAND D - A = E	E				
VOLUME OF JAR & ATTACHMENT (ml.)	V				
BULK DENSITY W_1 = (62.427E)/V (pcf)	W_1				
AVE. BULK DENSITY OF SAND (pcf)	W				

III. DETERMINE THE WEIGHT OF SAND REQUIRED TO FILL THE FUNNEL

WT. OF "A" PLUS SAND (INITIAL)	F				
WT. OF "A" PLUS SAND (FINAL)	G				
WT. OF SAND LOSS, H_1 = F-G (gm.)	H_1				
AVE. WEIGHT OF SAND LOSS (gm.)	H				

SIGNED _____

OHM Corporation

SAND CONE DENSITY TEST

Project Number _____ Report Number _____
Project Name _____ Sheet ____ of ____
Project Location _____

Sample I.D. Number _____ Task _____ Tested by _____ Date _____
Sample Location _____ Calculated by _____ Date _____
Field Density Test Number _____ Checked by _____ Date _____

DETERMINATION OF VOLUME

Wt. of Jar & Sand Before _____ g
Wt. of Jar & Sand After _____ g
Wt. of Sand in Hole & Cone _____ g
Wt. of Sand in Cone _____ g
Wt. of Sand in Hole _____ g

$$V = \frac{\text{Wt.}}{\text{Density of Sand}}$$

$$V = \frac{g}{1.510\ g/cc}$$

V = _____ cc

DETERMINATION OF UNIT WT.

Wt. of Wet Soil & Bag _____ g
Wt. of Bag _____ g
Wt. of Wet Soil _____ g

$$\gamma_t = \frac{\text{Wt. Wet Soil, g}}{\text{Vol. of Hole, cc}}$$

γ_t = _____ x 62.43 = _____ pcf

$$\gamma_d = \frac{\gamma_t}{1 + WC} = _____ \text{ pcf}$$

DETERMINATION OF WATER CONTENT

Tare Number _____
Wt. Wet Soil & Tare _____ g
Wt. Dry Soil & Tare _____ g
Wt. of Water _____ g
Wt. of Tare _____ g
Wt. of Dry Soil _____ g
Water Content (%) _____

Remarks _____

OHM Corporation

FIELD DENSITY TESTING SUMMARY

Project Number_____ Report Number_____ Sheet ____ of ____

Project Name_____

Inspector_____ Date_____

Moisture Standard_____ Optimum Moisture Content_____ Gauge No._____ Max. Dry Density_____

Proctor Curve No._____ Standard or Modified_____ Density Standard_____ Required % Compaction_____

TEST DATA					DENSITY DETERMINATION						MOISTURE/DENSITY VERIFICATION				
Test No.	Station	Offset	Elev.	Borrow Area	Test Depth	Wet Density	Dry Density	Moisture Content	Percent Compaction	Pass or Fail	Oven Moisture	Moisture Correction	Density Correction	Sample Obtained	Remarks

APPENDIX B

SOQ: GEOTECHNICAL LABORATORY

Geotechnics

January 17, 1994

Mr. Gene MacEvoy
OHM Corporation
1000 RIDC Plaza
Suite 600
Pittsburgh, PA 15238

Transmittal
Geotechnics Inc.
Summary of Qualifications
Prepared For
OHM Corporation

RECEIVED JAN 20 ENGINEERING

Dear Mr. MacEvoy,

As requested, please find a brief statement describing our qualification for geotechnical and geosynthetic laboratory testing services. Enclosed please find a copy of a USDA compliance form No. 519, our brochure and a representative list of clients. Also enclosed is a copy of our last soil testing proficiency program report from AASHTO Materials Reference Laboratory in which we participate.

Geotechnics recognizes complex client schedules and the need for accurate easy-to-read analysis and reporting of data. Geotechnics has performed geotechnical testing services for numerous projects since being formed in 1984. In the past ten years Geotechnics has provided quality and cost-effective laboratory testing services for companies throughout the United States, performing testing services for over 1,000 projects including municipal and hazardous solid waste landfills including Super Fund sites, bentonite slurry wall containment projects, foundation design, and earth dam construction. We have extensive experience in performing soil classification, compaction, consolidation, strength, and permeability testing, as well as specialty testing with soil bentonite mixtures, slurry wall properties and various solid residual waste materials such as coal refuse and fly ash.

Geotechnics routinely handles very large QA/QC projects with hundreds of samples for landfill liner construction. We are very familiar with the difficult time schedules often required on these projects, and have developed a computerized system of data presentation in report ready format. Our software automatically classifies the soil using the USDA and USCS systems which are utilized by most regulatory agencies and our computerized data reduction and report formatting produces a polished final product for presentation to you and your clients.

Geotechnics offers you the following capabilities to ensure an accurate, timely and cost-effective service on your soil, environmental projects:

- *state-of-the-art laboratories including custom designed evaluation equipment*
- *a comprehensive Quality Assurance Program*
- *test procedures consistent with EPA, USDA, ASTM, COE, GRI, industry practice and project specifications*

801 East Maiden Street
Washington, PA 15301
412-229-7337
FAX 412-229-7288

P.O. Box 10623
11628 Frankstown Road
Pittsburgh, PA 15235
412-243-0333
FAX 412-243-7850

700 William Pitt Way
Pittsburgh, PA 15238
412-664-7865
FAX 412-243-7850

geotechnics

In addition, we do not charge for the following services:

- *Report Generation*
- *Special Report Formatting*
- *Facsimile Transmissions*
- *Rush Turnaround Samples*
- *Sample Storage (Geotechnics will retain samples for 90 days. Samples will be disposed of at no charge to client unless requested to return samples to client)*

We would appreciate being considered for future projects and are available to support any projects presently underway. Thanks to the express shipping industry we receive samples from projects nation wide. Our testing services are just one day away!

In addition to geotechnical testing we also provide **geosynthetic testing services** including same day seam results and 48 hour conformance testing. If you have any questions or require immediate assistance please call. We are at your services.

Sincerely,

David R. Backstrom
Laboratory Director

enclosure (s)

P.O. Box 10623 • Pittsburgh, PA 15235 • 412-243-0333 • FAX 412-243-7850

GEOTECHNICAL SERVICES

Hatcher-Sayre, Inc. has the qualifications and experience to provide a full complement of geotechnical engineering services on a regional basis. All services are available in-house with the exception of drilling, which we routinely subcontract. Our laboratory in the Richmond office is equipped to provide a broad range of materials testing as outlined by the attached summary. Technicians are trained annually through participation in VDOT and ACI materials certification schools. Our laboratory was certified by the U. S. Army Corp of Engineers in April 1993 and the technician staff is involved in the AASHTO proficiency testing program twice a year.

We have extensive experience on a variety of geotechnical projects including commercial and municipal office buildings, shopping centers and regional malls, business parks, industrial facilities, airports, dams, ports, and municipal infrastructure improvements. We have provided design recommendations and monitored the installation of a number of foundation types including spread footings, mats, various pile types, drilled piers, pressure injected footings and rock anchors.

Construction monitoring and testing services are provided by trained technicians under the supervision of a geotechnical engineer. We are capable of providing the normally specified monitoring and testing services related to placement of earthwork, concrete, fireproofing and steel. Construction service areas are outlined by the attached summary.

HATCHER\GEO-SERV.sum\dy

SINCE
1881

FROEHLING & ROBERTSON, INC.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES
"OVER ONE HUNDRED YEARS OF SERVICE"

833 Professional Place, W.
Chesapeake, Virginia 23320
Telephone: (804) 436-1111
Fax: (804) 436-1674

Serial No: 93-2856

January 17, 1994

Gene MacEvoy
OHM

Re: Qualifications Statement
Soils Analysis - Puerto Rico

Dear Mr. MacEvoy:

Froehling & Robertson, Inc. (F&R) is one of the oldest independent testing/inspection firms in the United States. The company was founded in 1881 and employs professional engineers, geologists, environmental scientists, metallurgists and engineering technicians. Our Chesapeake office has continuously served the Hampton Roads area for over 60 years.

Our facilities meet the requirements of ASTM E329 and are inspected on a regular basis by the Army Corps of Engineers and the Cement and Concrete Reference Laboratory (CCRL) program of the National Institute of Standards and Technology (NIST).

The following information is provided to amplify our qualifications:

1) All our technical personnel work under the direction of a registered professional engineer (resume enclosed)

2) USDA Permit # Richmond (IC) No. 3

3) Our laboratory meet the requirements of the following ASTM Standards:

C1077 "Practice for Laboratories Testing Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation".

C1093 "Practice for This Accreditation of Testing Agencies for Unit Masonry.

D3666 "Practice for Evaluation of Inspection and Testing Agencies for Bituminous Paving Materials".

D3740 "Practice for Evaluation of Agencies Engaged in the Testing and/or Inspection of Soils as Rock as Used in Engineering Design and Construction".

A880 "Practice for Criteria for Use in Evaluation of Testing Laboratories and Organization for Examination as Inspection of Steel, Stainless Steel and Related Alloys".

E543 "Practice for Determining the Qualification of Non-Destructive Testing Agencies".

Enclosed is additional information regarding our operation.

We hope this information has been of assistance and ask that you contact this office should there be any questions, or if additional data is required.

Respectfully,
FROEHLING & ROBERTSON, INC.

C.F. Starnes, Manager
CHESAPEAKE BRANCH OFFICE

CFS/bbb

Enclosures: Resume (John P. Sensabaugh)
Certification & Qualification Statement

JOHN P. SENSABAUGH, P.E.
Senior Geotechnical Engineer

Experience/Qualifications

1979-Present: Responsibilities include various supervisory duties in the areas of geotechnical and materials engineering, and in the areas of field and laboratory testing of soils, concrete and asphalt.

Mr. Sensabaugh is experienced in performing analysis and reviewing data pertinent to foundation design and site preparation for residential and commercial structures, including subsurface structures, pipelines, multi-story structures, storage tanks, and water treatment plant structures. Analyses have included deep (pile and caissons) and shallow (spread footing and mat) foundations. Mr. Sensabaugh has also coordinated and supervised construction monitoring services for these projects.

Mr. Sensabaugh has also performed geotechnical and materials analyses for design of light and heavy duty pavements, and evaluations regarding existing pavements.

Field evaluations performed by Mr. Sensabaugh have included pile and caisson installation, load testing (displacement and auger-cast piles), proofrolling of subgrade soils, and evaluation of shallow foundation bearing soils. His experience with field instrumentation has included pneumatic piezometers, vane shear, settlement plate, and plate bearing tests. He has developed methods for performing field permeability tests on both low and high flow rate soils.

He has performed geotechnical analyses and design for numerous dams in the Hampton Roads area. Projects have included the geotechnical engineering analysis and construction monitoring services at Fords Colony Dams, James City County, and Beaverdam, Gloucester, Virginia. He also performed geotechnical engineering analysis and cross-section design for Tyseden Farms Dam, Northampton County, Virginia.

Certifications

Professional Engineer, Commonwealth of Virginia, 1985
Professional Engineer, State of North Carolina, 1987

Professional Affiliations

American Society of Foundation Engineers (ASFE)

Education

Old Dominion University, 1980, B.S. Civil Engineering

APPENDIX C

SOQ: ANALYTICAL LABORATORY

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

January 20, 1994

Mr. Larry Stearns
OHM Corporation
1000 RIDC Plaza Suite 600
Pittsburgh, PA 15238

Dear Mr. Stearns:

As per your request enclosed please find information regarding ***Beckton Environmental Laboratories*** *capabilities.*

Qualifications

Beckton *is a leading environmental analytical services company. We provide analytical testing services to identify and assess the presence and extent of contamination in the environment. This includes water, wastewater, groundwater, soil, sediment, sludge, hazardous wastes and asbestos in air samples. Over the past year* ***Beckton*** *has been called upon by industry, utilities, remediation firms and government to provide the analytical testing for numerous private site remediation and environmental assessment audits. In addition,* ***Beckton*** *posses the technical expertise, experience and in-house laboratory facilities to effectively and successfully meet your specific analytical testing needs.*

We take pride in our ability to provide reliable, meaningful data and responsive service. We achieve these goals through our well trained chemists, biologist and technicians with specific experience in environmental analysis. Our resources are state-of-the-art equipment consisting of GC's, GC/MSD, A.A., ion analyzer; all in a more than 6,000 square feet laboratory. Over one year was invested in validation of EPA approved analytical methods, instrumentation and operators. Our QA/QC Program is designed to monitor laboratory procedures, analytical and instrument performances, and to assure compliance with established quality assurance standards.

192 VILLA STREET
PONCE, P.R. 00731

TEL. (809) 841-7373
FAX (809) 841-7313

State-of-the-art instrumentation and equipment is utilized for the analysis complex mixtures. Among the instrumentation available to analyze organic pollutants are a gas chromatograph-mass spectrometer fully computerized, several gas chromatographs with photoionization and electrolytic detectors, and several gas chromatographs with dual electron capture detectors. All chromatographs are equipped with autosamplers and under computer control. The chromatography section, using chromatographic procedures can achieve low part-per-billion detection limits for many compounds. In addition to detection of trace level contaminants, this section has the capability to characterize waste streams for target organic constituents, so that appropriate disposal procedures can be chosen.

The experience of our chemists ensures reliable results performing GC/MS analyses of complex mixtures and environmental samples, using EPA methods and current technologies. The GC/MS section uses the state-of-the-art instrumentation for the quantitative assessment of trace level organic pollutants. Analyses are performed on a wide variety of matrixes, including oil, water, sludge, oil, and solvent. Target analyses performed by this section include Organic Priority Pollutants, EPA Hazardous Substance List, TCLP List, and others. The qualitative power of GC/MS is routinely used to screen hazardous waste samples for disposal decision making.

Trace metal analysis is done by Atomic Absorption Spectrometry. Capabilities for trace and ultra trace analysis through the use of graphite furnace are also available. Our chemists have years of experience analyzing metals in matrixes from high purity water to air particulate and biological material. State of the art equipment in microwave sample preparation is also available.

Our rigorous in house quality control program coupled with participation in major certification programs ensures the validity of the data reported to our customers. A consistent document data quality control program with appropriate blanks, duplicate analyses, surrogate and spike analyses, and the use of both internal and external reference standard that meet or exceed EPA and EQB standards.

Complementing the laboratory resources, ***Beckton's*** *investigative field capabilities allow collection of samples to be returned to the laboratory for comprehensive analysis. Our services include multi-media sampling: process streams, soil, water and waste.*

*The dedicated, experienced team of **Beckton's** chemists and support personnel takes pride in providing high quality, timely, and cost effective chemical and biological analysis.*

Proven Performance

***Beckton Environmental Laboratories** have provided environmental testing services for major chemical and pharmaceutical companies in Puerto Rico. We have been able to meet stringent sampling and reporting requirements. This responsive service is the trademark of **Beckton**, you can count on us to meet your environmental testing needs. **Beckton** have been audited many times and is fully qualified by the Puerto Rico Aqueduct and Seaward Authority to conduct all pretreatment analysis. We are a participant laboratory in proficiency testing programs. References are enclosed.*

Should you need additional information, I will be pleased to furnish any additional information that you may require.

Sincerely,

Rafael Infante
Laboratory Director

Enclosures

Quality of Key Personnel

NAME	DEGREE	MAJOR	SCHOOL	YEARS OF EXPERIENCE	POSITION	APPROPRIATE TRAINING IN ANALYTICAL TESTING
Jorge Amufat	B.A.	Bussiness	Interamerican University	13	Executive VP	
Rafael Infante Chemist License 1888	B.S. M.S.	Chemistry Chemistry	Catholic University of PR University of Nebraska Lincoln	15	Director GC/MS spectral interpretation expert	Ph.D. studies in analytical chemistry Training courses in environmental-analytical chemistry 25 publications in the field
María Pagán Chemsit License 1752	B.S.	Chemistry	Catholic University of PR	14	Manager	Formal training courses Continous education courses In-house training
María Vidal	B.S.	Chemistry	Catholic University of PR	5	GC/MS Supervisor Purge & trap expert	M.S. studies in chemistry In-house training Formal training courses and seminars
Nilsa Rodríguez	B.S.	Chemsitry	Catholic University of PR	5	AA Supervisor	M.S. studies in chemistry In-house training Formal training courses and seminars
Elena Rondón	B.S.	Biology	University of Puerto Rico Mayaguez Campus	4	Microbiology Supervisor QA/QC Coordinator	Formal training courses In-house training Seminars and workshops
Wanda Vázquez	B.S.	Biology	Interamerican University	6	GC/MS operator Extraction and concentration	Formal training courses (minor in chemistry) In-house training Seminars and workshops Courses in environmental sciences
Nilda Lugo	B.S.	Biology	Catholic University of PR	8	Wet chemistry analist Autoanalyzer expert	Formal training courses (minor in chemistry) In-house training Former working experience
Hilda Soto	B.S.	Biology	Catholic University of PR	4	Flame, graphite, and cold vapor spectroscopist Inorganic sample preparation expert	Formal training courses (minor in chemistry) In-house training Seminars and workshops

NAME	DEGREE	MAJOR	SCHOOL	YEARS OF EXPERIENCE	POSITION	APPROPRIATE TRAINING IN ANALYTICAL TESTING
José Pérez	B.S.	Chemistry	University of Puerto Rico Mayaguez Campus	2	Wet chemistry group leader	Formal training courses Continous education courses In-house training
Hector Maldonado	B.S. BSMT	General Sciences Medical Technology	Catholic University of PR Catholic University of PR	4	Wet chemistry analist UV/Vis spectroscopist CN- Analyst	Formal training courses Continous education courses In-house training
Miguel Vélez	A.D.	Environmental Control Tech.	Instituto Tecnológico de PR	2	Flame, and cold vapor spectroscopist Inorganic sample preparation analyst	Formal training courses In-house training
Luissette Berastain (part time)	B.S. 1994	Chemistry	Catholic University of PR	2	Flame, graphite, and cold vapor spectroscopist Inorganic sample preparation analyst	Formal training courses and seminars In-house training
Ruben Centeno	A.D.	Environmental Engineer	Instituto Tecnológico de PR	4	Flame, graphite, and cold vapor spectroscopist Inorganic sample preparation analyst RCRA sample preparation expert	Formal training courses and seminars In-house training Former working experience
José Mercado	A.D.	Chemistry	Instituto Tecnológico de PR	4	Sampling coordinator	Formal training courses In-house training Seminars and workshops Hazardous substance training
Neftalí Rivera	A.D. 1994	Instrumentation	Instituto Tecnológico de PR	2	Sampling technician	In-house training Hazardous substance training

NAME	DEGREE	MAJOR	SCHOOL	YEARS OF EXPERIENCE	POSITION	APPROPRIATE TRAINING IN ANALYTICAL TESTING
Ricardo Castillo	H.S.	Basic	Peñuelas High School	1	Sampling technician	In-house training Hazardous substance training
Angel Vera	H.S.	Basic	Ponce High Scholl	3	Sampling technician	In-house training Hazardous substance training Former working experience

List of Business References

REFERENCES- BECKTON ENVIRONMENTAL LABORATORIES, INC.

COMPANY	ADDRESS	CONTACT PERSON	SERVICES RENDERED
Aqueduct and Seward Authority	Apto. 6066 Bo. Obrero Station Santurce, Puerto Rico 00916	Sra. Martha Rivera Ing. Juan Vázquez	Pre treatment monitoring
Alberto Culver	P.O. Box 177 Naguabo, Puerto Rico 00718	Mr. Juan Delgado	Pre treatment monitoring; RCRA Stormwater
Albergue Olímpico	Apto. 2004 Salinas, Puerto Rico 00751	Mr. Angelino Alvárez	Treatment plant discharges
ABB- Salinas	P.O. Box 1153 Salinas, PR 00751	Mr. Edgar Rivera	Organics
Abbot	P.O. Box 278 Barcelonela, PR 00617	Mr. Mañón	RCRA
Avon Mirabella	P.O. Box 3918 Aguadilla, PR 00605	Mr. Ismael Camacho	Asbestos
Allergan Medical	P.O. Box 1408 Añasco, PR 00610	Eng. Pedro Monrolg	Special Samples
Alcon	P.O. Box 3000 Humacao, PR 00792	Eng. Justo Martinez	Pre treatment monitoring; RCRA Stormwater; Special analysis
Alpla Caribe	P.O. Box 2907 Guayama, PR 00785	Eng. Raúl Muñoz	Stormwater
Anaquest	P.O. Box 1290 Guayama, PR 00785	Lcdo. Víctor Guzmán	Pre treatment monitoring; RCRA Stormwater
Alonso and Camus	P.O. Box 5600 Cataño, PR 00963	Eng. Nelson Benitez	RCRA Special sampling
BFI	G.P.O. Box 7104 Ponce, PR 00731	Mr. Rey González	RCRA
Bristol Myers	P.O. Box 609 Humacao, PR 00661	Mr. Hector Rivera	Pre treatment
Bristol Myers	P.O. Box 897 Mayaguez, PR 00681-0987	Eng. Elvin Quiles	Pre treatment; RCRA
Baxter- Añasco	P.O. Box 1577 Añasco, PR 00610	Eng. Rigoberto Feliciano	RCRA; Ground water
Baxter- Aibonito	P.O. Box 1389 Aibonito, PR 00609	Marta Quintana	Special samples
Baxter- Carolina	P.O. Box 2025 Carolina, PR 00630	Hector Ramos	RCRA
Baxter- Toa Alta	P.O. Box 1321 Toa Alta, PR 00758	Eng. Irizarry	Pre treatment
Boehringer Manheim	P.O. Box 7021 Ponce, PR 00731	Adela Zayas	Pre treatment Special samples
Borinquen Biscuit	P.O. Box 1607 Yauco, PR 00768	Hector Fabre	Pre treatment
Caribe G.E.- Patillas	P.O. Box 667 Patillas, PR 00723	César Pérez	RCRA Special samples
Celclus	P.O. Box 5639 Caguas, PR 00726	Hayde Redondo	RCRA

BECKTON ENVIRONMENTAL LABORATORIES- LIST OF REFERENCES

COMPANY	ADDRESS	CONTACT PERSON	SERVICES RENDERED
Caribe Hydroblasting	Ave. Muñoz Rivera 102 Peñuelas, PR	Mr. Jorge Amufact	RCRA; Closure plan sampling Special samples
Clear Ambient	P.O. Box 1675 San Juan 00936	Mr. Richard Viera	RCRA; Special sampling
Caribbean Petroleum (Gulf)	P.O. Box 36-1988 San Juan, PR 00936-1988	Eng. Ferdinand Quiñones Eng. Domingo Pérez	Treatment plant discharges (special intensive monitoring)
Citron Exports	P.O. Box 1025 Adjuntas, PR 00601	Rimmert Djong	Ground Water
Colgate Palmolive	P.O. Box 540 Guayama, PR 00785	José Norat	RCRA
CPI del Caribe	Carretera 698 # 12 Dorado, PR 00646	Alberto Alvarado	Pre treatnemnt
Ceramco Manufacturing Co.	HC-01 Box 8122 Las Piedras, PR 00771-9738	Juan Alvarez	Pre treatment; Ground water RCRA
Cyanamid	P.O.Box 243 Manatí, PR 00674	Dr. Roberto Aguayo	Pre treatment; RCRA Special samples
CORCO	Firm Delivery Ponce, PR 00731	Lic. Pedro Colón	Pre treatment Special samples
Circo Caribe	P.O. Box 5050 San Germán, PR 00683	Lic. Ismenio Ruiz	RCRA; Pre treatment Asbestos; Special samples
DIGITAL	P.O. Box 106 San Germán, PR 00753	Eng. Angel Serrano	RCRA - closure plan; Pre treatment Ground water; Special samples
Dupont Agrochemicals	P.O. Box 30000 Manatí, PR 00674-3000	Alda Feliciano	Pre treatment
Dupont Merk	P.O. Box 471 Ramey Branch Aguadilla, PR 00604	Lic. Luis Mercado	Special samples
Destañería Goldsmith	P.O. Box 1174 Salinas, PR 00751	Fé M. Rivera	Ground water
Eli Lilly	P.O. Box 1748 Mayaguez, PR 00715	Peter Rodríguez Lourdes Hernández	RCRA
ENSAT	Plaza San Francisco- Suite #5 Ave. De Diego, Río Piedras 00927	Doel Miranda Ralph Abbondanza	RCRA
Ecodyne			RCRA
FDI-Corp (Frutsi)	P.O. Box 280 Aguire, PR 00704		Pre treatment
Golden Laudry	Urb. Villa Grillasca Ponce, PR 00731	Doris Martínez	Pre treatment
Hal Inc. (Las Cascadas)	P.O. Box 5257 Aguadilla, PR 00704	Victor Pérez	Pre treatment
IPR- Carolina	P.O. Box 1967 Carolina, PR 00984-1987	Eng. José Rodríguez	Pre treatment
IPR- Guayama	P.O. Box 3057 Guayama, PR 00785	Lic. Aníbal Torres	Pre treatment; RCRA Special samples
Kayser Roth	P.O. Box 286 Arecibo, PR	Mr. Víctor Colón	Pre treatment
Knogo Caribe	P.O. Box 1378 Ciéra, PR 00639	Emiliano Pérez	RCRA
Latas de Aluminio Reynolds	P.O. Box 1937 Guayama, PR 00655	Carlos Padilla	Pre treatment

BECKTON ENVIRONMENTAL LABORATORIES- LIST OF REFERENCES

COMPANY	ADDRESS	CONTACT PERSON	SERVICES RENDERED
Merk Sharp and Dome	P.O. Box 601 Barceloneta, PR 00617	Luis Rivera	Special samples
McNeil Pharmaceuticals- Dorado	P.O. Box 710 Dorado, PR 00646-0710	Ms. Elizabeth Kauffman	Pre treatment (Special Intensive monitoring)
Medtronics	Call Box 6001 Villalba, PR 00766	Eng. José Moreno	Pre treatment; RCRA Stormwater
McGaw of Puerto Rico	P.O. Box 729 Sabana Grande, PR 00637	Mr. Eddie Rivera	Pre treatment; RCRA Stormwater, Ground water
Ochoa Fertilizers	P.O. Box 32 Guanaica, PR 00653	Miguel A. Pacheco	RCRA
Osram Sylvania	HC-02 Box 19400 Gurabo, PR 00778-9635	Mr. Luis Benn	RCRA
Power Conversion Caribe	Playa Industrial Park B-St #13 Salinas, PR 00757		RCRA
Ponce Waste	P.O. Box 111 Mercedita, PR 00715-0111		RCRA
Pepsi Cola Bottling	P.O. Box 1558 Cidra, PR 00639	Vicente Rosario	Pre treatment
Pharmachem	P.O. Box 308- Playa Station Ponce, PR 00731	Eng. Oscar Cedeño	Special samples
Puerto Rico Sun Oil	P.O. Box 186 Yabucoa, PR 00767-0186	Eng. Carlos Martínez	Pre treatment; RCRA Special Samples
PREPA- Aguirre	P.O. Box 137 Aguirre, PR 00704		NPDES
PREPA-Ciclo Combinado	P.O. Box 137 Aguirre, PR 00704	Lic. Angel Lugo	RCRA; Pre treatment Special samples
PREPA- Costa Sur	P.O. Box 340 Guayanilla, PR 00656		RCRA
PREPA- Palo Seco	P.O. Box 4267- Correo General San Juan, PR 00936-4267	Lic. Moisés Soto	RCRA
PREPA- Central San Juan	P.O. Box 4267- Correo General San Juan, PR 00936-4267	Lic. Richard Concepción	RCRA
Power Parts	P.O. Box 878 Santa Isabel, PR 00757	Mr. Rubén Flores	
Programos	P.O. Box 786 Guanaica, PR 00653	Eng. Juan Díaz	Pre treatment
PROTECO	Firm Delivery Ponce, PR 00731		Stormwater
Quality Electroplating	P.O. Box 6570 Caguas, PR 00626-6570	Monserrat González	Pre treatment
Rodenstock	P.O. Box 8 Yauco, PR 00768	Mr. Luis Villamil	Pre treatment
Schering Plough	P.O. Box 486 Manatí, PR 00674	Lic. Carlos Cordero	Stormwater
Safety Kleen	P.O. Box 1098 Manatí, PR 00701	Eng. José Molina Mr. Angel Cruz	Pre treatment; NPDES ground water; special samples
SPS Añasco	P.O. Box 179 Añasco, PR 00610	Mr. Juan Vélez	RCRA
Searle	P.O. Box 363826 San Juan, PR 00936-3026	Mr. Edgardo Torres	Pre treatment

BECKTON ENVIRONMENTAL LABORATORIES- LIST OF REFERENCES

COMPANY	ADDRESS	CONTACT PERSON	SERVICES RENDERED
SKB-Cidra	P.O. Box 11975 Cidra, PR 00639-1975	Mr. Tony Garcia; Lic. Marisol Martinez	RCRA; Ground water
SKB-Guayama	P.O. Box 11975 Guayama, PR 00655	Lic. Wilfrido Torres	RCRA; Ground water Special samples
Syntex	HC-01 Box 16625 Humacao, PR 00601-9737	Mildred Pizarro	RCRA; Pre treatment
Union Carbide Caribe	Flim Delivery Ponce, PR 00731	Eng. William González	RCRA; NPDES; Stormwater Special samples
U.S. Army Corps of Engineers	P.O. Box 7274 Ponce, PR 00732	Rafael A. Rios	Special samples
Vassallo	P.O. Box 473 Coto Laurel, PR 00644	Edgard Comellas	Ground water; RCRA
Westinghouse	P.O. Box 359 Coamo, PR 00769	Alfonso Mateo	RCRA
Wheaton Plastics	P.O. Box R Cayey, PR 00737	Elias Maldonado	Stormwater
Whitehall Labs.	P.O. Box 208 Guayama, PR 00785	Lic. Enrique Negrón	RCRA
Wallace International	P.O. Box 1178 San Germán, PR 00673	Joseph Rodriguez	Pretreatment; Stormwater
Rollins	Ave. Isla Verde 6616 Carolina, PR 00979	Lic. Jaime Colón	RCRA
Texaco	P.O. Box 3666 Guayanilla, PR 00656	Eng. Irizarry	RCRA
Becton & Dickinson	P.O. Box P Cayey, PR 00737	Eng. Juan Medina	RCRA

Brochure of the Laboratory

Date: February 21, 1992
Revision Number: 1

BECKTON ENVIRONMENTAL LABORATORIES, Inc.

192 Villa Street
Ponce, Puerto Rico 00732

Tel.: (809) 841-7373
Fax.: (809) 841-7313

MANUAL OF ENVIRONMENTAL LABORATORY PRACTICES

Quality control and quality assurances (QC/QA) observed in the analysis of water, wastewater, and hazardous wastes in compliance with local and federal agencies requirements.

Prepared by: *Rafael Infante, Laboratory Manager*
Approved by: *Jorge Arrufat, CEO*
Date : *February 21, 1992*
Copy No. :

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1.0 INTRODUCTION

"Chemical measurement data are often the basis for critical decisions on vital matters, ranging from the health of individuals, to the protection of the environment, to the production of safe, reliable, and useful products and services. Obviously, the data used for such purposes must be reliable, and there must be unequivocal measurements to prove it. The philosophy and procedures by which this is achieved and demonstrated are called quality control." [John K. Taylor, Quality Control of Chemical Measurements, Lewis Publishers Inc., 1987.]

This manual is issued to describe the quality assurance system employed at Beckton Environmental Laboratories, Inc. in compliance with the intend of the general quality system requirements of the cognizant accrediting organization. The policy of Beckton Environmental Laboratories, Inc. is to apply the system to all testing and analytical activities undertaken on behalf of the customer or an accrediting organization.

The manual provides personnel and customers of Beckton Environmental Laboratories, Inc. with a description of company policy for maintaining an effective quality assurance system. This manual documents the procedures used to manage custody elements and analytical processes at Beckton. As such, the material contained within is subject to change. Changes may be based on specific project requirements or procedural system modifications geared toward operational process and quality improvement. This document is reviewed and updated on a minimum yearly basis.

Because of the variability of samples and matrices, is not unusual to find that performance criteria of a particular method is unachievable on particular samples. In such circumstances, any method or criteria modification will be noted on each final report.

Written procedures for implementing the policies described herein are amplified by the several sections comprising this manual. These procedures are binding on all personnel of the laboratory and shall be adhered to implicitly.

2.0 LETTER OF PROMULGATION

MEMORANDUM

TO: All Personnel of Beckton Environmental Laboratories, Inc.

FROM: Mr. Jorge Arrufat
Executive Vice-president, CEO

DATE: December 5, 1991

SUBJECT: ***QUALITY ASSURANCE PROGRAM***

The quality assurance program described in this Quality Assurance Manual has the absolute and unqualified support of Beckton Environmental Laboratories, Inc., management and is part of our Standard Operating Procedures (SOP).

Beckton Environmental Laboratories, Inc., testing and analytical services, precision, accuracy, fast delivery, and fair prices are the means by which we have gained enviable reputation and the trust of industries as well of the Puerto Rico and Federal regulatory agencies. Excellence in quality is Beckton number one priority and every member of the laboratory staff shares the responsibility of maintaining this standard.

At Beckton, excellence in quality is the responsibility of every one of us. Fulfilling this commitment will result in the continued satisfaction of our customers and the trust of Government regulatory agencies.

I will expect every one concerned to use this manual, as a guide to the continued maintenance and improvement of our laboratory services.

JAV/rsf

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3.0 QUALITY GOALS AND OBJECTIVES

GOAL: *- Assure the accuracy and precision, as well as the reliability of laboratory results produced for our customers, or at the request of regulatory or accrediting bodies. Management, administrative, statistical, investigative, preventive and corrective techniques will be employed to maximize reliability of the data.*

Specific objectives:

1. To develop laboratory practices that assure consistent and valid data.

2. To develop and put into service rugged methods capable of meeting the user's need for precision, accuracy, sensitivity, and specificity.

3. To ensure that all staff members receive training in basic quality technology, in sufficient depth to enable them to carry out the provisions of this manual.

4. To establish the level of quality of the laboratory's routine performance as a baseline against which to measure the effectiveness of quality improvement efforts.

5. To ensure that internal record keeping (documentation) is appropriate, well maintained, up-to-date, and used as an integral part of the routine work load.

6. To make any changes in routine methodology found necessary to make it compatible with performance needs.

7. To monitor the routine operational performance of the laboratory through participation in appropriate interlaboratory testing programs such as:

Government Agencies Laboratories such as the United States Environmental Protection Agency (EPA); the Puerto Rico Environmental Quality Board (EQB); Commonwealth of Puerto Rico, Puerto Rico Aqueduct and Sewer Authority; and the Puerto Rico Department of Health.
Commercial Laboratories such as Environmental Resources Associates (ERA)

and to provide for corrective actions as necessary.

8. To improve and validate laboratory methodologies by participation in method validation studies.

4.0 LABORATORIES SERVICES/PRACTICES

Quality control of environmental analyses involves consideration and control of the many variables that affect the production of reliable data. Described below are the laboratory facilities at hand and the quality of the laboratory services available.

4.1 General laboratory facilities

Beckton Environmental Laboratories, Inc. operations are divided in six (6) sections:

(a) balance room:- area designated for the analytical balance, this area is located away from laboratory traffic and protected from sudden drafts and humidity changes. Balances are mounted on heavy shockproof table with an adequate working surface.

(b) wet chemistry area:- in this area are located the necessary equipment for performing conventional wet chemistry analyses.

(c) microbiological room:- this area is designated for microbiological, asbestos and BOD analyses.

(d) chromatography room: this area is designated for the analysis of organic compounds following chromatographic procedures. The equipment at hand include three gas chromatographs equipped with various specific detectors (Hall, PID and ECD) and a mass spectrometer, automatic injectors and purge and trap for the analysis of volatile organics. All chromatographs are computer controlled.

(e) spectroscopy room: this room is dedicated for the analysis of trace metal. The instrumentation available include an atomic absorption spectrometer with flame, cold vapor, furnace, and hydride generator and a microwave digestion system. Also available is equipment necessary for conventional digestion procedures.

(f) storage area:- reagents are stored according to applicable and safety regulations and guidelines. Areas dedicated for chemical reagent storage are well maintained and orderly.

In addition the following items are available:

» adequate bench, instrumentation, storage and records- keeping space
» adequate lighting and ventilation
» efficient fume hood system; hoods are calibrated annually by outside contractor, the the blowing efficiency is checked periodically.
» hot plate, refrigerator for samples, pH meter, thermometer, balance
» electrical power for routine laboratory use and, if appropriate, voltage-regulated sources for delicate electronic instruments
» emergency equipment, fire extinguishers, eye wash stations, shower, first aid kit, gloves, goggles, equipment to control spills

4.2 Demineralized, high purity water

Demineralized, high purity water is used in the laboratory for dilution, preparation of reagent solutions, and final rinsing of glassware. Demineralized ultra pure water is obtained by reverse osmosis using a Millipore Milli RO 4 System (Millipore Corp. Bedford, Mass), the water produced by reverse osmosis feeds into a Corning Mega-pure water purification filter MP-190 (Corning, New York). This system consists essentially of disposable cartridges for prefiltration, organic absorption, deionization, and Millipore filtration. It is capable of producing 10 ML water, containing no particulate matter larger than 0.20 mm in size at the rate of 90 L/hr. The conductivity, pH, temperature, and residual chloride of the water are frequently monitored. When set values are higher than an established threshold cartridges and filtration are replaced. The system produces ultrapure water which meets or exceeds the following standards: ASTM Reagents Grade, Type 1; CAP Reagent Grade, Type 1; and NCCLS Reagent Grade, Type 1. Removal of organics is less than 10 ppb.

Standard operating procedure are available for the operation and maintenance of the system and a log book is kept.

4.3 Compressed air

A source of oil, water, and dirt free air is available at the laboratory (Craftsman). Absorption filters are used to prevent moisture to enter the piping system. Solder joint copper tubing is used for piping the air to the laboratory.

4.4 Vacuum system

A source of vacuum is available at the laboratory. The vacuum pump is an Edwards.

4.5 Glassware

Due to the importance of the analyses conducted and the concentration levels, specific glassware is available for each of the analyses listed. In addition, aware of the importance of the errors resulting from contamination of the glassware, procedures for cleaning the glassware have been implemented.

Cleaning procedures differ based on the intended use of the glassware but always include washing it with laboratory grade phosphate-free detergent, tap water rinse followed by deionized water rinse, and acid or solvent rinses or soaks depending on intended use.

4.6 Reagents- solvents and gases

One of the quality control practices of the laboratory is the utilization of reagents/solvents of such purity that meets the requirement of the analysis. The purity of the reagent required is determined by the parameter being measured and the sensitivity and specificity of the detection system. Reagent of lesser purity than that specified in the method are not used. Beckton Environmental Laboratory, Inc. maintain in stock the particular reagents/solvents needed for a particular method. The following practices are followed:

» working standard are checked frequently to determine changes in concentration and composition

» concentration of stock solutions are verified before being used to prepare new working standards

» laboratory supplies with limited shelf life are dated upon receipt and shelf life recommendations, including the discard date on the container and the storage requirements, are observed. Analyst and technicians are trained to date materials when received and upon opening as a tracking mechanism for the material. Periodically, inventories are reviewed and materials are evaluated for disposal.

» reagents are prepared and standardized against reliable primary standard

» standards and reagents are properly labeled

4.6 Instrumentation

Major pieces of equipment are illustrated in Appendix A.

4.7 Waste disposal

Beckton utilizes appropriate procedures to properly handle its laboratory waste disposal streams. Laboratory wastes are classified, segregated, and properly stored prior to disposal. Contracts are held with reputable waste disposal firms for removal the wastes from the facility and ultimate disposal. All required labelling and waste manifest documentation is performed.

5.0 TECHNIQUES FOR SAMPLING COLLECTION, HANDLING, AND PRESERVATION

Proper collection of samples is of paramount importance to environmental monitoring. This section provides guidance in making decisions pertinent to the validity and acceptability of the samples submitted for testing or analysis.
The sampling program is dependent upon the following six major activities:

(1) formulating the particular objectives of the sampling program
(2) collecting representative samples
(3) maintaining the integrity of the samples through proper handling and preservation
(4) adhering to adequate chain-of-custody and sample identification procedures
(5) practicing quality assurance in the field
(6) properly analyzing the pollutants in the sample

The objectives of the sampling program affect all other aspects of the sampling program. Sampling program objectives are determined by the following activities:

(1) planning *(2) permitting* *(3) compliance*
(4) enforcement *(5) design* *(6) process control*
(7) research and development

Factors that must be considered in meeting the objectives of the sampling program are the extend of manpower resources, the complexity of the parameters of interest, the duration of the survey, the number of samples, the frequency of sampling, the type of sample (grab or composite) and the method of sample collection (manual or automatic).

The objective of environmental sampling is to obtain a representative portion of the population under investigation. The techniques for obtaining representative samples may vary with: body of water being sampled (length, width and depth); physical and chemical parameters; type of water to be sampled (municipal or industrial effluent, surface water, bottom sediments, agricultural runoff, sludges, etc.). In collecting representative samples the following factors are considered:
(1) site selection:-
(2) type of sample:- the basic types of sampling methods are grab and composite. The choice of using the grab sampling method or one of six compositing sampling

methods is determined by program objectives and the parameters to be sampled. The grab sample will show the sample characteristics at the time of collection; grab sampling is usually required for analyses that have to be conducted rapidly after collected. Composite sample are collected in order to minimize the number of samples analyzed. Composite sampling can be performed by any of six possible methods: (a) constant sampling pumping rates, (b) sampling pumping rate proportional to flow, (c) constant sample volume and constant time intervals between samples, (d) constant sample volume and time intervals between samples proportional to stream flow rates, (e) constant time interval between samples and sample volume proportional to total stream flow volumes since last sample, and (f) constant time intervals between samples, and sample volumes proportional to total stream flow at time of sampling.

(3) sampling protocols:- sampling shall be performed in accordance with the techniques approved by EPA. Where 40 C.F.R. Part 136 does not include sampling or analytical techniques for the parameters in question, or where EPA determines that the Part 136 sampling and analytical techniques are inappropriate for the parameters in question, sampling and analysis will be performed using validated analytical and sampling methods.

(4) representativeness:- all samples and field measurements taken for the purpose of monitoring shall be representative of the mentioned activity.

Sample integrity is maintained by using proper handling and preservation procedures. The following guidance provides the basis for making decisions pertinent to the validity and acceptability of samples submitted for testing or analysis.

<u>(1) Sample containers.</u>
All sample containers are subject to the following laboratory cleaning and preparation procedures:

Bottle caps
- all bottle cap are Teflon lined
- new bottle caps are rinsed with deionized water, allowed to air dry in racks, then placed on bottles

Glass bottles (1L, 500 mL, 250 mL)
- only new glass bottles will be used for grab sampling; sampling bottles will not be reused
- rinse with deionized water

Clear glass vials (40 mL for volatile organics)
- Teflon lined septa for caps are stored in containers prior to use
- bottles, caps and septa are rinsed with deionized water, then baked for one

hour at 105°C
Hydrochloric acid preservative is added to each vial used for aqueous samples
upon client request 20 mg of sodium thiosulfate is added to remove residual chlorine in the sample

Plastic bottles
only new plastic bottles will be used for grab sampling; sampling bottles will not be reused
bottles and caps are rinsed with deionized water and allowed to air dry
bottles used to collect sample for the analysis of metals are rinsed in nitric acid solution

Coliform bags
all bags used for the sampling and analysis of coliform are purchased sterilized. They are received sealed and autoclaved.

(2) Physical conditions of the sample containers

If damage to a container is evident, it will be carefully opened and its content inspected. In the event of damage to the sample because of damage to the shipping container, the customer will be notified and the invalid sample discarded using the appropriate procedure.

(3) Sample integrity

Sample integrity refers to the cumulative result of those factors which contribute to the overall validity of the sample. Sample integrity is promoted and preserved by adhering to adequate custodial, handling, and identification procedures by those individual collecting the samples, up to the point of receipt of samples by the laboratory. When the sample are received they are checked for:

a. physical damage to the sample
b. loss of sample due to inadequate or improper sealing, leakage of liquids, loss of particulate material, inadequate sealing of solid sorbent sampling tubes, etc.
c. contamination of samples due to inadequate separation of sample types or bulk sampling materials
d. improper use of special shipping procedures designed to preserve the sample at temperatures other than ambient

(4) Sample identification

Accurate sample identification must be submitted with each sample. Sampling having inadequate, ambiguous, or nonexistent labels will be discarded unless the customer is able to provide immediate identification.

(5) Sample submittal forms

For each sample the following information is logged in: (a) sample number assigned (BEL- xxxx); (b) the current date; (c) the name of the organization and/or the individual submitting the sample for test or analysis; (d) sample description and source; (e) date of collection; (f) the test wanted; and chemical preservative as applicable.

(6) Sample preservation and handling

During and after collection, if immediate analysis is not possible, the sample must be preserved to maintain its integrity. The guidelines approved by EPA [i.e. Guidelines Establishing Test Procedures for the Analysis of Pollutants, Federal Register, 41, No. 232 (Dec. 1976)] are routinely used for preservation for the various constituents; the required sample holding time is strictly followed. Please see enclosed table in Appendix G.

Proper handling of sample insure valid data; when sampling consideration is given to the field container and cap material to make sure its compatibility with the sample constituents. Accepted guidelines are followed for cleaning, structure of containers, container preparation for determination of specific parameters, container identification, and volumes of samples.

(7) Quality assurance in the field

The quality assurance program for sampling equipment and field measurement procedures is as follows:

(a) strictly follow the analytical methodology, the sample handling and field documentation procedures

(b) sampling methodology is selected on the basis of sampling objectives; only accepted sampling methods are employed

(c) field and trip blanks are taken as required and analyzed periodically (5% of all samples)

(d) field instruments and samplers are calibrated according to manufacturer specifications before taking any measurement; calibration records are kept. Field instruments (pH, D.O., etc.) are calibrated twice a year by an outside contractor.

(e) field personnel must be qualified to conduct a particular sampling situation. Periodic training is given to all field personnel

(8) Sample custody

The chain of custody in the laboratory consists of two areas of concern:

- Receipt and log-in of samples, and
- Maintaining internal custody of samples transferred throughout the laboratory

Samples are considered physical evidence and are handled at **Beckton** according to certain procedural safeguards. For the purposes of some types of legal proceedings, a showing to the court that the laboratory is a secure area may be all that is required for the analyzed evidence to be admitted. However, in some cases, the court may require a showing of the hand-to-hand custody of the samples while they were at the laboratory. In the event that the court requires such a comprehensive chain of custody demonstration, **Beckton** is prepared to produce documentation that traces the in-house custody of the samples from time of receipt to completion of the analysis.

Maintaining custody by NEIC definition

Custody is maintained by EPA National Enforcement Investigations Center (NEIC) definition when:

the sample is in the actual possession of the responsible person, or
the sample is in the responsible person's view after being in their possession, or
the sample is in the responsible person's possession and they are locked or sealed it up to prevent tampering, or
the sample is in a secure area

Beckton laboratory procedures

To satisfy these custody provisions, the following standard operating procedures are employed:

- a sample security area is available that is dry, clean, and isolated, has sufficient refrigerated spaced, and is securely locked from the outside
- the grounds around the building are patrolled on a regular basis by a private security company (Plaza Security); the building is protected by burglar alarms
- visitors must register upon entering the lobby of the facility, and must be accompanied by their host at all times while they are on the building
- receipt and log-in of samples is fully documented and is performed in a controlled area
- samples remain in the secure storage area until removed for sample preparation or analysis
- the internal transfer of samples is controlled and documented through the use of color coded cards and laboratory records

Beckton sample custodian

The Service Manager is responsible for the custody of samples, he/she:

- receive, inspect, and record the condition of samples
- sign appropriate documents and retain the chain of custodyform as a permanent record
- verify and record correctness of sample documentation
- ensure that samples are properly stored and distributes the samples to

personnel who are to perform analysis
- control and monitor access and storage of samples

Sample receipt and log-in for client drop off of samples

The **Beckton** employee who accepts receipt of client samples upon arrival at the laboratory is a designated sample custodian. The sample custodian examines both the shipping container, chain of custody, and sample documents. The Service Manager is responsible for the receipt and log-in operations. The custody seal and documents are examined for compliance. Any and all noncompliances are documented and the client contacted.

The sample log-in notebook is an internal document designed to summarize all the relevant information concerning a sample's receipt and analytical requirements. It is circulated internally and instruct the laboratory with regards to the receipt, and the required analyses and reporting of the sample

Special handling for high hazard samples

If a shipping container is labeled "Caution-Hazardous Materials", or if it contains samples to be analyzed for extremely hazardous materials, the Laboratory Manager is notified prior to log-in. The container are opened by the custodian who have successfully completed respirator fit-test and safety training sessions in the necessary protective equipment. The containers are opened using all necessary safety measures deemed necessary by Beckton Safety Committee and department supervisor.

Maintaining internal chain of custody

Custody sample within the department is represented through the use of notebooks. The specific lab area procedures are summarized below:

(a) sample preparation- TCLP

The analyst claims custody of the sample from sample storage to the laboratory. Verification by the supervisor represents the completion of the preparation and subsequent transfer of the remaining sample to be disposed or back to sample storage refrigerator, and of the extract to the extract storage refrigerator.

(b) GC and GC/MS laboratory

Volatile organics (purgeables)- the analyst claims custody of the sample from sample storage to the laboratory. The supervisor signature represent the completion of the analysis and final disposition of the sample.

Semivolatile organics (extractables)- the analyst claims custody of the sample from sample storage or from the extract refrigerator to the laboratory. For raw samples, verification by the supervisor represents the completion of the preparation and subsequent transfer of the remaining sample to be disposed or back to sample storage refrigerator, and of the extract to the extract storage refrigerator.

The supervisor signature represent the completion of the analysis and final disposition of the extract.

(c) Metal laboratory

The analyst who signs for preparation is responsible for the transfer of the sample from initial storage to the laboratory. The supervisor signature represent the completion of the analysis and transfer of the remaining sample back to storage.

(d) Wet chemistry laboratory

The analyst who signs for preparation is responsible for the transfer of the sample from initial storage to the laboratory. The supervisor signature represent the completion of the analysis and transfer of the remaining sample back to storage.

Sample disposal

The laboratory custody of the sample ends with laboratory disposal. Beckton routine disposal of samples occur after the sample holding time is over or a minimum of thirty days from the mail date of the sample technical report. At Beckton discretion, hazardous samples may be returned to the client. Beckton has the capacity to retain samples for a longer period of time to comply with client or contract requirements.

6.0 ANALYTICAL METHODS - METHODOLOGY

The **Beckton** laboratory utilizes approved USEPA methodologies for all analysis, if available and applicable. The deliverables included in the sample technical reports are based upon the level of report deliverable requested and the quality assurance requirements of the method performed. Analytical results and quality assurance protocols are based on the following methods and guidelines:

» *Standard Methods for Water and Wastewater*, 14th, 15th, 16th Editions, 1985
» *Methods for chemical analysis of water and wastewater*, CFR Part 136-Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule. [Federal Register Vol. 49, No. 209, October 26, 1984]
» *USEPA Contract Laboratory Program Statement of Work for Organic Analysis*
» *USEPA Contract Laboratory Program Statement of Work for Inorganic Analysis*
» Environmental Resource Associates (ERA)- Quality control practices for waste and potable water analysis
» *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*, EPA-600/4-79-019, March, 1979
» Commonwealth of Puerto Rico, Puerto Rico Aqueduct and Sewer Authority-General Conditions
» Commonwealth of Puerto Rico, Environmental Quality Board Guidelines
» *Test Methods for Evaluating Solid Waste*, USEPA, SW-846, third edition, Revision 0, September, 1986.

In addition to performing these standard methods and procedures, **Beckton** has the capability of modifying external methods and performing client or project specified methods. Within normal laboratory operations, Beckton can design experiments and method improvements to offer its clients improved performance for specified parameter.

The table shown in *Appendix G* illustrates the parameters analyzed in **Beckton** Environmental Laboratories, Inc. along with the analytical method utilized and the corresponding SOP. The methodology employed in each of the analyses is in accordance with the appropriate regulatory agency (EPA, EQB, Puerto Rico Health Department, etc.).

7.0 DOCUMENTATION AND RECORD CONTROL

This section describes how the laboratory will control the issue and retrieval of all documents relating to the analytical and testing activities of the laboratory, to the control of quality of these activities and to the storage and security of the technical documentation generated by these activities.

The controls described in this section are limited to the documents and reports listed below, and do not affect documentation related to other laboratory management activities. Such document control procedures are described in other laboratory standard operating procedures.

The quality assurance program to which document control is applied include:

- *sampling procedures*
- *calibration procedures*
- *analytical and test procedures*
- *data collection and reporting procedures*
- *auditing procedures*
- *computational and data validation procedures*
- *the quality assurance manual*
- *analytical and testing reports*
- *laboratory notebooks*
- *validation reports*
- *calibration and preventive maintenance records*
- *chain-of-custody documentation*

The quality records listed above which are originated and maintained as hard copies will be retained for a period of three years in laboratory files. After a period of three years, they will be reviewed for disposition. Those not discarded will be retained for a period of five year (or longer at the request of the customer). Record generated by computer will be retained in that format indefinitely, with a backup and due care to keeping them in safe, hazard-free storage.

The information retained for long term storage include all sample reports which are delivered to clients, any raw data recorded on magnetic media, raw data not recorded on magnetic media, raw data which cannot be stored on magnetic media, and processed QC data not reported to the client

A file control will be maintained for all document distributed showing the following information:

Document title *Distribution*
Format *Issue date*
Signature of the person receiving the document

The Laboratory Manager is responsible for distribution and retrieval of documents and for obtaining the required signatures.

All files, when not in use will be kept in locked file cabinets. Computer data security will be maintained in accordance with data processing standard operating procedures for restricting entrance to computer data information.

7.1 Chain of custody practices

This section describes the procedures to be followed when strict chain-of-custody protocols for samples received must be followed.

When sampling, Beckton Environmental Laboratories, Inc. will follow strict chain-of-custody procedures in the handling of all samples. When submitting samples to the laboratory, the submitter will be responsible for determining whether chain-of-custody procedures are necessary for a particular sample or sample set.

The chain-of-custody documentation form (Figure 7.1) will be used as chain-of-custody record. One of these forms will be completed for each sample submitted for analysis. The form is to remain with the sample at all times. The chain-of-custody form will contain the following information: (1) person or organization submitting the sample; (2) sample number. In the case of multiple samples, each sample within a sample set will be given a unique number; (3) submitter's address; (4) submitter's telephone number; (5) sample description- in sufficient details that it can be distinguished from other samples; (6) sample source; (7) date and time of sample acquisition; (8) method of shipment, or if the sample was carried in, so note; (9) date of receipt; (10) individual receiving the sample; (11) conditions of the sample; (12) analysis to be performed; (13) final disposition.

7.2 Data reporting forms

A system for uniformly recording, processing, and reporting data is employed. In Appendix E the forms utilized by **Beckton Environmental Laboratories, Inc.** for routine reporting of analysis and/or testing results are included. The forms provides complete data documentation and permanent recording.

For each analysis reported:

- correct calculation formulas are used
- round-off rules are uniformly applied; significant figures are established for each analysis
- calculations are cross-checked by the analyst and the area supervisor

Effective Date 02-21-92	Subject	Section No. 7.0
By RNI	DOCUMENTATION AND RECORD CONTROL FIGURE 7.1	Page 3 of 4
Approved JA		Revised 02-21-92

BECKTON ENVIRONMENTAL LABORATORIES, INC.

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CHAIN OF CUSTODY RECORD

Proj No.
1. Project Name
2. Company Organized
3. Sta. No. | 4. Date | 5. Time | Comp | Grab | 6. Station Location | 7. No. of Containers | 8. Remarks

Relinquished by: (Signature) | Date Time | Received by: (Signature) | Relinquished by: (Signature) | Date Time | Received by: (Signature) | Relinquished by: (Signature) | Date Time | Received by: (Signature)

Relinquished by: (Signature) | Date Time | Received by: (Signature) | Relinquished by: (Signature) | Date Time | Received for Laboratory by: (Signature) | Remarks

» appropriate forms/units required for reporting are employed
» laboratory records are kept readily available to regulatory agencies for a minimum of three years
» laboratory notebooks and preprinted data forms are permanently bound to provide good documentation
» records are maintained showing calibration and maintenance records, original strip chart recording and/or raw data. These records are readily available for inspection
» documentation is kept on control chart approaches and statistical calculations

8.0 ORGANIZATION AND RESPONSIBILITIES

The **Beckton Environmental Laboratories** organizational chart is presented as Figure 8.0.1. This section depicts the organizational structure, functional responsibilities, levels of authority, and lines of communication.
Beckton is organized into three fundamental departments (Laboratory Operations, Administration and Sales, and Service, each reporting to the Chief Executive Officer. Each of the departments is discussed below in detail as to structure, role, organizational authorities and responsibilities within Beckton, and its interaction with other departmental units.

Within each area of assigned responsibility, while authority and responsibility for accomplishment of a specific task may be delegated to others, the ultimate responsibility resides with the Chief Executive Officer.

Responsibilities

8.0.1 Chief Executive Officer

Establish laboratory policies and procedures in conjunction with the respective department managers
Direct implementation and enforcement of the QA program
Direct implementation and enforcement of the Safety program
Develop and monitors budget for each department
Develop and monitor human resources requirements for staff and approve personnel actions for each department
Develop and implement long term business strategies
Coordinate production, sales, and quality assurance functions

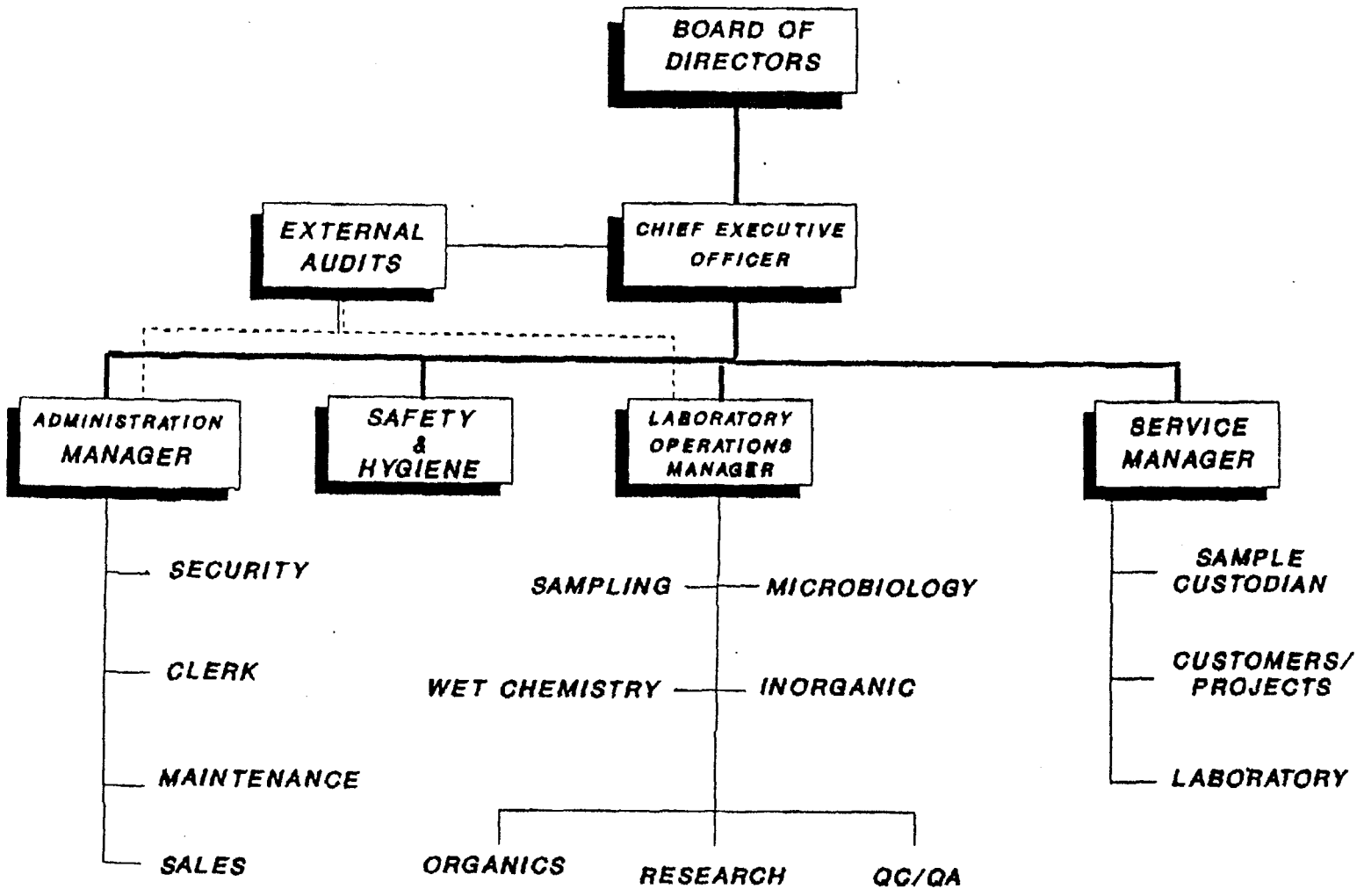
8.0.2 Laboratory Operations Department

The Laboratory Operations Department is responsible for the effective day-to-day management of all laboratory data production elements in such a way as to meet all client and procedural requirements, maintain and efficient and safe working environment, and meet business plan objectives. The department works under the direction of an Operations Manager. Reporting to the Operations Manager are Section Supervisors who are responsible for individual laboratory units.

8.0.2.1 Laboratory Operations Manager

Specific responsibilities include but are not limited to the following
Implement policies and procedures for Laboratory Operations Department
Monitor inventories and Laboratory Operations Department expenditures

BECKTON ENVIRONMENTAL LABORATORIES, INC.
ORGANIZATION CHART



Identify manpower needs, and assist the selection of prospective employees
Manage analytical resources within the lab in order to balance the workload to meet holding times and schedules
Perform technical reviews of analytical procedures and ensure compliance with required quality control standards
Review and approve data, and evaluate it for completeness, accuracy
Assist the Chief Executive Officer with coordination of production, quality assurance and sales efforts
Prepare quality assurance procedures in compliance with federal, state and **Beckton** requirements; train staff in these procedures
Conduct internal performance and system audits to monitor compliance with this Quality Assurance plan
Coordinate communications with laboratory accreditation and certification agencies
Statistically analyze QC results and update control limits for the laboratory, including performing trend analysis, to determine ongoing validity of analytical systems
Monitor data and final reports for compliance with defined objectives and for suitability and completeness

8.0.2.2 Section Supervisors

Section Supervisors manage the data production activities within their assigned groups and are responsible for the following:

Receive and distribute assignments, scheduling analyses in a timely manner to meet holding times and production schedules
Maintain assigned laboratory areas in a safe and clean condition
Review and approve data, and evaluate it for completeness, accuracy, and compliance with stated specific objectives
Perform technical reviews of analytical procedures and ensure compliance with required quality control standards
Monitor the throughput of the laboratory section
Provide analytical method training to analysts
Identify capital equipment and capital appropriation needs for the respective laboratory section and communicate these need to the Laboratory Operation Manager

8.0.3 Service Department

Service department is responsible for implementing a marketing and sales program which is consistent with the goals and objectives of **Beckton.** The specific responsibilities for the Service Manager are described below:

Develop proposal opportunities and prepare proposals

Communicate with present client to assess levels of satisfaction with the quality of service and performance of Beckton and provide input to Operations Manager when quality issues are raised
Communicate with potential clients to determine work opportunities, and identify service requirements of both new and existing clients
Maintain a high level of involvement in the negotiation of blanket purchase orders from clients
Coordinate with Laboratory Operation Manager to ensure meeting client requirements on projects
Monitor sales and service expenditures
Assist the Chief Executive Officer and the Laboratory Operations Manager with coordination of sales, production, and quality assurance efforts

8.1 Personnel training, qualification, and motivation

This section set forth the training methods, evaluation and qualifications procedures, and responsibilities for motivational programs in the laboratory.

All personnel involved in any function effecting the data quality, will have sufficient training in their appointed position. The Laboratory Manager is responsible for seeing that the required training is made available to these personnel and that records are maintained on each person reflecting satisfactory completion of training program or qualification test.

The following training methods are available to all laboratory personnel:
(a) experience training- on-the-job training learning how to cope with problems using prior experience or knowledge as the basis for action
(b) guidance training- on-the-job training given by supervisors and/or co-workers. This kind of training will be conducted as follows:
i. observe an experience operator perform the different tasks in the measurements process
ii. performing the operation under the direct supervision of an experience operator
(c) independent study- outside reading, attendance at seminar or professional society meetings
(d) in-house training- formal courses given by qualified personnel or outside consultants

Training sections are evaluated the following way:
(a) written test following training in order to assess effectiveness
(b) proficiency checks- trainees will be assigned work tasks related to training subject matter
(c) interviews

From time to time the Laboratory Manager conducts motivational campaigns. He will also make recommendations with regards to efforts to increase employee awareness of each individual's responsibility for the quality laboratory output.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The purpose of the laboratory control procedure is to ensure high-quality sampling and analyses by the use of control samples, control charts, reference materials, and instrument calibrations.

The quality control activities are based on standard guidelines references:

» *Standard Methods for Water and Wastewater*, 16th Ed., 1985
» *Methods for chemical analysis of water and wastewater*, CFR Part 136, October 26, 1984- Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule.
» Environmental Resource Associates (ERA)- Quality control practices for waste and potable water analysis
» *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*, EPA-600/4-79-019, March, 1979
» Commonwealth of Puerto Rico, Puerto Rico Aqueduct and Sewer Authority- General Conditions
» Commonwealth of Puerto Rico, Environmental Quality Board Guidelines
» *Test Methods for Evaluating Solid Waste*, SW-846, latest edition.
» *Quality Assurance of Chemical Measurements*, John Keenan Taylor, Lewis Publishers, Chelsea, MI. 1987.

The responsibility for internal analytical quality control checks rests with the laboratory analyst. The type, frequency, and acceptance criteria of the checks performed are based upon the reference analytical methodology employed and the client project requirements.

The following figure summarize the quality program for **Beckton Environmental Laboratories, Inc.** (Figure 9.0.1)

General QC/QA Practices:

(a) daily analytical balance calibrations (sensitivity and zero checks) using NIST (NBS) weights
(b) outside contractor- annual balance calibration and maintenance
(c) oven and refrigerator maintenance- temperature accurately measured by comparing with certificate traceable NIST thermometers. For ovens, accuracy of temperature gauge is checked periodically
(d) pH meter calibration by using certified buffer solution (4.0, 7.0 and 10.0-

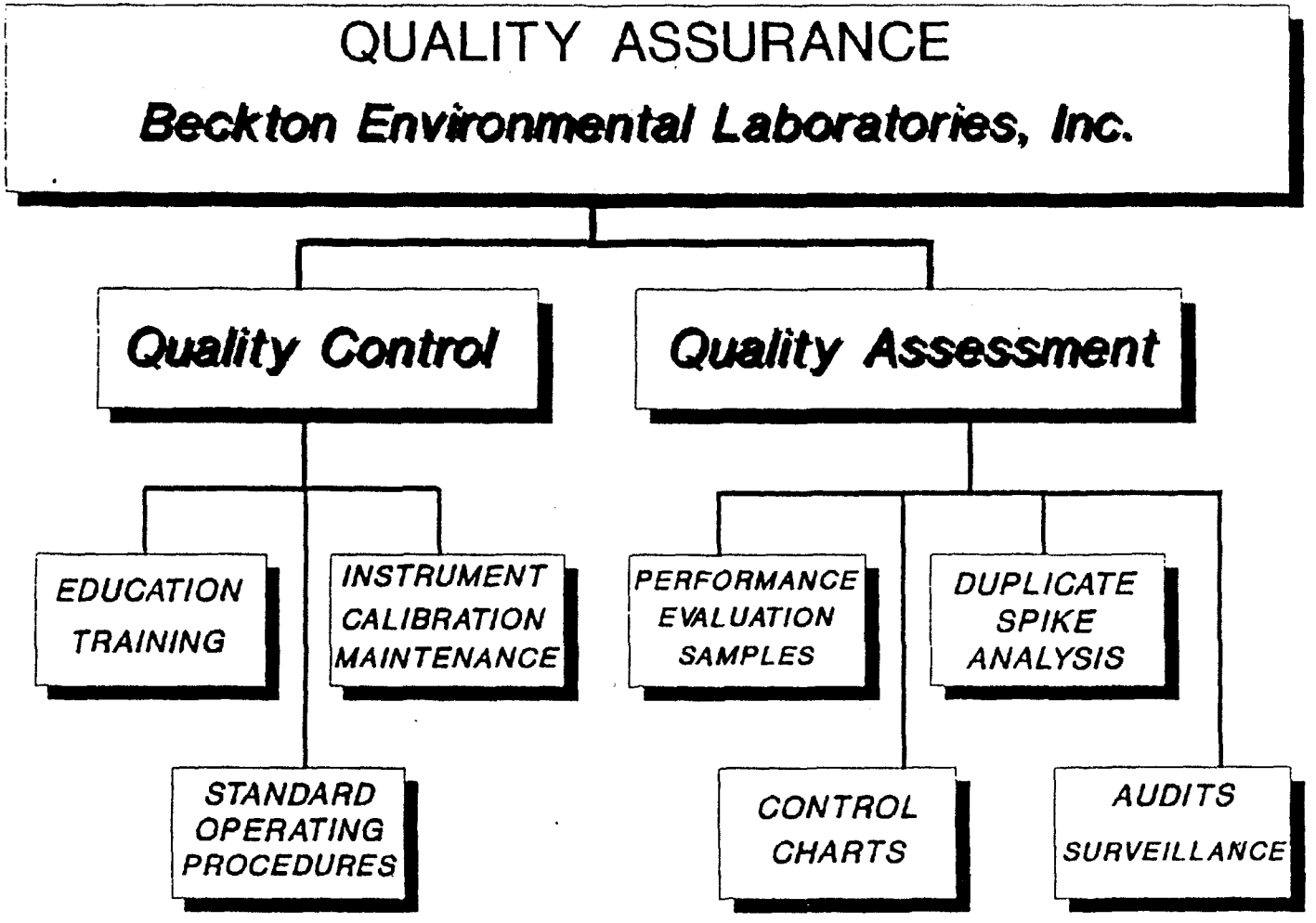

QUALITY ASSURANCE
Beckton Environmental Laboratories, Inc.
Quality Control
Quality Assessment
EDUCATION TRAINING
INSTRUMENT CALIBRATION MAINTENANCE
STANDARD OPERATING PROCEDURES
PERFORMANCE EVALUATION SAMPLES
DUPLICATE SPIKE ANALYSIS
CONTROL CHARTS
AUDITS SURVEILLANCE

Figure 9.0.1

NIST). Meter calibrated against mV standard.
(e) electrode daily maintenance- check filling solution and storage solution daily. Ensure that electrodes are properly caped and stored in accordance to manufacturer instructions. Store in appropriate solution.
(f) outside contractor- annual pH meter calibration and maintenance
(g) incubators- daily recording of temperature
(h) exhaust hoods- annual measurement of the air uptake with the air velocity meter to verify that air intake meet required standards, 100 cfm.

General QC/QA Practices, spectrophotometric analyses:

(a) daily spectrophotometric calibration is a mandatory requirement of performing quantitative analytical methodology. The laboratory must meet method criteria for instrument calibration and calibration verification before before proceeding with sample analysis. Beckton will meet the calibration criteria specified in the methods The analyst will not continue with an analysis or accept data unless the calibration requirements have been met.
(b) preparation of calibration curves for each parameter based on method specifications; correlation coefficient of the linear calibration; periodic check of calibration curve (check standard analyzed at least once in every ten (10) samples)
(c) routine instrument calibration summary is shown in the appendix

General QC/QA Practices, metal analyses:

(a) outside contractor (Jarrel-Ash) for maintenance and repair
(b) AA calibration: lamp alignment, burner adjusted, atomizer adjustment
(c) verification of baseline noise (blank)
(d) verification of sensitivity and linear working range
(e) preparation of linear working curve
(f) periodic check of linear working curve (check standard, low and/or high level concentration level, analyzed at least once in every ten (10) samples)

General QC/QA Practices, GC analyses:

(a) outside contractor (Hewlet-Packard) for maintenance and repair
(b) calibration program; correlation coefficient of the linear calibration
(c) system suitability studies for each parameter
(d) daily- inject low level standard to evaluate the flatness of the baseline, retention time, peak area, peak shape. Evaluate sensitivity and reproducibility of the analytical system during standardization. Efficiency and resolution check with calibration and qc samples (column check samples)
(e) retention time window determination for each parameter; typical reproducibility is ± 0.05 minutes

General QC/QA Practices, GC/MS analyses:

(a) outside contractor (Hewlet-Packard) for maintenance and repair
(b) daily tunning to meet EPA criteria (DFTPP for semi-volatiles; BFB for volatiles)
(c) calibration program; correlation coefficient of the linear calibration
(d) system suitability studies for each parameter
(e) periodical determination of efficiency and resolution; column check samples

General QC/QA Practices, microbiology:

(a) maintenance of the area to avoid cross contamination
(b) certification for the analysis of asbestos in air; performance is periodically monitored by outside contractor (PAT)
(c) analysis of blanks
(d) BOD analysis- calibration curve, check standard and blank determinations
(e) daily check of dissolve oxygen probe membrane, replacement when necessary
(f) outside contractor, annual calibration of dissolve oxygen meter and autoclave

QC samples that are used routinely

Trip blank:- analyte free reagent grade water prepared by the laboratory, shipped, and analyzed with the samples to detect accidental or incidental contamination during transport. Used as the discretion of the Laboratory Manager and as required for specific project plan.

Field blank:- reagent grade water provided by the laboratory that is transferred on site to an additional clean sample container to evaluate the environmental procedural effects of a sampling event; used to determine if contamination occurred during field sampling. Analyzed upon request of the client or Laboratory Manager.

Equipment blank (rinsate blank):- reagent grade water provided by the laboratory that is passed through sampling equipment to determine the effectiveness of the field equipment cleaning procedures. Analyzed upon request of the client or Laboratory Manager.

Method blank (reagent blank):- a blank used to check chemical reagent or process introduced contamination in the laboratory. Analyzed with each laboratory defined batch of samples (of up to a maximum of 20 samples per batch), or at the method required frequency.

Quality control spiked blank:- standard reference materials spiked into reagent grade water or other blank material and carried through the entire preparation and/ or analytical process to verify or demonstrate method performance. Analyzed at the method required frequency.

Spiked sample (matrix spike):- a client sample spiked with standard reference materials and carried through the entire preparation and/or analytical process to evaluate matrix spike effects on analyte recovery and accuracy. Analyzed at 5-10% frequency within a sample batch for metals and wet chemistry analyses or at the

method required frequency.

Unspiked laboratory duplicate:- a client sample which is slip and carried through the entire preparation and/or analytical process as a replicate sample to evaluate laboratory reproducibility an precision. Analyzed at 5-10% frequency within the sample batch for metals and wet chemistry, or at method specified frequency.

Spiked laboratory duplicate (matrix spike and matrix spike duplicate):- a client sample which is split, spiked with standard reference materials, and carried through the entire preparation and/or analytical process as a replicate sample to evaluate sample matrix effect on analyte recovery and accuracy as well as laboratory reproducibility and precision. Analyzed for organic analyses with each laboratory defined batch or set of samples (of up to a maximum of 20 samples), or at the method required frequency.

The following are added to field and quality control samples for organic analyses:

Internal standards:- compounds that possess similar chemical and physical properties to the target analytes. Added to samples and extracts prior to analysis, and used as retention and response reference points and to verify instrument performance. Evaluated as specified in the method.

Surrogates:- compounds that possess similar chemical and physical properties to the target analytes. Added to all samples to check for matrix effects or other difficulties related to method application. USEPA CLP and SW-846 recommended surrogate recovery limits are used and reported when available.

Specific QC/QA practices for each parameter tested:

For every batch of sample analyzed, a series of quality control samples are analyzed to assess precision, accuracy and the validity of the analysis. These data are reviewed before the release of the data.

The following summarizes QC/QA practices routinely performed at **Beckton**:

(a) only validated methods accepted by regulatory agencies will be employed

(b) demonstrate the proficiency of the analyst by analyzing replicate quality control check samples for each parameter, determine recovery and check with accepted criteria.

(c) each testing batch (or each parameter analyzed for permit compliance) must contain at least one blank, duplicate, and/or spike (as applicable) on 5% of the samples, or at least in one sample per month. If the analysis frequency is less than one sample per month, duplicate and spiked samples must be run for each analysis. [For Puerto Rico Aqueduct and Sewer Authority, duplicate samples are not required for color and temperature; spiked samples are not required for: acidity, alkalinity, bacteriological, color, dissolved oxygen, hardness, pH, oil and grease, radiological, residues, and temperature]

(d) to determine precision and accuracy Beckton Environmental Laboratories,

Inc. will:

- *analyze replicate quality control check samples*
- *analyze performance samples obtained from an external source (United States Environmental Protection Agency; Environmental Resource Associates (ERA), or similar) for each parameter at least once a year*
- *precision is characterized by the degree of agreement of a measured value to another measured value. Precision measurements are performed for each parameter according to the specification of the particular method employed.*
- *for each type of replicate sample and matrix spike/matrix spike duplicate pair, precision control charts are developed, limits will be established based on standard deviations with upper and lower limits being established at three times the standard deviation above and below the central line or according to the requirements of the methodology. Upper and lower warning limits are established at twice the standard deviation above and below the central line*

<u>Calculations to determine precision</u>

Precision is calculated as follows:

Relative Percent Difference

$$RPD = \{[A - B]/(A + B)/2\} \times 100$$

where: RPD = Relative Percent Difference
A = replicate value 1
B = replicate value 2

Range Control

$R = A - B$

$X = [A + B]/n$

where: R = range
X = average value
A = replicate value 1
B = replicate value 2
n = 2 (single duplicate pair)

To graphically represent the data of numerous duplicate pairs on control charts, the following calculations are performed:

Grand Mean = $X = Sx/n$
Mean Range = $R = SR/n$

where: X = average value
R = range
n = number of data points

Control limits for ranges:

UCL = 3.27 (R)
UWL = R + 2/3(3.27R - R)

where: R = mean range
UCL = upper control limit
UWL = upper warning limit

To determine if the proper range control chart is being used for evaluation of duplicate pair of results, the X control chart may be used:

Control limit for averages:

UCL = X + 1.88(R)
LCL = X - 1.88(R)
UWL = X + 2/3(1.88 R)
LWL = X - 2/3(1.88 R)

where: X = Grand mean
R = Mean range
UCL = upper control limit
LCL = lower control limit
UWL = upper warning limit
LWL = lower warning limit

» until sufficient data have been generated to calculate acceptance limits, the following limits will apply:

Range: ± 2 times the practical quantitation limit
RPD: ± 25%

Acceptance limits are calculated as follows, where x represents the individual values and n is the number of values:

Upper control limit, UCL 3s
Upper warning limit, UWL 2s
Center line, X (Sx)/n

Acceptance limit will be updated quarterly at a minimum whenever 10 or more new values have been generated. The summary of acceptance limits is revised and distributed to the appropriate lab group after each update

» corrective actions are taken when data fall outside the warning and control limits

» spiked samples are used to monitor accuracy; percent recovery for each

parameter will be calculated and compared to established limits.

Calculations to determine accuracy

Accuracy is calculated as follows:

Accuracy, R = [(X-T)/K] * 100

where K= known addition of the spiked compound

X = analytical result from the spiked sample

T = analytical result from the unspiked sample

R = Accuracy = % Recovery

Standard deviation (Sp) is used for determining the variation among several recovery samples, and establish upper and lower warning and control limits. Standard Deviation is calculated as follows:

$Sp = [(Ri-R)^2/(n-1)]^{1/2}$

Sp = standard deviation of % recovery

Ri = observed value

R = mean or average of all observations

n = number of observations

» construct accuracy control charts, limits will be established based on standard deviations with upper and lower limits being established at three times the standard deviation above and below the central line or according to the requirements of the methodology. Upper and lower warning limits are established at twice the standard deviation above and below the central line

Calculations to determine control limits for accuracy

Control limits are created to determine the acceptable range of analyte recovery and are used to compare actual spike recovery results against past spike recovery results. Control limits are calculated as follows:

UCL = X + 3 Sp

LCL = X - 3 Sp

UWL = X + 2 Sp

LWL = X - 2 Sp

where: UCL = upper control limit

LCL = lower control limit

UWL = upper warning limit

LWL = lower warning limit

Sp = standard deviation

X = spike recovery average

Until sufficient data have been generated to calculate acceptance limits, the following limits will apply:

Inorganic chemistry (wet chemistry): ± 25.0% recovery
Metals: ± 25.0% recovery
Organic chemistry- volatiles: ± 25.0% recovery
Organic chemistry- semi-volatile: ± 50.0% recovery
Other analysis: ± 25.0% recovery

Acceptance limits are calculated as follows, where x represents the individual values and n is the number of values:

Parameter	Symbol	Formula
Upper Control Limit	UCL	X + 3s
Upper Warning Limit	UWL	X + 2s
Center Line	X	Sx/n
Lower Warning Limit	LWL	X - 2s
Lower Control Limit	LCL	X - 3s

Acceptance limits are tested initially by determining the percentage of points falling in the range X ± 1s. It is expected that approximately 68% of the data fall within this range. If < 50% of the data fall within this range, the limits are suspect and must be verified prior to use

» corrective actions are taken when data fall outside the warning and control limits

» out of control situations:- whenever an out-of-control situation occurs, with the possible exception of matrix spike recoveries, corrective action is required prior to continuation of the analysis and or reporting the data for the entire batch. The corrective action taken for each out of control event must be described in the analysis log.

The following are considered out-of-control situations:

exceed the acceptance limits
1 point outside the control limits
2 consecutive points are outside the warning limits
7 consecutive points are on one side of the center line
7 consecutive points increase or decrease
an obvious cyclical pattern is observed in the distribution of points

In order to evaluate the data in this manner, the quality control data will be graphed on control charts or tabulated in chronological order.

» addition of surrogate standards; surrogate compounds spikes of blanks, calibration standards, samples and matrix spikes/matrix duplicates

» any other QC/QA practices indicated by the reference method or the laboratory SOP.

(e) an annual report summarizing QC/QA activities will be produced at the end of each year summarizing duplicate and spike samples; field, trip and laboratory blanks; any other QC/QA activity it deems necessary

(f) identification of outliers:- outliers, which are excluded from the data used to calculate acceptance limits, are identified following statistically acceptance procedure (ie. procedure described in ASTM E178-80, Sections 4.1 and 4.2; Q-test; etc.)

9.1 Quality documentation

The quality documentation include the system for maintaining necessary records and reports and for updating and controlling the issuance of technical documents and operating procedures. Document control at Beckton Environmental Laboratories, Inc. include:

1. sampling procedure
2. calibration procedures
3. analytical and test methods
4. data collection and reporting procedure
5. auditing procedures
6. sample receiving and storage
7. computation and data validation
8. quality assurance manuals
9. sample data sheets
10. analytical and testing reports
11. laboratory notebooks
12. validation reports
13. calibration and preventive maintenance records
14. chain-of-custody documentation

The quality records listed above which are originated and maintained as hard copies will be retained for a period of three years in laboratory files. After the period they will be reviewed for disposition. Records generated by computer will be retained in that format

The laboratory manager will maintain full control over the distribution of documents. The laboratory manager will issue new documents whenever a change is made to a controlled document.

9.2 Data validation

Data validation is the process in which data are checked and accepted or rejected based on a set of criteria. This involves a critical review of a body of data in order to identify spurious values or outlying observations.

Both the technician and the laboratory area supervisor will inspect the results for questionable values. The criteria for determining extreme values are derived from

prior data obtained from similar tests or analytical work.

9.3 Corrective action

This section describes the procedures for correcting a departure from standard of any sort, fixing responsibility for the action to be taken, documenting the steps taken, and securing a report on the resolution of the problem.

Kinds of corrective action

On the spot or immediate- to correct or repair nonconforming data or equipment malfunction of equipment:- the operator has the responsibility for conducting immediate corrective action. Plan of action:

1. found in method SOP being used
2. troubleshooting checklist provided by the laboratory
3. troubleshooting guides provided by instrument manufacturer
4. in the event that the solution to the problem is not found in the sources above, or is beyond the capabilities of the operator, he will report his finding to higher authority

Long term- to eliminate cause of non-conformance and take measures to see that they do not recur.

The steps comprising the corrective action system are:

a. define the problem
b. assign responsibility for investing the problem
c. determine corrective action to eliminate the problem
d. assign and accept responsibility for implementing the corrective action
e. establish the effectiveness of the corrective action and implement the correction
f. verify that the corrective action has eliminated the problem

Other types of corrective actions:

Sample problems:- individual samples or matrix problems are usually handled within the analytical laboratory. Corrective actions may include repreparation and re-analysis, clean-ups, dilutions or matrix modifications. All actions taken are documented with the analytical results.

Instrument	Model	Methods	Range	Procedure	Frequency
Mercury, cold vapor	AVA 440	7470 A	0.5 - 10 ug/L	5 point cal.	Daily; every 10 samples
		7471 A	0.5 - 10 ug/L	5 point cal.	Daily; every 10 samples
Atomic absorption, graphite furnace	Jarrell Ash CTF 188	As 206.2/7060A	5 - 50 ug/L	5 point cal.	Daily; every 10 samples
		Se 270.2/7740	5 - 50 ug/L	5 point cal.	Daily; every 10 samples
		Pb 239/7421	5 - 50 ug/L	5 point cal.	Daily; every 10 samples
		Cd 213.2/7131A	1 - 10 ug/L	5 point cal.	Daily; every 10 samples
		Ag 272.2/7761	1 - 25 ug/L	5 point cal.	Daily; every 10 samples
Atomic absorption, flame	Jarrell Ash Smith-Hieftje 22	Al 202.1/7020	0.8 - 10 ug/L	5 point cal.	Daily; every 10 samples
		Sb 204.1/7040	1 - 20 ug/L	5 point cal.	Daily; every 10 samples
		Ba 208.1/7080A	0.3 - 9.0 ug/L	5 point cal.	Daily; every 10 samples
		Cd 213.1/7130	0.01 - 2.0 ug/L	5 point cal.	Daily; every 10 samples
		Ca 215.1/7140	0.1 - 3.0 ug/L	5 point cal.	Daily; every 10 samples
		Cr 218.2/7190	0.03 - 1.0 ug/L	5 point cal.	Daily; every 10 samples
		Cr VI 218.4	0.04 - 1.0 ug/L	5 point cal.	Daily; every 10 samples
		Co 219.1/7200	0.05 - 5.0 ug/L	5 point cal.	Daily; every 10 samples
		Cu 220.1/7210	0.03 - 4.0 ug/L	5 point cal.	Daily; every 10 samples
		Fe 236.1/7380	0.1 - 3.5 ug/L	5 point cal.	Daily; every 10 samples
		Pb 239.1/7420	0.04 - 2.0 ug/L	5 point cal.	Daily; every 10 samples
		Mg 242.1/7450	0.1 - 3.0 ug/L	5 point cal.	Daily; every 10 samples
		Mn 243.1/7460	0.05 - 5.0 ug/L	5 point cal.	Daily; every 10 samples
		Mo 246.1/7480	1 - 20 ug/L	5 point cal.	Daily; every 10 samples
		Ni 249.2/7520	0.10 - 3.0 ug/L	5 point cal.	Daily; every 10 samples
		K 258.1/7610	0.05 - 1.5 ug/L	5 point cal.	Daily; every 10 samples
		Ag 272.2/7760A	0.03 - 1.0 ug/L	5 point cal.	Daily; every 10 samples
		Na 273.1/7770	0.05 - 2.0 ug/L	5 point cal.	Daily; every 10 samples

Instrument	Model	Methods	Range	Procedure	Frequency
Spectrophotometer	Spectronic 20D	Phenolics 420.1	0.05 - 1.0 mg/L	7 point cal.	Per batch; after 10 samples
		Boron 213.3	0.0001 - 1.0 mg/L	5 point cal.	Per batch; after 10 samples
		Cyanide 335.1	10 - 200 mg/L	7 point cal.	Per batch; after 10 samples
		COD	0.50 - 50.00 mg/L	11 point cal.	Per batch; after 10 samples
		Surfactants	0.001 - 1.20 mg/L	5 point cal.	Per batch; after 10 samples
Turbidimeter meter	Cole-Palmer Model 8391-35	Turbidity	0.50 - 40 NTU	3 point cal.	Per batch; after 10 samples
Fluoride Ion Activity Electrode	Fisher Model 950	Fluoride 340.2	0.001 - 2.00 mg/L	9 point cal.	Per batch; after 10 samples
pH meter	Fisher	pH	4 - 10 SU	3 point cal.	Per batch; after 10 samples
Conductivity meter	Cole-Palmer	Conductance 120.1/9050	0.01 NKCl @ 1496 umho/cm	single point	Per batch; after 10 samples

Instrument	Model	Methods	Range	Procedure	Frequency
		Tl 279.1/7840	0.5 - 10 ug/L	5 point cal.	Daily; every 10 samples
		Sn 282.1/7870	1 - 10 ug/L	5 point cal.	Daily; every 10 samples
		V 286.1/7910	2 - 75 ug/L	5 point cal.	Daily; every 10 samples
		Zn 289.1/7950	0.01 - 0.4 ug/L	5 point cal.	Daily; every 10 samples

Instrument	Model	Methods	Range	Procedure	Frequency
Gas chromatograph	HP 5890 II	601/8010	1.0 - 100 ug/mL	3/5 point cal.	Initial; after 10 injections
Gas chromatograph	HP 5890 II	602/8020	1.0 - 100 ug/mL	3/5 point cal.	Initial; after 10 injections
		608/8080	1.0 - 100 ug/mL	3/5 point cal.	Initial; after 10 injections
		8150	Compound Dependent (ug/mL)		
			0.5 - 10 ug/L	5 point cal.	Initial; after 10 injections
			0.10 - 2.00 ug/mL	5 point cal.	
Gas chromatograph/ mass spectrometer	HP 5970	624/8240	20 - 200 ug/L	3/5 point cal.	Initial; every 12. hours
			10 - 50 ug/L	3/5 point cal.	
		625/8270	20 - 200 ug/L	3/5 point cal.	Initial; every 12 hours
		613/8280	20 - 200 ng	3/5 point cal.	Initial; every 12 hours

Instrument	Model	Methods	Range	Procedure	Frequency
Ion Analyzer	Lachat 1300-000	Total Phosphurus in Kjeldahl Digest (365.1)	0.001 - 4.0 mg/L	7 point cal.	Per batch; after 10 samples
		Nitrate & Nitrate Nitrite (353.2)	0.02 - 2.0 mg/L	6 point cal.	Per batch; after 10 samples
		Chloride (325.2)	1.00 - 100 mg/L	9 point cal.	Per batch; after 10 samples
		Ammonia (Phenolate) 350.1	0.010 - 2.00 mg/L	7 point cal.	Per batch; after 10 samples
		Alkalinity (methyl organge) 310.1	10 - 500 mg/L	6 point cal.	Per batch; after 10 samples
		Phosphurus as Orthophosphate 365.1	2.00 - 100 mg/L	6 point cal.	Per batch; after 10 samples
		Sulfate (Methylthymol blue) 375.2	2.00 - 40 mg/L	5 point cal.	Per batch; after 10 samples

Instrument	Model	Methods	Range	Procedure	Frequency
		TKN as NH3 351.2	0.001 - 5.00 mg/L	6 point cal.	Per batch; after 10 samples

Beckton Environmental Laboratories, Inc., being a highly computerized and instrument oriented laboratory, maintains maintenance contracts with major instrument manufacturer. **Beckton** performs routine maintenance to prevent instrument malfunction and minimize downtime, and optimize instrument capabilities

The schedule of preventive or routine maintenance checks are, in general, outlined within the specific equipments' operators manuals and in the analytical procedures performed. The laboratory maintains an inventory of replacement parts for all analytical instrumentation.

Analyst are trained to respond to instrument maintenance needs. Criteria for this type of maintenance is based on instrument performance. Failure of instrument to perform according to stated methodologies and criteria limits drives the need for daily maintenance.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, RAFAEL INFANTE, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS., INC.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS., INC.

a. I shall not intentionally report data values that are not the actual values obtained;

b. I shall not intentionally report the dates and times of data analyses that are not the actual dates and times of data analyses; and

c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform MR. JORGE ARRUFAT of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform MR. JORGE ARRUFAT of any accidental or intentional reporting of non-authentic data by other employees.

Rafael Infante
(Signature)

02/25/92
(Date)

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PONCE, PUERTO RICO

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, JORGE ARRUFAT, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS., INC.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS., INC.

a. I shall not intentionally report data values that are not the actual values obtained;

b. I shall not intentionally report the dates and times of data analyses that are not the actual dates and times of data analyses; and

c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

(Signature)

Feb / 25 / 92

(Date)

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BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, JOSE RENTAS, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS., INC.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS., INC.

a. I shall not intentionally report data values that are not the actual values obtained;

b. I shall not intentionally report the dates and times of data analyses that are not the actual dates and times of data analyses; and

c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

(Signature)

2/25/92
(Date)

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BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, MARIA DEL C. PAGAN, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

a. I shall not intentionally report data values that are not the actual values obtained;

b. I shall not intentionally report the dates and times of data analyses that are not the actual dates and times of data analyses; and

c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

María del Carmen Pagán
(Signature)

February 24 1992
(Date)

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122 VILLA CLEMENTE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, GRISELDA HERENCIA, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

a. I shall not intentionally report data values that are not the actual values obtained;

b. I shall not intentionally report the dates and times of data analyses that are not the actual dates and times of data analyses; and

c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Griselda Herencia
(Signature)

2/24/92
(Date)

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TEL (809) 841-2553
FAX (809) 841-2553
109 VILLA SI PONCE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, MARIA J. VIDAL, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Maria J. Vidal Cintrón
(Signature)

February 27, 1992
(Date)

P.O. BOX 180
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PONCE, P.R. 00731-3180

TEL (809) 841-2553
FAX (809) 841-2213
105 VILLA SEPARKE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, WANDA I. VAZQUEZ, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

a. I shall not intentionally report data values that are not the actual values obtained;

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c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Wanda I. Vázquez Barrio
(Signature)

February 24 1992
(Date)

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PLAZA STATION
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TEL (809) 841-[illegible]
FAX (809) 841-[illegible]
102 VILLA ST. PONCE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, ROBERTO RUIZ, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

a. I shall not intentionally report data values that are not the actual values obtained;

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c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Roberto Ruiz

(Signature)

2/24/92

(Date)

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FAX (809) 841-2143
122 VILLA ST. PONCE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, ANGEL L. VERA, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Angel Luis Vera Torres
(Signature)

February-24-1992
(Date)

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FAX (809) 841-2553
102 VILLA CAPE PONCE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, HILDA SOTO, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

a. I shall not intentionally report data values that are not the actual values obtained;

b. I shall not intentionally report the dates and times of data analyses that are not the actual dates and times of data analyses; and

c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Hilda S. Soto Soto

(Signature)

03-24-92

(Date)

P.O. BOX 100
PLAZA STATION
PONCE, P.R. 00731-0100

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, ELENA RONDON, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform LCDO. RAFAEL INFANTE of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Elena Rondon
(Signature)

February 24, 1992.
(Date)

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TEL (809) 841-2553
FAX (809) 841-2512
122 VILLA GUADALUPE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, José A. Mercado, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

(Signature)

(Date)

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TEL (809) 841-2553
FAX (809) 841-2553
102 VILLA GUERRERO, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, HECTOR L MALDONADO, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Héctor L. Maldonado Hernández
(Signature)

7/24/92
(Date)

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TEL (809) 841-[illegible]
FAX (809) 841-[illegible]
[illegible] VILLA SLOPE, P.R.

BECKTON ENVIRONMENTAL
LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, NILDA LUGO, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

(Signature)

Feb. 12/90
(Date)

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PLAYA STATION
PONCE, P.R. 00734-3180

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, LESBIA FEBLES, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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(Signature)

24 feb - 92

(Date)

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FAX (809) 841-[illegible]
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BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, LUISETTE BERASTAIN, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

Luisette Berastain Jarrett
(Signature)

34/03/92
(Date)

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TEL (809) 841-[illegible]
FAX (809) 841-[illegible]
122 VILLA GLORIOSE, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, JOSE A. MEDINA, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

(Signature)

2-24-92

(Date)

P.O. BOX 180
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PONCE, P.R. 00734-3180

TEL (809) 841-2323
FAX (809) 841-2313
102 VILLA STREET, P.R.

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, GERARDO RODRIGUEZ, state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at BECKTON ENVIRONMENTAL LABS.

II. I agree that in the performance of my duties at BECKTON ENVIRONMENTAL LABS.

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IV. I agree to inform LCDO. RAFAEL INFANTE of any accidental or intentional reporting of non-authentic data by other employees.

(Signature)

24/02/92

(Date)

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PLAYA STATION
PONCE, P.R. 00734-3180

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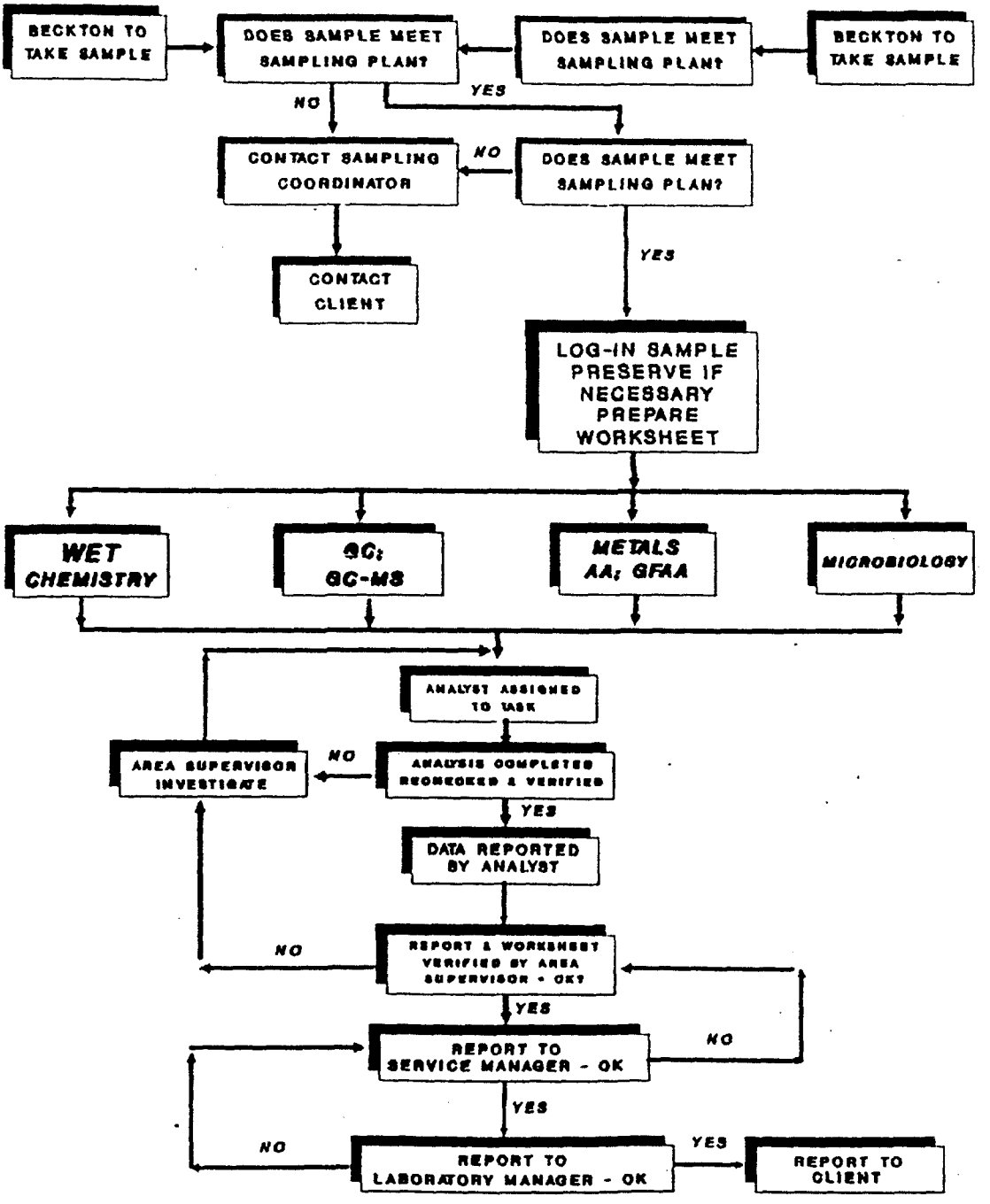
FAX (809) 841-2313
122 VILLA ST. PONCE, P.R.

Effective Date 02-21-92	Subject	Section No. 10-D
By RNI	APPENDIX D	Page 1 OF 1
Approved JA	LABORATORY WORKLOAD	Revised 02-21-92

BECKTON ENVIRONMENTAL

LABORATORIES, INC.



QUALITY ASSURANCE STEPS FOR SAMPLE PROCESSING AT BECKTON ENVIRONMENTAL LABORATORIES, INC.

PAGE	FORM
2	Alkalinity
3 - 4	Boron Colorimetrically
5	Phenolics
6	Fluorides
7	Oil & Grease
8	Settleable Solids
9	Cyanides
10	Conductance
11	Color
12	Hardness
13	Iodide
14	Metals (inorganic analysis)
15	Initial Calibration - Volatile Compounds for TCLP
16	Pesticides for TCLP
17 - 18	Semivolatile Compounds for TCLP
19	Pesticides / PCB Standard Summary

ALKALINITY

BEL _____ DATE: _____

PERFORMED BY: _____

Alkalinity, mg/L $CaCO_3$ = $\frac{A \times N \times 50{,}000}{\text{ml of sample}}$

Where: A = ml standard Acid

N = normality standard acid

pH Inicial Muestra	pH Final Muestra	Standard Acid Consumido

BECKTON ENVIRONMENTAL
LABORATORIES, INC.

BORON (COLORIMETRIC, CURCUMIN)

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____ DATE: _____

$$mg\ B/l = \frac{A_2 \times C}{A_1 \times S}$$

Where: A_1 = absorbance of standard

A_2 = absorbance of sample

C = mg B in standard taken

S = mL sample

TABLE I : INSTRUMENT DATA

INSTRUMENT	SERIAL NO.	MODEL
SPECTRONIC 20		

TABLE II : CALIBRATION CURVE DATA

STANDARD mg	ABSORBANCE
BLANK	
0.25	
0.50	
0.75	
1.00	

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192 VILLA ST PONCE, P.R.

TABLE III : SAMPLE RESULTS

SAMPLE NO.	ABSORBANCE	SAMPLE VOLUME (ml.)	BORON CONCENTRATION mg/l

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

PHENOLICS

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____

NO. _____

TABLE I : SAMPLES CONCENTRATION

SAMPLE NUMBER	ABSORBANCE	CONCENTRATION Mg/l
1		
2		
3		

TABLE IV : CALIBRATION CURVE DATA

(DIRECT PHOTOMETRIC METHOD)

STANDARD	CONCENTRATION µg/l	ABSORBANCE
STD 1	0.0	
STD 2	50.0	
STD 3	100.0	
STD 4	200.0	
STD 5	500.00	
STD 6	800.00	
STD 7	1000.0	

BECKTON ENVIRONMENTAL

LABORATORIES, INC.

FLUORIDE

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____ DATE: _____

TABLE II : CALIBRATION CURVE DATA

mL OF STANDARD USED	CONCENTRATION mg F/l	ELECTRODE POTENTIAL mV	Efficiency

TABLE III : SAMPLES RESULTS

BEL SAMPLE NUMBER	CONCENTRATION mg F/l	ELECTRODE POTENTIAL mV	TEMPERATURE °C

BECKTON ENVIRONMENTAL
LABORATORIES, INC.

OIL & GREASE

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____ DATE: _____

TABLE I : OIL & GREASE DATA AND RESULTS

SAMPLE NUMBER	EMPTY DIST. FLASK WEIGHT (g)	RESIDUAL AND FLASK WEIGHT (g)	RESIDUAL WEIGHT (g)	RESIDUAL WEIGHT mg/BOTTLE

mg/BOTTLE TOTAL OIL & GREASE = R - B

WHERE: R = RESIDUE, GROSS WEIGHT OF EXTRACTION FLASK MINUS TARE WEIGHT, IN MILLIGRAMS.

B = BLANK DETERMINATION, RESIDUE OF EQUIVALENT VOLUME OF EXTRACTION SOLVENT, IN MILLIGRAMS.

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BECKTON ENVIRONMENTAL

LABORATORIES, INC.

SETTLEABLE SOLIDS FORM

BEL_____ DATE _____

PERFORMED BY: _____

SAMPLE	TSS	TSS grav.	RESULT (mg/L)

Settleable Solids = TSS - TSS grav.

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BECKTON ENVIRONMENTAL

LABORATORIES, INC.

CYANIDE

PERFORMED BY: _____

DATE: _____

TABLE I : SAMPLES CONCENTRATION

SAMPLE TYPE	ABSORBANCE	CONCENTRATION g/l
BLANK		
STD		

TABLE II : CALIBRATION CURVE DATA

STANDARD	CONCENTRATION ug CN	ABSORBANCE
STD 1	0.0	
STD 2	10	
STD 3	20	
STD 4	50	
STD 5	100	
STD 6	150	
STD 7	200	

BECKTON ENVIRONMENTAL
LABORATORIES, INC.

CONDUCTANCE

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____ DATE: _____

SAMPLES RESULTS

SAMPLE NUMBER	DILUTION	CONDUCTIVITY umhos/cm
1		
2		
3		
4		
6		
6		

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FAX (809) 841-7313
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BECKTON ENVIRONMENTAL

LABORATORIES, INC.

COLOR VALIDATION FORM

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____ DATE: _____

STANDARDS REPORT TABLE

ml. OF STANDARD SOLUTION	COLOR IN CHLOROPLATINATE UNITS
0.0	0
0.5	5
1.0	10
1.5	15
2.0	20
2.5	25
3.0	30
3.5	35
4.0	40
4.5	45
5.0	50
5.5	55
6.0	60
6.5	65
7.0	70

DILUTED SAMPLES REPORT RESULTS TABLE

COLOR UNITS	RECORD TO THE NEAREST
1 - 50	1
51 - 100	5
101 - 250	10
251 - 500	20

$$\text{COLOR UNITS} = \frac{A \times 50}{B}$$

WHERE: A = ESTIMATE COLOR OF DILUTED SAMPLE

B = ml. SAMPLE TAKEN FOR DILUTION

TABLE 1 : SAMPLES TRUE COLOR RESULTS

SAMPLE NUMBER	A (CHLOROPLATINATE UNITS) READ	A (CHLOROPLATINATE UNITS) REPORTED	B ml.
1			
2			
3			
4			
5			

BECKTON ENVIRONMENTAL
LABORATORIES, INC.

HARDNESS FORM

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____ DATE: _____

TABLE I : SAMPLES DATA AND RESULTS

$$\text{Hardness (EDTA) mg } CaCO_3/l = \frac{A \times N \times 50{,}000}{\text{mL sample}}$$

Where: A = mL of EDTA titrant.

B = normality of EDTA titrant.

SAMPLE NO.	A (mL)	N	SAMPLE (mL)	$CaCO_3$ (mg/l)

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BECKTON ENVIRONMENTAL
LABORATORIES, INC.

IODIDE FORM

PERFORMED BY: _____ APPROVED BY: _____

DATE: _____ DATE: _____

_____ _____

TABLE I : SAMPLES RESULTS

$$I^- \text{ (mg/l)} = 21{,}150 \left(\frac{mL \times N}{V}\right)$$

Where: mL = the number of mL of PAO needed to titrate the sample.

N = the normality of the PAO used to titrate the sample.

V = the volume of sample taken (100 mL or a fraction thereof).

SAMPLE NO.	PAO mL	PAO N	SAMPLE VOLUME V
1			
2			
3			

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BECKTON ENVIRONMENTAL LABORATORIES, INC.

INORGANIC ANALYSIS DATA SHEET

LAB. I.D. _____ DATE: _____

CUSTOMER SAMPLE ID. NO. _____

Elements Identified and Measured

Matrix: Water _____ Soil _____ Sludge _____ Other _____

ug/L or mg/kg dry weight (Circle One)

1.	Aluminum	13.	Magnesium
2.	Antimony	14.	Manganese
3.	Arsenic	15.	Mercury
4.	Barium	16.	Nickel
5.	Beryllium	17.	Potassium
6.	Cadmium	18.	Selenium
7.	Calcium	19.	Silver
8.	Chromium	20.	Sodium
9.	Cobalt	21.	Thallium
10.	Copper	22.	Vanadium
11.	Iron	23.	Zinc
12.	Lead	24.	Chromium VI _____

Comments: _____

Lab Manager _____

Initial Calibration Data
Volatile Compounds

Case No: _____ Instrument I D: _____

Laboratory Name _____ Calibration Date: _____

FOR TCLP ANALYSIS

Laboratory ID								
Compound	AREA 1	AREA 2	AREA 3	AREA 4	AREA 5		% RSD	
Vinyl Chloride								
Internal Std. 1								
Internal Std. 2								
1, 1-Dichloroethene								
Chloroform								
1, 2-Dichloroethane								
Carbon Tetrachloride								
Surrogate 1								
Surrogate 2								
Trichloroethene								
Benzene								
4-Methyl-2-Pentanone								
Tetrachloroethene								
Chlorobenzene								
1,4-Dichlorobenzene								

RF -Response Factor (subscript is the amount of ug/L)
$\overline{RF}$ -Average Response Factor
%RSD -Percent Relative Standard Deviation

Revision _____
Date _____

BECKTON ENVIRONMENTAL LABORATORIES, Inc.
PESTICIDES [To comply with TCLP analysis]

CALIBRATION CURVE Date:

COMPOUND	AREA 1	AREA 2	AREA 3	AREA 4	AREA 5	File #
LINDANE						
HEPTACHLOR						
HEPTACHLOR EPOXIDE						
ENDRIN						
METOXYCHLOR						
CHLORDANE						
TOXAPHENE						
INTERNAL STANDARD 1						
INTERNAL STANDARD 2						

COMPOUND	RF 1	RF 2	RF 3	RF 4	RF 5	AVG. RF	RSD (%)
LINDANE							
HEPTACHLOR							
HEPTACHLOR EPOXIDE							
ENDRIN							
METOXYCHLOR							
CHLORDANE							
TOXAPHENE							
INTERNAL STANDARD 1							
INTERNAL STANDARD 2							

RSD must be less than 30%
AVG. RF should be used for quantitation

Revision _____
Date: _____

Initial Calibration Data
Semivolatile Compounds
(Page 1)

Case No: _____ Instrument ID: _____

Laboratory Name _____ Calibration Date: _____

Minimum $\overline{RF}$ for SPCC is 0.050 Maximum % RSD for CCC is 30%

Laboratory ID								
Compound	RF_{20}	RF_{50}	RF_{80}	RF_{120}	RF_{160}	$\overline{RF}$	% RSD	CCC* SPCC**
Phenol								*
bis(-2-Chloroethyl)Ether								
2-Chlorophenol								
1, 3-Dichlorobenzene								
1, 4-Dichlorobenzene								*
Benzyl Alcohol								
1, 2-Dichlorobenzene								
2-Methylphenol								
bis(2-chloroisopropyl)Ether								
4-Methylphenol								
N-Nitroso-Di-n-Propylamine								* *
Hexachloroethane								
Nitrobenzene								
Isophorone								
2-Nitrophenol								*
2, 4-Dimethylphenol								
Benzoic Acid	†							
bis(-2-Chloroethoxy)Methane								
2, 4-Dichlorophenol								*
1, 2, 4-Trichlorobenzene								
Naphthalene								
4-Chloroaniline								
Hexachlorobutadiene								*
4-Chloro-3-Methylphenol								*
2-Methylnaphthalene								
Hexachlorocyclopentadiene								* *
2, 4, 6-Trichlorophenol								*
2, 4, 5-Trichlorophenol	†							
2-Chloronaphthalene								
2-Nitroaniline	†							
Dimethyl Phthalate								
Acenaphthylene								
3-Nitroaniline	†							
Acenaphthene								*
2, 4-Dinitrophenol	†							* *
4-Nitrophenol	†							* *
Dibenzofuran								

Response Factor (subscript is the amount of nanograms)
$\overline{RF}$ -Average Response Factor
%RSD -Percent Relative Standard Deviation
CCC -Calibration Check Compounds (*)

SPCC -System Performance Check Compounds (**)
† -Not detectable at 20 ng

Revision _____
Date _____

Initial Calibration Data
Semivolatile Compounds
(Page 2)

Case No: _____ Instrument ID: _____

Laboratory Name _____ Calibration Date: _____

Minimum $\overline{RF}$ for SPCC is 0.050 Maximum % RSD for CCC is 30%

Laboratory ID								
Compound	RF_{20}	RF_{50}	RF_{80}	RF_{120}	RF_{160}	$\overline{RF}$	% RSD	CCC* SPCC**
2, 4-Dinitrotoluene								
2, 6-Dinitrotoluene								
Diethylphthalate								
4-Chlorophenyl-phenylether								
Fluorene								
4-Nitroaniline	†							
4, 6-Dinitro-2-Methylphenol	†							
N-Nitrosodiphenylamine (1)								*
4-Bromophenyl-phenylether								
Hexachlorobenzene								
Pentachlorophenol	†							*
Phenanthrene								
Anthracene								
Di-N-Butylphthalate								
Fluoranthene								*
Pyrene								
Butylbenzylphthalate								
3, 3'-Dichlorobenzidine								
Benzo(a)Anthracene								
bis(2-Ethylhexyl)Phthalate								
Chrysene								
Di-n-Octyl Phthalate								*
Benzo(b)Fluoranthene								
Benzo(k)Fluoranthene								
Benzo(a)Pyrene								*
Indeno(1, 2, 3-cd)Pyrene								
Dibenz(a, h)Anthracene								
Benzo(g, h, i)Perylene								

Response Factor (subscript is the amount of nanograms)
$\overline{RF}$ -Average Response Factor
%RSD -Percent Relative Standard Deviation
CCC -Calibration Check Compounds (*)

SPCC -System Performance Check Compounds (**)
† - Not detectable at 20 ng
(1) -Cannot be separated from diphenylamine

Revision _____
Date _____

PESTICIDE/PCB STANDARDS SUMMARY

Case No. _____ Laboratory Name _____

GC Column _____ GC Instrument ID _____

	DATE OF ANALYSIS _____ TIME OF ANALYSIS _____ LABORATORY ID _____				DATE OF ANALYSIS _____ TIME OF ANALYSIS _____ LABORATORY ID _____			
COMPOUND	RT	RETENTION TIME WINDOW	CALIBRATION FACTOR	CONF. OR QUANT.	RT	CALIBRATION FACTOR	CONF. OR QUANT.	PERCENT DIFF. **
alpha-BHC								
beta-BHC								
delta-BHC								
gamma-BHC								
Heptachlor								
Aldrin								
Heptachlor Epoxide								
Endosulfan I								
Dieldrin								
4,4'-DDE								
Endrin								
Endosulfan II								
4,4'-DDD								
Endrin Aldehyde								
Endosulfan Sulfate								
4,4'-DDT								
Methoxychlor								
Endrin Ketone								
Tech. Chlordane								
alpha-Chlordane								
gamma-Chlordane								
Toxaphene								
Aroclor - 1016								
Aroclor - 1221								
Aroclor - 1232								
Aroclor - 124								
Aroclor - 1248								
Aroclor - 1254								
Aroclor - 1260								

** CONF. = CONFIRMATION (<20% DIFFERENCE)
QUANT. = QUANTITATION (<15% DIFFERENCE)

Revision _____
Date _____

The following sampling plan is designed to evaluate the physical and chemical properties of a solid/hazardous waste. It meet the specification of SW-846 Test Methods for Evaluating Solid Wastes-Chapter Nine, Revision 0, September 1986 and is in compliance with the environmental regulation. The information presented in this section is relevant to the samplling of any solid waste which have been defined by EPA in its regulations for the identification and listing of hazardous wastes to include solid, semisolid, and liquid materials. However, the physical and chemical diversity of those materials, as well as the dissimilarity of storage facilities and sampling equipment associated with them, preclude a detailed consideration of any specific sampling plan. Detailed consideration of specific sampling plan will depend of the type of waste and the waste producer.

Sampling goal:- to collect samples that will allow the measurements of chemical and physical properties of the waste that are both accurate and precise.

Sampling plan:

A general approach to the sampling of solid waste is shown in Table 1. Depending on the type of waste one of the following types of sampling will be performed:

Simple random sampling
Stratified random sampling
Systematic random sampling
Authority sampling

Sampling accuracy will be achieved by random sampling as the individual concentration of the contaminant is assumed to exhibit a normal distribution. In order to obtain a random sample, the sampling population will be divided by an imaginary grid, a series of consecutive numbers will be assigned to the units of the grid, and the units to be sampled will be selected through the use of a random number generator.

Sampling precision will be achieved by taking an appropriate number of samples from the population or by maximizing the physical size of the sample. This will also produce a secondary effect of increasing sampling accuracy.

The statistical approach to sampling will be followed using the equations presented in Tables 2 and 3. The equipment to be utilized will depend on the type of waste to be sample and the waste container as shown in Table 4.

Safety considerations

Aware of the importance of following safety rules in the sampling of potentially toxic compounds, all sampling technician will be trained in safety practices and the use of the appropriate safety gear. The following practices will be observed at all times:

1. Wear protective clothing and equipment as required for the hazardous substance to be sampled.
2. Identify potential explosive and/or flammable conditions that might be present
3. Emergency equipment available and its location. The personnel have the necessary training in the use of emergency equipment.

4. Inspect any confined space that have to be entered for the presence of airborne contaminats

In addition the safety rules aspresented in *"Characterization of Hazardous Waste Sites-A Method Manual, Volume I, Site Investigations"*, EPA 600/4-84/075, April 1985 and the Safety and Hygiene Practices for Beckton Environmental Laboratories, Inc. will be followed.

In order to obtain preliminary information, the customer will have to fill aquestionnaire regarding the waste to be sampled and its potential hazardous characteristics in order to customize the sampling plan to meet the generator's needs.

TABLE 1 - GENERAL SAMPLING APPROACH

Type of waste	Type of sampling	Sampling accuracy	Sampling precision
General solid wastes (little or no information available)	Random	Randomness in the selection process	Appropriate number of samples
'Waste is completely homogeneous (chemical homogeneity is uniform over time)	Random	Single sample at random	Single sample
Randomly heterogeneous (random chemical heterogeity remains constant from batch to batch)	Simple random sampling	Randomness in the selection process	Appropriate number of samples
Batch of waste randomly heterogeneous	Stratified random sampling	Stratify over space (locations or points in a batch of waste) and/or time (each batch of waste). Identify each unit numerically and take a simple random sample from each unit	Appropriate number of samples and sample size
Waste lagoon/effluent	Systematic random sampling	First sample at random; subsequent samples of a specified space or time interval	Appropriate number of samples and sample size
Solid waste well characterized (acquaintance with the	Authority sampling	Sample selected without regard to randomization	Single sample

TABLE 2- . BASIC STATISTICAL TERMINOLOGY APPLICABLE TO SAMPLING PLANS FOR SOLID WASTES

Terminology	Symbol	Mathematical equation	(Equation)
· Variable (e.g., barium or endrin)	x	—	
· Individual measurement of variable	x_i	—	
· Mean of all possible measurements of variable (population mean)	μ	$\mu = \frac{\sum_{i=1}^{N} x_i}{N}$, with N = number of possible measurements	(1)
· Mean of measurements generated by sample (sample mean)	$\bar{x}$	<u>Simple random sampling and systematic random sampling</u> $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$, with n = number of sample measurements	(2a)
		<u>Stratified random sampling</u> $\bar{x} = \sum_{k=1}^{r} W_k \bar{x}_k$, with $\bar{x}_k$ = stratum mean and W_k = fraction of population represented by Stratum k (number of strata [k] range from 1 to r)	(2b)
· Variance of sample	s^2	<u>Simple random sampling and systematic random sampling</u> $s^2 = \frac{\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2/n}{n - 1}$	(3a)
		<u>Stratified random sampling</u> $s^2 = \sum_{k=1}^{r} W_k s_k^2$, with s_k^2 = stratum variance and W_k = fraction of population represent by Stratum k (number of strata [k] ranges from 1 to r)	(3b)

TABLE 3- STATISTICAL APPROACH TO SAMPLING

Terminology	Symbol	Mathematical equation	(Equation)
• Standard deviation of sample	s	$s = \sqrt{s^2}$	(4)
• Standard error (also standard error of mean and standard deviation of mean) of sample	$s_{\bar{x}}$	$s_{\bar{x}} = \frac{s}{\sqrt{n}}$	(5)
• Confidence interval for μ[a]	CI	$CI = \bar{x} \pm t_{.20}\, s_{\bar{x}}$, with $t_{.20}$ obtained from Table 2 for appropriate degrees of freedom	(6)
• Regulatory threshold[a]	RT	Defined by EPA (e.g., 100 ppm for barium in elutriate of EP toxicity)	(7)
• Appropriate number of samples to collect from a solid waste (financial constraints not considered)	n	$n = \frac{t^2_{.20} s^2}{\Delta^2}$, with $\Delta = RT - \bar{x}$	(8)
• Degrees of freedom	df	$df = n - 1$	(9)
• Square root transformation	---	$X_i + 1/2$	(10)
• Arcsin transformation	---	Arcsin p; if necessary, refer to any text on basic statistics; measurements must be converted to percentages (p)	(11)

[a]The upper limit of the CI for μ is compared with the applicable regulatory threshold (RT) to determine if a solid waste contains the variable (chemical contaminant) of concern at a hazardous level. The contaminant of concern is not considered to be present in the waste at a hazardous level if the upper limit of the CI is less than the applicable RT. Otherwise, the opposite conclusion is reached.

TABLE 4 - SAMPLING EQUIPMENT

	Waste location or container								
Waste type	Drum	Sacks and bags	Open-bed truck	Closed-bed truck	Storage tanks or bins	Waste piles	Ponds, lagoons, & pits	Conveyor belt	Pipe
Free-flowing liquids and slurries	Coliwasa	N/A	N/A	Coliwasa	Weighted bottle	N/A	Dipper	N/A	Dipper
Sludges	Trier	N/A	Trier	Trier	Trier	a	a		
Moist powders or granules	Trier	Trier	Trier	Trier	Trier	Trier	Trier	Shovel	Dipper
Dry powders or granules	Thief	Thief	Thief	Thief	a	Thief	Thief	Shovel	Dipper
Sand or packed powders and granules	Auger	Auger	Auger	Auger	Thief	Thief	a	Dipper	Dipper
Large-grained solids	Large Trier	Large Trier	Large Trier	Large Trier	Large Trier	Large Trier	Large Trier	Trier	Dipper

[a]This type of sampling situation can present significant logistical sampling problems, and sampling equipment must be specifically selected or designed based on site and waste conditions. No general statement about appropriate sampling equipment can be made.

BECKTON ENVIRONMENTAL LABORATORIES, INC.

POTENTIAL HAZARDOUS WASTE SITE PRELIMINARY ASSESSMENT
PART 1 - SITE INFORMATION AND ASSESSMENT

I. IDENTIFICATION
01 STATE | 02 SITE NUMBER

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)
02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER
03 CITY
04 STATE | 05 ZIP CODE | 06 COUNTY | 07 COUNTY CODE | 08 CONG DIST
09 COORDINATES LATITUDE __ __ __ . __ | LONGITUDE __ __ __ __ __ . __
10 DIRECTIONS TO SITE (Starting from nearest public road)

III. RESPONSIBLE PARTIES

01 OWNER (If known)
02 STREET (Business, mailing, residential)
03 CITY
04 STATE | 05 ZIP CODE | 06 TELEPHONE NUMBER ( )
07 OPERATOR (If known and different from owner)
08 STREET (Business, mailing, residential)
09 CITY
10 STATE | 11 ZIP CODE | 12 TELEPHONE NUMBER ( )
13 TYPE OF OWNERSHIP (Check one)
☐ A. PRIVATE ☐ B. FEDERAL: _____ (Agency name) ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL
☐ F. OTHER: _____ (Specify) ☐ G. UNKNOWN
14 OWNER/OPERATOR NOTIFICATION ON FILE (Check all that apply)
☐ A. RCRA 3001 DATE RECEIVED: __/__/__ (MONTH DAY YEAR) ☐ B. UNCONTROLLED WASTE SITE (CERCLA 103 c) DATE RECEIVED: __/__/__ (MONTH DAY YEAR) ☐ C. NONE

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 ON SITE INSPECTION
☐ YES DATE __/__/__ (MONTH DAY YEAR)
☐ NO
BY (Check all that apply)
☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. STATE ☐ D. OTHER CONTRACTOR
☐ E. LOCAL HEALTH OFFICIAL ☐ F. OTHER: _____ (Specify)
CONTRACTOR NAME(S): _____
02 SITE STATUS (Check one)
☐ A. ACTIVE ☐ B. INACTIVE ☐ C. UNKNOWN
03 YEARS OF OPERATION
BEGINNING YEAR | ENDING YEAR ☐ UNKNOWN
04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED
05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION

V. PRIORITY ASSESSMENT

01 PRIORITY FOR INSPECTION (Check one. If high or medium is checked, complete Part 2 - Waste Information and Part 3 - Description of Hazardous Conditions and Incidents)
☐ A. HIGH (Inspection required promptly) ☐ B. MEDIUM (Inspection required) ☐ C. LOW (Inspect on time available basis) ☐ D. NONE (No further action needed, complete current disposition form)

VI. INFORMATION AVAILABLE FROM

01 CONTACT
02 OF (Agency/Organization)
03 TELEPHONE NUMBER ( )
04 PERSON RESPONSIBLE FOR ASSESSMENT
05 AGENCY
06 ORGANIZATION
07 TELEPHONE NUMBER ( )
08 DATE __/__/__ (MONTH DAY YEAR)

BECKTON ENVIRONMENTAL LABORATORIES, INC.

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES (Check all that apply)

- A SOLID
- B POWDER FINES
- C SLUDGE
- D OTHER _____ (Specify)
- E SLURRY
- F LIQUID
- G GAS

02 WASTE QUANTITY AT SITE (Measures of waste quantities must be independent)

TONS _____
CUBIC YARDS _____
NO OF DRUMS _____

03 WASTE CHARACTERISTICS (Check all that apply)

- A TOXIC
- B CORROSIVE
- C RADIOACTIVE
- D PERSISTENT
- E SOLUBLE
- F INFECTIOUS
- G FLAMMABLE
- H IGNITABLE
- I HIGHLY VOLATILE
- J EXPLOSIVE
- K REACTIVE
- L INCOMPATIBLE
- M NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE			
OLW	OILY WASTE			
SOL	SOLVENTS			
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS			
IOC	INORGANIC CHEMICALS			
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

IV. HAZARDOUS SUBSTANCES (See Appendix for most frequently cited CAS Numbers)

01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE/DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION

V. FEEDSTOCKS (See Appendix for CAS Numbers)

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS			FDS		
FDS			FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

Parameter	Container	Holding Time	Preservative
Wet Chemistry, Standard Analyses			
Acidity	100 mL, p, g	14 days	Cool, 4oC
Alkalinity, Total	100 mL, p, g	14 days	Cool, 4oC
Biochemical Oxygen Demand (BOD)	1 L, p, g	48 hours	Cool, 4oC
Chromium, Hexavalent	200 mL, p, g	24 hours	
Color	50 mL, p, g	48 hours	Cool, 4oC
Corrosivity	200 g, p, g	None	Cool, 4oC
Flashpoint	200 g, g	None	None
Hardness	100 mL, p, g	6 months	H2SO4, pH<2; Cool, 4oC
MBAS Surfactants	500mL, p, g	48 hours	None
Oil and grease	1L, g	28 days	H2SO4, pH<2; Cool, 4oC
Orthophosphate, colorimetric	100 mL, g	48 hours	Filter; Cool, 4oC
Total Dissolved Solids- TDS	100 mL, p, g	7 days	Cool, 4oC
Total Suspended Solids- TSS	100 mL, p, g	7 days	Cool, 4oC
Total Solids- TSS	100 mL, p, g	7 days	Cool, 4oC
Settleable Solids	1 L, p, g	48 hours	Cool, 4oC
Total Volatile Solids- TVS	100 mL, p, g	None	None
Turbidity	50 mL, p, g	48 hours	Cool, 4oC
Total Organic Carbon (TOC)	1 x 125 mL, g	28 days	H2SO4, pH<2; Cool, 4oC
Total Organic Halides (TOX)	1 x 1 L, g	28 days	H2SO4, pH<2; NaSO3

Parameter	Container	Holding Time	Preservative
Chemical Oxygen Demand (COD)	1 x 125 mL, g	28 days	H2SO4, pH<2; Cool, 4oC
Cyanide, Total	1 x 125 mL, g	14 days	NaOH, pH>12 Cool, 4oC
Phenol, Total	1 x 125 mL, g	28 days	H2SO4, pH<2; Cool, 4oC
Sulfate	1 x 125 mL, g	28 days	Cool, 4oC
Chloride	1 x 125 mL, g	28 days	Cool, 4oC
Nitrate as N	1 x 125 mL, g	28 days	H2SO4, pH<2; Cool, 4oC
Nitrite as N	1 x 125 mL, g	28 days	H2SO4, pH<2; Cool, 4oC
Fluoride	1 x 125 mL, g	28 days	Cool, 4oC
Ammonia	1 x 500 mL, g	28 days	H2SO4, pH<2; Cool, 4oC
Specific Conductance	1 x 500 mL, g	28 days	Cool, 4oC
pH	1 x 125 mL, g	immediate	Cool, 4oC
Sulfide	2 x 125 mL, g (i)	7 days	Zn acetate and NaOH, pH>9,
Inorganics, Standard Analyses			
Metals, except Mercury	1 x 1 L, p	6 months	HNO3, pH<2
Mercury	1 x 1 L, p	28 days	HNO3, pH<2
Organics, Standard Analyses			
Voaltiles, purge & trap (GC)	3 x 40 mL, g (i)	14 days	HCl, pH<2; Cool, 4oC
Semi-volatiles,	2 x 1 L, g	7/14 days	Cool, 4oC

Parameter	Container	Holding Time	Preservative
Acid/base/neutral (GC/MS)		(prep); 40 days (analysis) (g)	
Pesticides and/or Aroclors (GC, GC/MS)	2 x 1 L, g	7/14 days (prep); 40 days (analysis) (g)	Cool, 4oC
Herbicides (GC)	2 x 1 L, g	7/14 days (prep); 40 days (analysis) (g)	Cool, 4oC
Polychlorinated Dibenzo-p-Dioxin/Furans (GC/MS)	2 x 1 L, g (water) 1 x 500 mL, g (soil)	30 days (prep); 5 days (analysis) (g)	Cool, 4oC
Toxicity Characteristic Leaching Procedure Preparation of the TCLP extract			
Volatiles	1 x 125 mL, g (i)	14 days	HCl, pH<2; Cool, 4oC
Semi-volatile	1 x 1 L, g	14 days	Cool, 4oC
Metals, except Mercury	1 x 1 L, g	180 days	Cool, 4oC
Mercury	1 x 1 L, g	28 days	Cool, 4oC
Toxicity Characteristic Constituents Analysis of TCLP extract			
Volatiles, purge & trap	3 x 40 mL, g (i)	14 days (f)	HCl, pH<2; Cool, 4oC
Semi-volatile Acid/base/neutrals, pesticides	2 x 1 L, g (i)	7 days (prep) 40 days (analysis) (g)	Cool, 4oC
Semi-volatile Herbicides	2 x 1 L, g (i)	7 days (prep) 40 days	Cool, 4oC

Parameter	Container	Holding Time	Preservative
		(analysis) (g)	
Metals, except Mercury (h)	1 x 1 L, p	180 days (f)(h)	HNO3, pH<2
Mercury (h)	1 x 1 L, g	28 days	HNO3, pH<2
TTO Constituents- Analysis			
Volatiles, purge & trap	3 x 40 mL, g (i)	14 days (f)	HCl, pH<2; Cool, 4oC
Semi-volatile organics Acid/base/neutrals	2 x 1 L, g (i)	5 days (prep) 40 days (analysis) (g)	Cool, 4oC
Semi-volatile organics Pesticides/PCB's	2 x 1 L, g (i)	5 days (prep) 40 days (analysis) (g)	Cool, 4oC
Polychlorinated Dibenzo-p-Dioxin	2 x 1 L, g (water) 1 x 500 mL, g (soil)	10 days (prep); 45 days (analysis) (g)	Cool, 4oC

Parameter	Method- EPA Approved	EPA	References Std. Method	SOP
Acidity	Titrimetric	305.1		703-001
Alkalinity	Titrimetric	310.1		703-002
Alkalinity	Colorimetric, methyl orange	310.2		703-003
Bicarbonate				703-004
BOD (5 days)	Electrode method (20°)	405.1	508 C	704-001
Boron	Colorimetric, Curcumin	212.3	404 A	703-005
Bromide	Titrimetric	320.1		703-006
Chloride	Colorimetric	325.1		703-007
Chlorine, Residual	Titrimetric	330.4		703-008
COD	Colorimetric-standard ampule	410.1		703-009
Color		110.2		703-010
Conductance	Conductivity meter	120.1		703-011
Corrosivity	pH meter, electrode	150.1		703-012
Cyanide, Total	Titrimetric-Spectrophotometric	335.2	412 C	703-013
Fluoride	Potentiometric	340.2	413 B	703-014
Hardness, Total	Titrimetric	130.2		703-015
Iodide	Titrimetric	345.1		703-016
NH3-N	Titrimetric	350.1		703-017
N-TKN	Colorimetric	351.2		703-018
NO3-N	Colorimetric	353.2		703-019
NO3 + NO2-N	Colorimetric	353.2		703-020
Oil and grease	Gravimetric	413.1	503 A	703-021
Oxygen, Dissolved	Electrode	360.2		703.022
pH	Potentiometric, electrode	150.1		703-012
Phenols		420.1		703-023
Phosphate, Ortho		365.3		703-024
Phosphate, Total		365.4		703-025
Solids				
Residue, Total	Gravimetric (103°-105° C)	160.3	209 A	703-026
Residue, Volatile	Gravimetric (550° C)	160.4	209 D	703-027
Settable solids	Imhoff cone-volumetric	160.5	209 E	703-028
Settable solids	Gravimetric (103°-105° C)			703-029
Residue, Filterable	Gravimetric (180° C)	160.1	209 B	703-030
Total suspended solids (non-filterable)	Gravimetric (103°-105° C)	160.2	209 C	703-031
Sulfate	Colorimetric	375.2		703-032
Sulfate	Turbidimetric	375.4	426 C	703-033
Sulfide (as S)	Titrimetric	376.1		703-034
Sulfite (as SO3)	Titrimetric	377.1	428 A	703-035
Surfactants	Colorimetric, methylene blue	425.1		703-036
Turbidity	Nephelometry	180.1		703-037
Temperature		170.1		703-038

Parameter	Method- EPA Approved	EPA	Reference Std. Method	SOP
Aluminum	AA Direct aspiration	7020/202.1		702-002
Antimony	AA Direct aspiration	7040/204.1		702-003
Arsenic	AA Graphite furnace	7060A/206.2		702-004
Barium	AA Direct aspiration	7080A/208.1	308	702-005
Cadmium	AA Graphite furnace	7130/213.1	310 A	702-006
Calcium	AA Direct aspiration	7140/215.1		702-008
Chromium, Hex.	AA Direct aspiration		218.4	702-010
Chromium, Total	AA Direct aspiration	7190/218.2	312 A	702-009
Cobalt	AA Direct aspiration	7200/219.1		702-011
Copper	AA Direct aspiration	7210/220.1	313 A	702-012
Iron	AA Direct aspiration	7380/236.1	315 A	702-013
Lead	AA Direct aspiration	7420/239.1	316 A	702-014
Magnesium	AA Direct aspiration	7450/242.1		702-016
Manganese	AA Direct aspiration	7460/243.1	319 A	702-017
Mercury	AA Cold vapor	7470A/245.2	320 A/7471A	702-018
Molybdenum	AA Direct aspiration	7480/246.1		702-019
Nickel	AA Direct aspiration	7520/249.2		702-020
Potassium	AA Direct aspiration	7610/258.1		702-021
Selenium	AA Graphite furnace	7740/270.2		702-022
Silicon	AA Direct aspiration			
Silver	AA Direct aspiration	7760A/272.2	324 A	702-023
Sodium	AA Direct aspiration	7770/273.1		702-025
Thallium	AA Direct aspiration	7840/279.1		702-026
Tin	AA Direct aspiration	7870/282.1		702-027
Vanadium	AA Direct aspiration	7910/286.1		702-028
Zinc	AA Direct aspiration	7950/289.1	328 A	702-029

GAS CHROMATOGRAPHY, GC/MASS SPECTROMETRY

Many other options and combinations are available. A few are shown below:

Parameter	Method- EPA Approved	EPA	Reference Std. Method	SOP
Purgeables	P&T GC/MS; P&T GC/PID/HALL	502.2 524.2 601/602 8010 (SW-846) 8020 (SW-846) 8021 (SW-846) 8240 (SW-846)		
Trihalomethanes	P&T/GC/HALL	501.1		
Base/Neutrals	GC/MS	525 625 8270 (SW-846)		
Acid Extracts	GC/MS	525 625 8270 (SW-846)		
Pesticides/PCBs	GC/ECD	508 608 8080		
Herbicides	GC/ECD	8150		
Volatile organics (VOC's)	GC/PID/HALL	502.2		
Full scan priority pollutants	GC/MS			
Total Toxic Organic	GC/ECD; GC/PID/HALL: GC/MS			
Dioxin (TCDD)	GC/ECD; GC/MS	8280		
Ignigtability Test	Flash Point-Penskyn Martens	SW-846 1010		
Corrosivity Test	pH Meter/electrode	150.1		703-012
Reactivity Test	Sulfide, cyanide	376.1 335.2		703-034 703-013
Asbestos Monitoring	Reflectance microscope	7400 (NIOSH)		704-002
Fecal coliform		9221-C		704-003
Total coliform		9221-B		704-004

APPENDIX D

SOQ: HEALTH AND SAFETY LABORATORY

MDS
Laboratories

MDS LABORATORIES

Industrial Hygiene and Environmental Testing

STATEMENT OF QUALIFICATIONS

4418 Pottsville Pike
Reading, PA 19605
(610) 921-8833
(800) 345-4026
(610) 921-9667 fax

MDS Laboratories
Statement of Qualifications

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Appendix III	Laboratory & Individual Certifications

MDS Laboratories
Statement of Qualifications

COMPANY PROFILE: MDS HEALTH GROUP, LTD.

MDS Health Group, Ltd., headquartered in Toronto, is a publicly held firm engaged in laboratory testing and other related health care and health based ventures. In the testing business for over 20 years, MDS has more than 350 locations in the United States and Canada, earning annual revenues in excess of $600 million. We have approximately 5000 employees, with 60% of these holding technical positions and scientific degrees. Our reference facility in Reading, PA is one of the largest and most modern in the company. All industrial hygiene and environmental testing is performed at our Reading facility.

Other MDS locations are dedicated to different types of testing and related ventures. Clinical laboratory testing, community health screening services, wellness centers, occupational physician and nursing services, audiometric screening and the manufacturing of nuclear medicine products are key parts of MDS Health Group's mission -- **" to be a premier provider of services that benefit the health and well being of people".** Other activities of MDS include the distribution of medical supplies and equipment, development and marketing of ultra-trace mass spectrometry equipment, provision of computer billing services to physicians, and medical office building development.

Our operations in Reading have grown steadily and diversified significantly since first gaining accreditation by AIHA in 1979. Now, over ten years later, we are fully computerized, offer comprehensive testing capabilities, and take advantage of high-tech reporting to get results to you literally minutes after testing is completed.

OUTLINE OF SERVICES AND CAPABILITIES

MDS Laboratories provides a complete line of industrial hygiene and environmental testing to an international clientele. Our industrial hygiene laboratory specializes in analyzing air and wipe samples from work environments for the presence of regulated industrial contaminants. The environmental laboratory tests water, soil, and wastes in order to determine and classify their toxicity. These laboratories share a state-of-the-art facility in Reading, PA that includes over 9000 square feet of laboratory space.

MDS Laboratories, a division of MDS Health Group Ltd., is a testing company only, and does not provide consulting services nor management/planning services for hazard remediation. Our focus is on testing and related laboratory services, i.e. sample pickup and handling via our courier system, provision of supplies to clients, and expeditious reporting of analytical results.

At MDS we currently serve about 300 clients, from large corporations, to small businesses, to individual consultants. Our reputation is built on providing consistent, dependable laboratory support to clients who need to rely on that support to remain competitive. And, our commitment is to combine efficiency and responsiveness in finding creative ways to meet your individual needs.

LABORATORY LICENSES AND CERTIFICATIONS

MDS Laboratories has been accredited by the American Industrial Hygiene Association since 1979. Our AIHA accreditation number is 135. Other credits to our industrial hygiene laboratory include New York State Department of Health approval for testing asbestos fibers (air and bulk samples) and NIST/NVLAP accreditation for testing asbestos containing materials by PLM and air filters by TEM.

Regarding environmental samples, MDS is approved by the New York State Department of Health for testing non-potable water, air and emissions, and solid and hazardous waste. These certifications are reciprocally accepted by all other states except California. In addition, we are certified by the Pennsylvania Department of Environmental Resources to test drinking water and the New Jersey Department of Environmental Protection for testing drinking and waste water.

Please call us if you have and questions on our licenses, certifications, or other credentials pertaining to specific assays performed by MDS Laboratories.

MDS Laboratories
Statement of Qualifications

Key Personnel

FRED USBECK, MS, CIH **DIRECTOR OF LABORATORY SERVICES**

Fred has worked for MDS Laboratories since 1982, beginning in the laboratory as an industrial hygiene chemist. After a brief time as laboratory supervisor, he took over the directorship of the entire laboratory operation in 1985. Fred has been integral in growing MDS's client base through diversifying our testing capabilities, most notably by adding an environmental testing laboratory and both TEM and GC/MS testing. Perhaps Fred's largest single contribution came as he specified and then implemented a comprehensive computer data handling system in Reading. This system, based on Fred's custom designed software, enables us to provide reporting, billing, sample tracking, Q.C. reports, and remote data transmission from one integrated system. Earning his CIH designation in 1987, Fred has concentrated his expertise on the chemical (analytical) aspects of industrial hygiene. He has served as an officer for the Central Pennsylvania AIHA, and also as an instructor on analytical aspects of hygiene for continuing education classes sponsored by that organization. Fred has overall operating responsibility in Reading.

CARMINE FIORIGLIO **TECHNICAL DIRECTOR**

Carmine joined MDS Laboratories in 1993 and assumed the technical responsibility for the environmental testing laboratory. Having over 19 years of laboratory experience, including various aspects of chemical and environmental applications, Carmine's areas of expertise include environmental regulations, analytical methodologies, and laboratory certifications. Carmine has an MS degree in analytical chemistry from Indiana University of Pennsylvania and has attended numerous seminars relating to the management of environmental laboratories. He has responsibility for all technical issues relating to the operation of the laboratory.

Key Personnel (con't)

DAVID SHIREY **INDUSTRIAL HYGIENE LABORATORY MANAGER**

Dave has been with MDS since his graduation from Moravian College in 1983, serving as chemist, principal chemist, supervisor and now manager of the industrial hygiene laboratory. Having a strong technical background, he has been instrumental in establishing and validating analytical methods, in writing and compiling testing procedures, in serving as a technical resource contact for clients and in establishing training programs for chemists and microscopists. Dave has completed several graduate level courses in industrial hygiene and environmental health topics and is active in the local AIHA section. He has been a guest lecturer on analytical subjects for training in the nuclear power industry. Dave had start-up responsibility for MDS's branch office in Buffalo, NY and has operating responsibility for the industrial hygiene laboratory. He also coordinates advertising, marketing, recruiting and development projects for the entire operation.

WILLIAM WOOD, PE, CSP, CIH **QA/QC, SAFETY CONSULTANT**

Bill has served MDS since 1984, having over 38 years of experience in safety and industrial hygiene. He administers the industrial hygiene QA/QC program, and is responsible for inter- and intralaboratory QC, proficiency testing coordination, statistical analysis of QC data, documentation of QC, and lab safety and hygiene at MDS. Bill has his own industrial hygiene consulting firm, serves as the primary I.H. consultant to several large companies, teaches in Temple University's graduate program, is active in both the local and national AIHA, and has authored many technical articles on various safety and hygiene topics.

LABORATORY PERSONNEL AND INSTRUMENTATION

MDS Laboratories' full time staff includes 10 degreed (BS/MS) chemists, 5 degreed microscopists 1 chemical technician, 4 clerical support people, 2 laboratory managers, 1 sales representative and a laboratory director. This staff is supplemented by a few degreed part-time analysts and our quality control coordinator.

The facility in Reading occupies about 9,000 square feet. The facility is equipped with 8 gas chromatographs, 4 atomic absorption spectrophotometers, 1 transmission electron microscope, 2 GC/mass spectrometers, 1 high performance liquid chromatograph, 1 ion chromatograph, 3 UV/visible spectrophotometers, 1 infrared spectrophotometer, 1 TOC analyzer, 1 TOX analyzer, 3 polarized light microscopes, and three phase contrast microscopes.

TRAINING OF LABORATORY PERSONNEL

It is the responsibility of the laboratory managers to see that all chemists, microscopists and technicians are thoroughly trained and to make sure they are producing quality results and acceptable QC. The analysts must also be proficient at interpreting data and at calculating results. It is our policy at MDS to make training one of our highest priorities. We believe in an eclectic approach to training, beginning by hiring personnel who have scientific degrees and significant experience in a laboratory setting. Then, a combination of classroom and on-the-job training at MDS is enhanced by training courses offered by NIOSH, the American CHemical Society, universities, and instrument manufacturers.

MDS Laboratories provides each member of its technical staff with reimbursement for all university studies undertaken by the employee. We also encourage the entire staff to schedule one week of professional training in their area of expertise each year.

QA/QC PHILOSOPHY

The purpose of MDS Laboratories' QA/QC program is to insure that testing performed by our personnel meets acceptable limits of precision and accuracy as determined by the agencies that accredit us and by the accepted guidelines of good practice within the industry.

ESSENTIAL FUNCTIONS OF THE QC PLAN

(a) To insure that sample receipt, logging and handling are performed so as to maintain sample integrity and chain-of-custody.

(b) To maintain a repertoire of up-to-date, approved analytical methods by periodic review and modifications of methods in use, and by validation of new methodology for future use.

(c) To insure testing is performed within acceptable limits of precision and accuracy by requiring our chemists to analyze spiked controls, media blanks, field blanks and duplicates along with each batch of samples they test.

(d) To maintain analytical instrumentation in peak operating condition by having all instruments professionally serviced as needed, and maintained at least once per year for calibration and preventive maintenance.

(e) To continually compare our analytical results to those generated by other reputable laboratories and analysts by participating in NIOSH proficiency testing, the NVLAP program, the AIHA's Asbestos Registry, and state run proficiency testing programs.

ESSENTIAL FUNCTIONS OF THE QC PLAN (con't)

(f) To further insure inter-laboratory credibility of analytical data by participating in a round robin sample exchange arrangement with at least three other AIHA accredited laboratories.

(g) To be fully committed to quality control as a priority at MDS by employing a person whose sole function is administering our QA/QC program.

(h) To have available for inspection the entire documentation of QC data, including daily entries, computer-generated summaries, proficiency testing results (1979 to present), round robin comparisons, instrument maintenance logs, etc.

MDS Laboratories
Statement of Qualifications

REFER YOUR QUESTIONS TO:

Account Balance.....Lucy Ruhnke
Accounts Payable.....Lucy Ruhnke
Air Sampling.....Dave Shirey or Fred Usbeck
Asbestos Testing.....Dave Shirey
Billing Discrepancies.....Fred Usbeck
Copies of Reports.....Diana Kehler
Courier Service (pickups).....Rita Galantuomo
Credit Information.....Fred Usbeck
Directions to MDS.....Dave Shirey
Discount Information.....Fred Usbeck* or Dave Shirey**
Employment Opportunities.....Fred Usbeck
Environmental Testing.....Carmine Fioriglio
Industrial Hygiene Testing.....Dave Shirey
List of Environmental
Consultants.....Carmine Fioriglio
List of Industrial Hygiene
Consultants.....Dave Shirey
Quality Control Program.....Carmine Fioriglio
Round Robin Sample Exchange.....Bill Wood
Sample Results/Status.....Diana Kehler
Supplies.....Carmine Fioriglio* or
Dave Shirey**
TEM Analysis.....Dave Shirey
Water Testing.....Carmine Fioriglio

* environmental testing ** industrial hygiene testing

1-800-345-4026

APPENDIX I

Information contained in Appendix I is meant to be used as a fast reference for those unfamiliar with conversions and computations. This is not intended as a substitute for professional instruction on these topics, nor is this section complete in its explanation of many of the underlying concepts related to its contents. MDS assumes no liability for information contained within this booklet.

CONVERSIONS

1000 ng (nanograms)	=	1.0 ug (microgram)
1000 ug (micrograms)	=	1.0 mg (milligram)
1000 mg (milligrams)	=	1.0 g (gram)
1000 g (grams)	=	1.0 Kg (kilogram)
1000 uL (microliters)	=	1.0 mL (milliliter)
1000 mL (milliliters)	=	1.0 L (liter)
1000 L (liters)	=	1.0 M^3 (cubic meter)
1.0 mL (milliliter)	=	1.0 cc (cubic centimeter)

Some examples of these conversions are:

7465 ng = 7.465 ug	7.465 ug = 0.007465 mg
0.339 mg = 339 ug	0.07891 Kg = 78.91 g
244.7 mL = 0.2447 L	1.349 M^3 = 1349 L
1428.7 L = 1.4287 M^3	564 cc = 564 mL

CALCULATING AIR VOLUMES

Calculating accurate air volumes (exact amounts of air drawn through air sampling media) is imperative in reaching meaningful results. The air volume is simply the product of two terms, flowrate and sampling time:

Air Volume = Flowrate X Sampling Time

The flowrate is usually expressed in liters/minute or in milliliters/minute (mL/minute is the same as cc/minute). The sampling time needs to be expressed in minutes, and therefore the product of these two terms, the air volume, will be either liters or milliliters.

Some samples of calculating air volumes are:

11.7 L/min.	X	240 minutes	=	2808 L	
20 mL/min.	X	462 minutes	=	9240 mL	(= 9.240 L)
540 cc/min.	X	366 minutes	=	197640 cc	(= 197.640 L)
3.4 L/min.	X	480 minutes	=	1632 L	(= 1.632 M^3)

CONCENTRATIONS: AN IMPORTANT CONCEPT

Concentration is an important concept in expressing analytical results in environmental and industrial hygiene testing. A concentration is, simply, so much of something per so much of something else. The key word is per. Any time you hear that word being used to separate two quantities (such as in "parts per million" and mg/M^3) you know you are dealing with a concentration. There is an almost endless number of possibilities (of combinations) of ways to express a concentration, however the most commonly used concentrations are:

mg/Kg	(milligrams per kilogram)
mg/M^3	(milligrams per cubic meter)
ppm	(parts per million parts)
fibers/cc	(fibers per cc of air)
mg/L	(milligrams per liter)

Note that there are basically two types of concentration, weight per weight and weight per volume. Weight per weight concentrations (for example mg/Kg) are used to express contaminant levels of solids, for instance the level of lead in paint chips. Weight per volume concentrations (for example mg/M^3 and mg/L) are used to express contaminant levels of both air and liquids. The amount of benzene vapor in air and the amount of iron in water (most likely expressed as mg/M^3 and mg/L, respectively) would both be weight per volume concentrations.

Obviously, concentrations are necessary to make sense out of analytical results. Knowing only the total weight of metal found on a filter is useless without knowing the exact amount of air in which that amount of metal was contained.

WHEN YOU SEND SAMPLES TO MDS LABORATORIES PLEASE INCLUDE THE AIR VOLUMES IF THEY ARE AIR SAMPLES. WHEN WE HAVE AIR VOLUMES WE REPORT CONCENTRATIONS TO YOU. IF YOU DO NOT SEND THE AIR VOLUMES, WE CANNOT CALCULATE CONCENTRATIONS!

You can always calculate your own concentrations if you know the amount of contaminant and the volume of air drawn through the sampler. Simply start with the weight amount of contaminant found on the entire

sample, and then divide by the air volume (in whatever units you prefer) to arrive at the concentration, for example:

You send a charcoal tube to the lab for benzene analysis, but do not include the air volume, which was 24.17 L. The lab sends you a result of 0.03mg benzene. To compare to a PEL or TLV, you need to know the concentration.

$$\frac{0.03 \text{ mg benzene}}{0.02417 \text{ M}^3 \text{ air}} = 1.24 \text{ mg/M}^3 \text{ benzene}$$

Notice that you converted liters to cubic meters because you wanted the result expressed as mg/M^3, not mg/L.

For fiber counting, as in asbestos analysis, the application is similar, except that the concentration is now <u>number of fibers</u> per <u>volume of air</u>.

You send a 1243.7 L air sample to the lab, but do not tell them the air volume. They send you a result of: 7847 fibers/filter. Knowing the total number of fibers on the entire filter, and the air volume, you can easily calculate the concentration of fibers in air:

$$\frac{7847 \text{ fibers}}{1{,}243{,}700 \text{ cc air}} = 0.0063 \text{ fibers/cc}$$

Notice that you chose to convert liters to cubic centimeters, because you wanted the result in fibers/cc, not in fibers/L.

Remember, when working with concentrations you are always in charge of what units you will have in the end, because you can manipulate both the weight value and the volume value into whatever units you prefer, before you perform the division. For example, a result of:

517.3 mg/L chlordane in water

can be correctly expressed as any of the following, without changing the result:

517300 ug/L 517.3 ug/mL 0.000000517 g/uL

The last example makes it obvious why certain ways of expressing con-

centrations are preferred over others. The broader point made is that you can perform conversions with concentrations as easily as you can with weights and with volumes.

One last word about concentrations. Parts per million, or ppm, is frequently used to express concentrations as volume per volume of air, volume per volume of liquid (usually water-- aqueous solutions), and weight per weight. By the way, "parts per million" as a concept would be better understood if we would say "parts per million parts", since the "million" in ppm refers to a million parts of whatever is being analyzed-- air, water or solid. For example, if testing a solid for its amount of lead we found that it contained 34 ug of lead per gram of solid, we could say that the solid contained 34 ppm lead, since there are a million ug in one gram.

Applying ppm values to lead contamination in water, for example, is not difficult if we remember one very important premise in chemistry. One milliliter (1.0 mL) of water weighs exactly one gram (1.0 g). Knowing this, it is easy to understand that if we find water contains 69 ug of lead per mL, we can correctly say that that water is 69 ppm lead. This is because 69 ug/mL is the equivalent of saying 69 ug/g (remember, 1.0 mL water weighs 1.0g), and you know there are a million ug in a gram. So, 69 ug of lead per gram of water means, by definition, 69 ppm.

Lastly, ppm can refer to volume of contaminant per volume of air. In this case the contaminant is usually an organic vapor. This type of ppm application is the most difficult to understand. It is based on two chemical principles: 1) a chemical's molecular weight is the number of grams of that chemical found in one mole of that chemical, and 2) at normal temperature and pressure conditions, one mole of any chemical (in a vapor state if it is normally a liquid) or gas occupies exactly the same amount of airspace, 24.45 liters. You can express volume per air volume results of solvent vapors and gases in ppm by using the following:

$$\frac{\text{mg contaminant}}{\text{M}^3\text{ air}} \times \frac{24.45\text{ L/mole}}{\text{m.w. as g/mole}} = \text{ppm contaminant in air}$$

Always remember, when using ppm you must always be expressing either volume per volume or weight per weight-- never "mixed" values such as weight per volume.

Sometimes it is handy to convert results expressed in ppm to results expressed as a percentage (or vice versa). Do this as follows:

$$\text{parts per million} = (\text{percent})\ (0.0001)$$

$$\text{percent} = \frac{\text{parts per million}}{0.0001}$$

TIME WEIGHTED AVERAGES (TWA's)

Time weighted averages are expressions of concentrations that have been "time weighted" for the purpose of comparison with 8-hour contaminant concentrations. In other words, if a sample was taken in a time frame of either less than or greater than 8 hours, the sample result (always as a concentration) would be multiplied by a factor that would make the resultant concentration represent the contaminant level <u>if the sampling time had been exactly eight hours</u>, instead of more or less than eight hours. If you sampled for exactly 8 hours, the sample result (concentration) is already, by definition, an 8-hour TWA.

If you sampled <u>less</u> than eight hours, you would multiply your sample concentration by a factor that is <u>less than 1</u>; this would take the concentration of contaminant the employee was exposed to and "spread it out" so as to represent what the concentration would have been if the exposure was 8 hours, but the <u>weight</u> of contaminant was unchanged. If you sampled <u>more</u> than 8 hours (for instance a worker who works 4 10-hour days), you would multiply your sample concentration by a factor that is <u>greater than 1</u>; this would take the concentration of contaminant the employee was exposed to and "squeeze it into an 8-hour time frame" so as to represent what the concentration would have been if the exposure was 8 hours, but the <u>weight</u> of contaminant was unchanged.

TWA's are expressed as either ppm or mg/M^3 values. Hygienists need to calculate TWA's for all their sample results because the OSHA PEL's and the ACGIH TLV's are all expressed as either ppm TWA's or as mg/M^3 TWA's. In order to compare your results to the standards, both

values need to be time weighted averages. Use the following calculations to arrive at 8-hour TWA's for your results:

$$\frac{mg}{M^3} \times \frac{\text{minutes sampled}}{480 \text{ minutes}} = \frac{mg}{M^3} \text{ TWA}$$

$$\text{ppm} \times \frac{\text{minutes sampled}}{480 \text{ minutes}} = \text{ppm TWA}$$

For example, you are sampling a painter for mineral spirits. The pump ran for 6 hours and 15 minutes while he was painting, and he spent the remainder of his shift unexposed to solvent vapors. The lab reports a result of 0.344 mg/M^3 mineral spirits for the charcoal tube. You need to convert this concentration to an 8-hour TWA.

$$0.344 \text{ mg/M}^3 \times \frac{375 \text{ minutes}}{480 \text{ minutes}} = 0.269 \text{ mg/M}^3 \text{ TWA}$$

Remember, you sampled for less than 8 hours, so the factor you multiply the concentration by is less than 1.

You receive a lab report for formaldehyde saying the exposure was 0.85 ppm. This sample was taken on a worker working a 12-hour shift, but was sampled for 11 hours and 15 minutes because he took a break. You need to calculate an 8-hour TWA so you can compare his exposure to the standard.

$$0.85 \text{ ppm} \times \frac{675 \text{ minutes}}{480 \text{ minutes}} = 1.20 \text{ ppm TWA}$$

Since you sampled for more than 8 hours, you multiply by a factor greater than 1, raising the concentration so as to represent what the concentration would have been during an 8-hour period, had the <u>weight</u> of formaldehyde found remained the same.

APPENDIX II

Both types of MDS Laboratories request forms are available. Call the laboratory to order these forms. Also included in this section are sample reports from the industrial hygiene, T.E.M., and environmental laboratories.

MDS Laboratories
4418 POTTSVILLE PIKE
READING, PA 19605
215-921-8833 or 1-800-345-4026

INDUSTRIAL HYGIENE REQUEST FORM

PURCHASE ORDER NUMBER

CLIENT INFORMATION	INVOICE TO:
	LAB REPORT TO:
NUMBER OF SAMPLES / TYPE OF SAMPLES	

LAB USE ONLY	CLIENT ID NUMBER, AIR VOLUME & ANALYSIS REQUESTED	SPECIAL INSTRUCTIONS

Samples Relinquished by Sampler (Signature)	Samples Rec'd. by Courier (Signature)	Date	Time
Samples Relinquished by Courier (Signature)	Samples Rec'd. by Laboratory (Signature)	Date	Time
Samples Relinquished for Analysis (Signature)	Samples Rec'd. for Analysis (Signature)	Date	Time
Samples Relinquished *after* Analysis (Signature)	Analyzed Samples Rec'd. for Retention (Signature)	Date	Time

NOTES:	I am submitting these samples for testing, at the regular fee, within the customary turnaround time.	I request priority handling of these samples, *have already scheduled them by telephone*, and authorize the additional fee for this service.
	Initial for approval	Initial for approval

TO INCLUDE PURCHASE ORDER NUMBER

CLIENT TO RETAIN PART 3 OF FOR

MDS Laboratories
4418 Pottsville Pike
Reading, Pennsylvania 19605
(215) 921-8833 (800) 345-4026
FAX (215) 921-9667

CHAIN OF CUSTODY RECORD

PROVIDING A COMPLETE LINE OF INDUSTRIAL HYGIENE AND ENVIRONMENTAL SERVICES

REPORT RESULTS TO:			SEND INVOICE TO:		
NAME	TITLE		PURCHASE ORDER NO.	CLIENT JOB NO.	
COMPANY			NAME		
MAILING ADDRESS			COMPANY	DEPT.	
CITY, STATE, ZIP			ADDRESS		
TELEPHONE NO.	FAX NO.		CITY, STATE, ZIP		

TURNAROUND TIME REQUESTED

☐ STANDARD (2-3 weeks) ☐ STANDARD PLUS (2 WEEKS)

THE FOLLOWING REQUIRE PRIOR LAB AUTHORIZATION:
(Additional charges may apply)

AUTHORIZATION NO. _____ AUTHORIZED BY: _____ DATE: _____

☐ 1 Week ☐ 72 Hours ☐ 48 Hours ☐ 24 Hours

ANALYSIS REQUESTED

SAMPLE IDENTIFICATION/DESCRIPTION	MATRIX TYPE	DATE SAMPLED	TIME SAMPLED	PRES.	NO. CONT.	Full TCLP	TCLP Metals	TCLP Organics	Volatile Organic Compound	BTEX	PCB'S	Pesticides	Base/Neutral Compounds	Acid Extractable Compounds	Petroleum Hydrocarbons	Total Metals (Specify):	Ignitability	pH/Corrosivity	Reactivity: Cyanide/Sulfide	TOX			COMMENTS

EMPTY CONTAINERS DISPATCHED BY:	DATE	TIME	RECEIVED BY:	SAMPLER (SIGNATURE)			
RELINQUISHED BY:	DATE	TIME	RECEIVED BY:	RELINQUISHED BY:	DATE	TIME	RECEIVED BY:
RELINQUISHED BY:	DATE	TIME	RECEIVED FOR LABORATORY BY:	DATE	TIME	CONDITION OF SAMPLES UPON RECEIPT:	CUSTODY SEALS INTACT Y N N/A

COMMENTS:

DATA DELIVERABLES
(ADDITIONAL CHARGES MAY APPLY)

☐ TIER I
☐ TIER II
☐ ECRA
☐ RESULTS ONLY
☐ OTHER (SPECIFY): _____

ORIGINAL - LABORATORY COPY YELLOW - REPORT COPY PINK - CUSTOMER COPY

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE — ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 776

SAMPLE REPORT

Work Order number: R021690-124

samples received: 02/16/90
report date: 02/16/90

MDS number	client number		results	concentration
0047156	MET-0290-A			
1.	ARSENIC (GRAPHITE FURNACE)	<	0.020 mcg	< 0.044 mcg/m3
2.	NICKEL		0.005 mg	0.011 mg/m3
3.	VANADIUM	<	0.001 mg	< 0.002 mg/m3
	Air volume: 455.6 liters			
0047157	MET-0290-B			
1.	ARSENIC (GRAPHITE FURNACE)		0.130 mcg	0.256 mcg/m3
2.	NICKEL		0.067 mg	0.132 mg/m3
3.	VANADIUM	<	0.001 mg	< 0.002 mg/m3
	Air volume: 507.2 liters			
0047158	MET-0290-C			
1.	ARSENIC (GRAPHITE FURNACE)	<	0.010 mcg	< 0.043 mcg/m3
2.	NICKEL	<	0.001 mg	< 0.004 mg/m3
3.	VANADIUM		0.007 mg	0.030 mg/m3
	Air volume: 232.3 liters			
0047159	BLANK			
1.	ARSENIC (GRAPHITE FURNACE)	<	0.020 mcg	N/A
2.	NICKEL	<	0.001 mg	N/A
3.	VANADIUM	<	0.001 mg	N/A

Lower limit of quantitation: 0.002 ug as,0.001 mg ni&v per sample
Analytical method: As-graphite furnace AAS,ni&v flame AAS

N/A: not applicable

Fred Usbeck, CIH
Laboratory Director

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE — ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 776

SAMPLE REPORT

P.O. number: XYZ-1234 — Work Order number: R021690-123

samples received: 02/16/90
report date: 02/16/90

MDS number	client number		results		concentration
0047152	RMO-1714-A				
1.	TOLUENE	<	0.010 mg	<	0.362 mg/m3
2.	METHYL ETHYL KETONE		1.060 mg		38.406 mg/m3
3.	TRICHLOROETHYLENE		0.370 mg		13.406 mg/m3
	Air volume: 27.6 liters				
0047153	RMO-1714-B				
1.	TOLUENE		0.030 mg		2.273 mg/m3
2.	METHYL ETHYL KETONE		0.500 mg		37.879 mg/m3
3.	TRICHLOROETHYLENE		0.150 mg		11.364 mg/m3
	Air volume: 13.2 liters				
0047154	RMO-1714-C				
1.	TOLUENE		0.270 mg		42.188 mg/m3
2.	METHYL ETHYL KETONE	<	0.010 mg	<	1.563 mg/m3
3.	TRICHLOROETHYLENE	<	0.010 mg	<	1.563 mg/m3
	Air volume: 6.4 liters				
0047155	BLANK				
1.	TOLUENE	<	0.010 mg		N/A
2.	METHYL ETHYL KETONE	<	0.010 mg		N/A
3.	TRICHLOROETHYLENE	<	0.010 mg		N/A

Lower limit of quantitation: 0.01 mg each analyte per sample
Analytical method: gas chromatography

N/A: not applicable

Fred Usbeck, CIH
Laboratory Director

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE | ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 77678

SAMPLE REPORT

P.O. number: 9001007 Work Order number: R021690-122

samples received: 02/16/90
report date: 02/16/90

MDS number	client number	mean count	fibers/cc
0047146	PCM-A-1	0.075	less than 0.01
		Air volume: 1200.0 liters	
0047147	PCM-B-2	0.235	0.03
		Air volume: 385.0 liters	
0047148	PCM-C-3	1.065	0.13
		Air volume: 392.0 liters	
0047149	PCM-D-4	2.300	0.29
		Air volume: 389.0 liters	
0047150	PCM-E-5	0.055	less than 0.01
		Air volume: 1260.0 liters	
0047151	BLANK	0.000	less than 490 (fibers/filter)

Lower limit of quantitation: 1 fiber per 100 fields counted
Analytical method: NIOSH 7400 (P&CAM 239 counting rules)

N/A: not applicable

Fred Usbeck, CIH
Laboratory Director

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
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- NY DOH 10903
- PA DER 06-353
- NJ DEP 776

SAMPLE REPORT

P.O. number: ACME CONSTR.CO. Work Order number: R022090-106

MDS number	client number	samples received: 02/20/90 report date: 02/20/90

0051017 02-20-90-WALL
description: homogenous, no obvious layers, fibrous, color: tan
composition: asbestos-
NO ASBESTOS DETECTED
other fibrous materials-
CELLULOSE: 30-40%

0051018 022090-FLR.TILE
description: homogenous, no obvious layers, fibrous, color: green
composition: asbestos-
CHRYSOTILE: 2-4%
other fibrous materials-

0051019 022090-CEILING
description: homogenous, obvious layers, fibrous, color: tan
composition: asbestos-
NO ASBESTOS DETECTED
other fibrous materials-
CELLULOSE: 30-40%
SYNTHETIC: 20-30%

0051020 022090-PIPE INS
description: homogenous, obvious layers, fibrous, color: white
composition: asbestos-
AMOSITE: 30-40%
CROCIDOLITE: 2-4%
other fibrous materials-

Lower limit of quantification: 1% Asbestos
Analytical method: Dispersion Staining/Polarized Light Mic.

N/A: not applicable

Fred Usbeck, CIH
Laboratory Director

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 77678

TRANSMISSION ELECTRON MICROSCOPY (TEM) ASBESTOS ANALYSIS

Client: **ABC Company**
Client P.O.#: 123456
Client Sample #/Location: **Room 123 - East Wing**

MDS Sample #: 90-0301-111A

	Structures/9 G.O.	Structures/mm2
Asbestos Structures:	2	27.8
Non-Asbestos Structures:	0	N/A

Asbestos Structures/cc*: **0.007**
Type of Asbestos Present: **1 Chrysotile & 1 Amosite**

Details of the Analysis

Fiber Type: MCE
Air Volume*: 1500 L
Method: AHERA 40 CFR-763
Diameter: 25 mm
Grid Opening Area: 0.00800 mm2
Microscope: Zeiss EM10CRX
Analytical Sensitivity: 0.0039 structures/cc

COMMENTS

_____

_____

NOTE
MDS Laboratories is not responsible for the volume of air sampled or for the condition of the filter media. Also, the concentration in structures/cc is calculated as a courtesy to our clients.

Samples prepared by: _____ Date _____

Samples analyzed by: _____ Date _____

Results reported by: _____ Date _____

4418 POTTSVILLE PIKE, READING, PENNSYLVANIA 19605 215-921-8833 FAX 215-921-9667

MDS Health Group Inc.

TEM Count Sheet

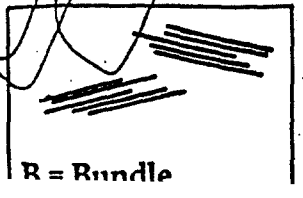
Lab ID # 90-0301-111A

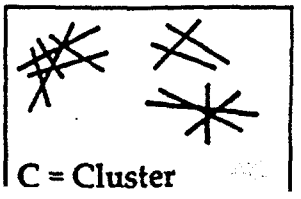
Client	Grids	TEM Conditions	Filter
Client Name: ABC Company	Grid Type: 200 mesh copper	Instrument/Ser. #: EE/SS EM10CR/P	Filter Manuf./Type: MCE
Sample ID: RM 123 - EAST WING	Grid Lot #: 03	Magnification: 16,000X	Filter Size: 25mm
Telephone #:	Ave. GO (mm): 20.00808	Calib. Date: 2-28-90	Pore Size: 0.45μm
Fax Results?: ☐ No ☐ Yes #	Box #: 09 Opening: 7P	Acc Voltage: 80KV	Air Vol (L): 1500 (9)

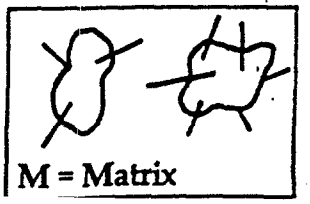
GO	STRUCTURE				S.A.E.D. OBSERVATION				EDXA	COMMENTS / NOTES
	No.	Type	Size	Loc.	Chry.	Amph.	Nonasb.	Neg ID		
1	NSD									
2	NSD									
3	1	F	8.5	01		✓			PCS	Amosite mg # 644
4	NSD									
5	NSD									
6	NSD									
7	NSD									
8	NSD									
9	1	B	4.0	02	✓645				PCS	Chrysotile Bundle

EM Technician's Name: [signature] Date of Analysis: 3/1/90

Comments





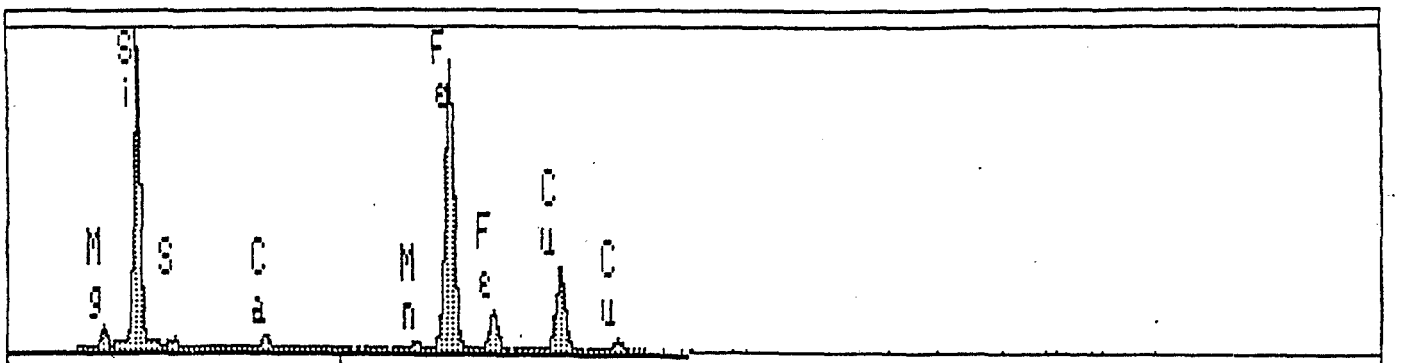


MDS Laboratories

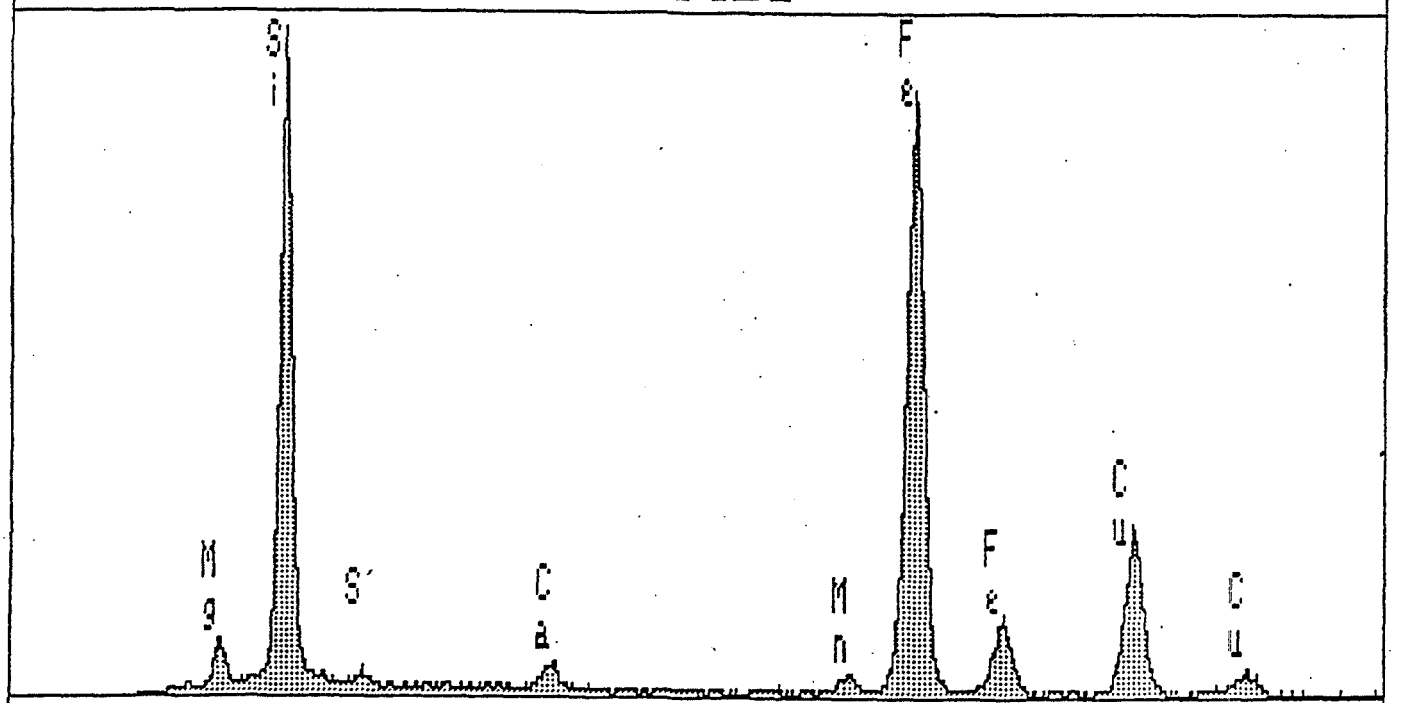
LABORATORY REPORT

INDUSTRIAL HYGIENE ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 77678



X-RAY: 0 - 20 keV
Live: 92s Preset: 100s Remaining: 8s
Real: 154s 40% Dead



4.800 keV 9.9 >
FS= 4K ch 250= 67 cts
MEM1:90-0301-111A GO 3-1 AMOSITE FIBR

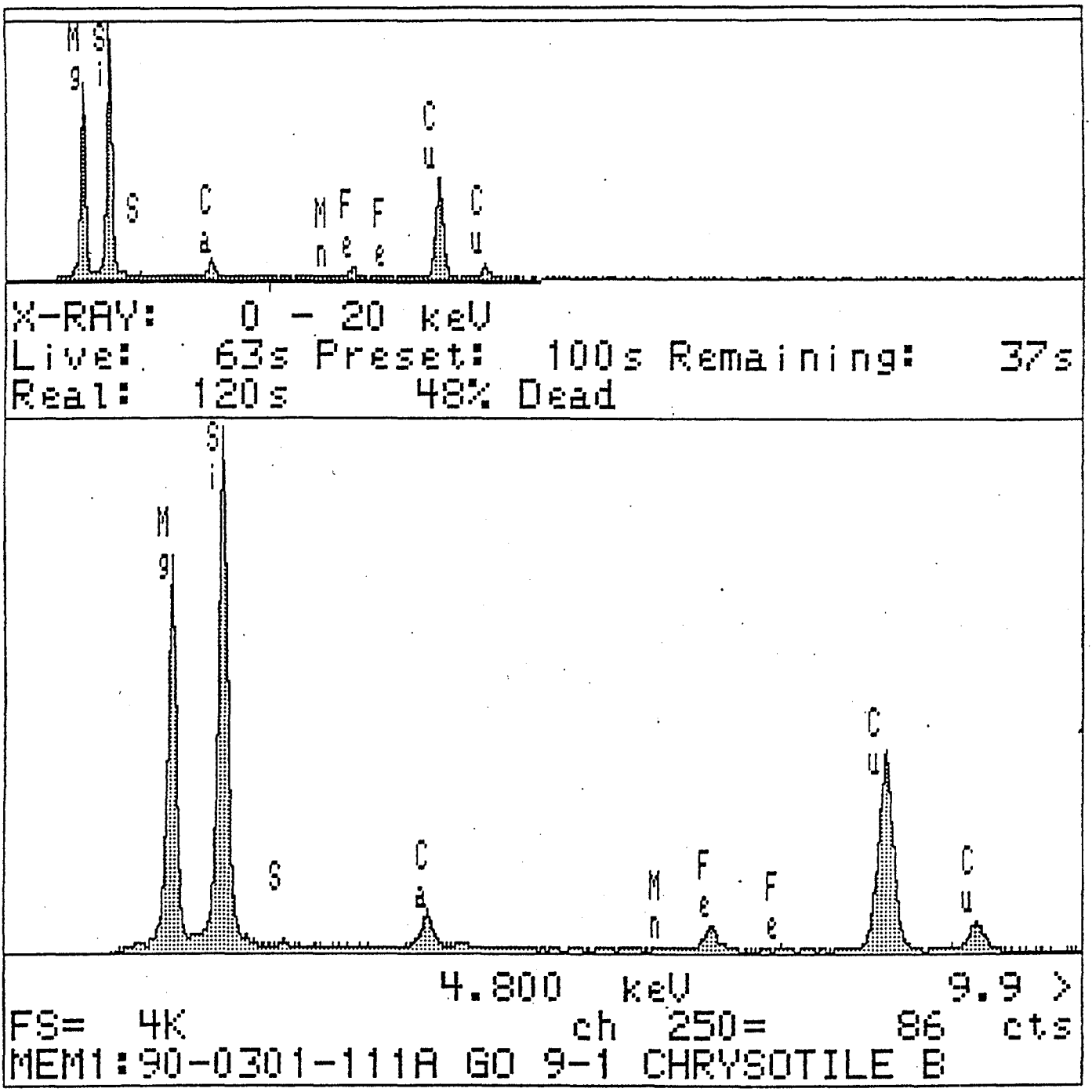
4418 POTTSVILLE PIKE, READING, PENNSYLVANIA 19605 215-921-9191 FAX 215-921-9667

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 77678



4418 POTTSVILLE PIKE, READING, PENNSYLVANIA 19605 215-921-9191 FAX 215-921-9667

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE — ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 776

CLIENT: ABC COMPANY
123 Main Street
Reading, PA 19605

Attn: D. Shirey

SAMPLE NUMBER: 02-1490-90
SAMPLE DATE: 02-13-90
SAMPLE TIME: 1800
SAMPLED BY: CRA
RECEIVED BY: ETD
DATE & TIME RECEIVED: 02-14-90 0845

PROJECT DESCRIPTION: East End of Lot
STATION: Composite of Bins 1 thru 5

PARAMETER	RESULT
BOD	
COD	
TOC	
Acidity	
Alkalinity	
Hardness	
pH	6.47
Conductivity	
Specific Gravity	
Color	
Odor	
Turbidity	
Bromide	
Chloride	
Fluoride	
Iodide	
Free chlorine	
Cyanide, total	1.82 mg/kg
Cyanide, amenable	
Ammonia nitrogen	
Nitrate nitrogen	
Nitrite nitrogen	
Kjeldahl nitrogen	
Organic nitrogen	
Phosphate, total	
Phosphate, ortho	
Silica as SiO2	
Sulfate	
Sulfite	
Sulfide	14.0 mg/kg
Total solids	
Dissolved solids	
Suspended solids	
Volatile solids	
Settleable solids	
Grease & oil	
Pet. hydrocarbons	
Detergents	
Phenols	

PARAMETER	E.P. TOX RESULT
Aluminum	
Antimony	
Arsenic	0.003 mg/L
Barium	< 0.10 mg/L
Beryllium	
Cadmium	0.013 mg/L
Calcium	
Chromium,total	0.16 mg/L
Chromium, hex.	
Copper	
Iron, total	
Lead	< 0.05 mg/L
Magnesium	
Manganese	
Mercury	< 0.0002 mg/L
Molybdenum	
Nickel	
Potassium	
Selenium	< 0.002 mg/L
Silver	< 0.01 mg/L
Silicon	
Sodium	
Thallium	
Tin	
Titanium	
Vanadium	
Zinc	

OTHER PARAMETERS:

Ignitability	Non-hazardous SW846 Nov. 19
Endrin	0.02 mg/L
Lindane	0.45 mg/L
Methoxychlor	10.0 mg/L
Toxaphene	0.53 mg/L
2,4-D	9.03 mg/L
2,4,5-TP	1.00 mg/L

Reviewed by: _____
Craig R. Achenbach
Laboratory Superviso

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE **ENVIRONMENTAL TESTING**

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 77678

CLIENT: ABC COMPANY
123 Main Street
Reading, PA 19605

Attn: D. Shirey

SAMPLE NUMBER: 02-1490-90
SAMPLE DATE: 02-13-90
SAMPLE TIME: 1800
SAMPLED BY: CRA
RECEIVED BY: ETD
DATE & TIME RECEIVED: 02-14-90 0845

PROJECT DESCRIPTION: Presque Isle II
STATION : 0130PG3

PURGEABLE AROMATICS--EPA METHOD 602/8020

PARAMETER	RESULTS
1. Benzene	< 50.0 ug/kg
2. Chlorobenzene	< 50.0 ug/kg
3. 1,2-Dichlorobenzene	< 50.0 ug/kg
4. 1,3-Dichlorobenzene	< 50.0 ug/kg
5. 1,4-Dichlorobenzene	< 50.0 ug/kg
6. Ethylbenzene	< 50.0 ug/kg
7. Toluene	< 50.0 ug/kg

OTHER PARAMETERS:

8. Xylene	1,050.0 ug/kg

Reviewed by: _____
Craig R. Achenbach
Laboratory Supervisor

MDS Laboratories

LABORATORY REPORT

INDUSTRIAL HYGIENE ENVIRONMENTAL TESTING

- EPA/NVLAP 1262
- AIHA ACCREDITATION NO. 135
- NY DOH 10903
- PA DER 06-353
- NJ DEP 77678

CLIENT: ABC COMPANY
123 Main Street
Reading, PA 19605

Attn: D. Shirey

SAMPLE NUMBER: 02-1490-90
SAMPLE DATE: 02-13-90
SAMPLE TIME: 1800
SAMPLED BY: CRA
RECEIVED BY: ETD
DATE & TIME RECEIVED: 02-14-90 0845

PROJECT DESCRIPTION: Presque Isle II
STATION : 0130PG3

ORGANOCHLORINE PESTICIDES AND PCB'S--EPA METHOD 608/8080

PARAMETER	RESULTS
1. Aldrin	< 330.0 ug/kg
2. alpha-BHC	< 330.0 ug/kg
3. beta-BHC	< 330.0 ug/kg
4. delta-BHC	< 330.0 ug/kg
5. gamma-BHC	< 330.0 ug/kg
6. Chlordane	< 330.0 ug/kg
7. 4,4'-DDD	< 330.0 ug/kg
8. 4,4'-DDE	< 330.0 ug/kg
9. 4,4'-DDT	< 330.0 ug/kg
10. Dieldrin	< 330.0 ug/kg
11. Endosulfan I	< 330.0 ug/kg
12. Endosulfan II	< 330.0 ug/kg
13. Endosulfan sulfate	< 330.0 ug/kg
14. Endrin	< 330.0 ug/kg
15. Endrin aldehyde	< 330.0 ug/kg
16. Heptachlor	< 330.0 ug/kg
17. Heptachlor epoxide	< 330.0 ug/kg
18. Toxaphene	< 330.0 ug/kg
19. A-1016	< 1.0 mg/kg
20. A-1221	< 1.0 mg/kg
21. A-1232	< 1.0 mg/kg
22. A-1242	< 1.0 mg/kg
23. A-1248	< 1.0 mg/kg
24. A-1254	< 1.0 mg/kg
25. A-1260	< 1.0 mg/kg

Reviewed by: _____
Craig R. Achenbach
Laboratory Supervisor

APPENDIX III

This section contains both laboratory and individual certifications currently held by MDS Laboratories and its employees.

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION

MDS Laboratories
MDS Laboratories-Reading

Reading PA

has fulfilled AIHA criteria for
Industrial Hygiene Laboratory Accreditation
since August 1, 1979.

This accreditation shall be effective until
the 1st day of August 1994
subject to continued compliance with
AIHA accreditation criteria.

Chairman
Labortary Accreditation
Committee

President
American Industrial Hygiene
Association

135
Accreditation Number

September 24, 1991
Date

United States Department of Commerce
National Institute of Standards and Technology

NVLAP

Certificate of Accreditation

MDS LABORATORIES
READING, PA

is recognized under the National Voluntary Laboratory Accreditation Program for satisfactory compliance with criteria established in Title 15, Part 7 Code of Federal Regulations. Accreditation is awarded for specific services, listed on the Scope of Accreditation, for:

AIRBORNE ASBESTOS FIBER ANALYSIS

October 1, 1994
Effective until

DEPARTMENT OF COMMERCE * UNITED STATES OF AMERICA *

For the National Institute of Standards and Technology

NVLAP LAB CODE: 1262

National Institute of Standards and Technology

NVLAP

National Voluntary Laboratory Accreditation Program

SCOPE OF ACCREDITATION

AIRBORNE ASBESTOS FIBER ANALYSIS

NVLAP LAB CODE 1262

MDS Laboratories
4418 Pottsville Pike
Reading, PA 19605-1286
David Shirey Phone: 800-345-4026

Accreditation Renewal Date: October 1, 1994

NVLAP Code	*Designation*
18/A02	40 Code of Federal Regulations Chapter I (1-1-87 edition) Part 763, Subpart E, Appendix A or the current U. S. Environmental Protection Agency TEM method for the determination of completion of response actions for asbestos.

DEPARTMENT OF COMMERCE • UNITED STATES OF AMERICA •

For the National Institute of Standards and Technology

United States Department of Commerce
National Institute of Standards and Technology

NVLAP

Certificate of Accreditation

MDS LABORATORIES
READING, PA

is recognized under the National Voluntary Laboratory Accreditation Program for satisfactory compliance with criteria established in Title 15, Part 7 Code of Federal Regulations. Accreditation is awarded for specific services, listed on the Scope of Accreditation, for:

BULK ASBESTOS FIBER ANALYSIS

October 1, 1994
Effective until

DEPARTMENT OF COMMERCE * UNITED STATES OF AMERICA *

For the National Institute of Standards and Technology

NVLAP LAB CODE: 1262

National Institute of Standards and Technology

NVLAP

National Voluntary Laboratory Accreditation Program

SCOPE OF ACCREDITATION

BULK ASBESTOS FIBER ANALYSIS

NVLAP LAB CODE 1262

MDS Laboratories
4418 Pottsville Pike
Reading, PA 19605-1286
David Shirey Phone: 800-345-4026

Accreditation Renewal Date: October 1, 1994

NVLAP Code	*Designation*
18/A01	40 Code of Federal Regulations Chapter I (1-1-87 edition) Part 763, Subpart F, Appendix A or the current U. S. Environmental Protection Agency method for the analysis of asbestos in building materials by polarized light microscopy.

DEPARTMENT OF COMMERCE • UNITED STATES OF AMERICA

For the National Institute of Standards and Technology

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION

Asbestos Analyst Registry

QUALITY COUNTS

AAT Performance Results

2700 Prosperity Ave., Suite 250, Fairfax, VA 22031 Tel. (703) 849-8888 Fax (703) 207-3561

DAVID E SHIREY
MDS LABORATORIES
MDS LABORATORIES-READING
4418 POTTSVILLE PIKE
READING PA 19605

October 22, 1993

IT IS THE ORGANIZATION'S RESPONSIBILITY TO THOROUGHLY REVIEW RESULTS, AND TO IMMEDIATELY CONTACT AIHA IN WRITING TO REQUEST REMOVAL FROM THE ASBESTOS ANALYSTS REGISTRY OF ANY ANALYST WHO IS NO LONGER A MEMBER OF THEIR ORGANIZATION.

Report of performance for Round 27, Organization 8707

The following individuals have met all the requirements for listing in the AAR and have been Approved by the AIHA Board of Directors:

ID	NAME (*BdAprvd)	RESULTS (f/mm2) FOR THE CURRENT ROUND (R27)								OUTLIERS R27	R26	TOT	PERFORMANCE RATING
2091	*SHIREY, DAVID	A272	102	B272	243	C272	485	D272	475	0	0	0	ACCEPTABLE
3120	*SERAFINO, BARBAR	A272	113	B272	210	C272	346	D272	393	0	0	0	ACCEPTABLE

The determination of outliers for the above results are based on the following performance limits:

SAMPLE I.D.:	A271	B271	C271	D271	A272	B272	C272	D272
LOWER LIMIT:	101	203	138	256	93	185	311	278
REF. VALUE :	202	406	276	511	186	371	623	555
UPPER LIMIT:	404	813	552	1022	372	741	1245	1111

STATE OF NEW JERSEY

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Certifies That

MDS Laboratories
4418 Pottsville Pike
Reading, Pa. 19605

having duly met the requirements of the

Regulations Governing Laboratory Certification
And Standards Of Performance N.J.A.C. 7:18 et. seq.

is hereby approved as a

State Certified Water Laboratory

To perform the analyses as indicated on the Annual Certified Parameter List
which must accompany this certificate to be valid

77678
PERMANENT CERTIFICATION NUMBER

October 22, 1990
DATE

Judith A. Yaskin
COMMISSIONER
DEPARTMENT OF ENVIRONMENTAL PROTECTION

This certification is subject to unannounced laboratory inspections as specified by N.J.A.C. 7:18-2.11(d) and agreed to by the Laboratory Manager on filing the application

TO BE CONSPICUOUSLY DISPLAYED AT THE LABORATORY WITH THE ANNUAL CERTIFIED PARAMETER LIST.

DEPARTMENT OF ENVIRONMENTAL RESOURCES

OFFICE OF MANAGEMENT AND TECHNICAL SERVICES *BUREAU OF LABORATORIES*

COMMONWEALTH OF PENNSYLVANIA

Certifies that

MDS LABORATORIES
4418 POTTSVILLE PIKE
READING, PA 19605
I. D. # 06-353

having duly met the requirements of
Chapter 109, Subchapter H, Safe Drinking Water Rules and Regulations
issued under the Pennsylvania Safe Drinking Water Act of May 1, 1984
(P.L. 206, No. 43), (35 P.S. SS 721. 1-721.17)
is hereby approved as a

Certified Drinking Water Laboratory

To perform the following analyses:

Inorganic
Trace Metals (Groups 1-2), Fluoride, Sulfate

Organic
Total Trihalomethanes

Expiration Date: 2/1/95

Certificate not transferable
Surrender upon revocation
To Be Conspicuously Displayed at the Laboratory

Floyd Kefford, Bureau Director
Bureau of Laboratories

NEW YORK STATE DEPARTMENT OF HEALTH

MARK R. CHASSIN, M.D., M.P.P., M.P.H. *COMMISSIONER*

Expires 12:01 AM April 1, 1994
ISSUED August 16, 1993
REVISED September 23, 1993

INTERIM CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

Lab ID No.: 10903

Director: MR. CARMINE FIORIGLIO
Lab Name: MDS LABORATORIES
Address : 4418 POTTSVILLE PIKE
READING PA 19605

is hereby APPROVED as an Environmental Laboratory for the category

ENVIRONMENTAL ANALYSES NON POTABLE WATER

All approved subcategories and/or analytes are listed below:

rgeable Halocarbons :
- 1,1,1-Trichloroethane
- 1,1,2,2-Tetrachloroethane
- 1,1,2-Trichloroethane
- 1,1-Dichloroethane
- 1,1-Dichloroethene
- 1,2-Dichloroethene (total)
- Bromodichloromethane
- Bromoform
- cis-1,3-Dichloropropene
- Carbon tetrachloride
- Bromomethane
- Chloromethane
- Trichlorofluoromethane
- Dibromochloromethane
- Chloroethane
- Chloroform
- Dichlorodifluoromethane
- Methylene chloride
- trans-1,3-Dichloropropene
- Tetrachloroethene
- Trichloroethene
- Vinyl chloride

Nutrient :
- Kjeldahl Nitrogen, Total
- Ammonia (as N)
- Nitrite (as N)
- Nitrate (as N)

Nitroaromatics and Isophorone :
- 2,6-Dinitrotoluene
- Isophorone

Chlorophenoxy Acid Pesticides (ALL)
Haloethers (ALL)

Chlor. Hydrocarbon Pesticides :
- 4,4'-DDD
- 4,4'-DDT
- Aldrin
- beta-BHC
- Captan
- Chlordane Total
- delta-BHC
- Dichloran
- Dicorol
- Endrin aldehyde
- Endosulfan I
- Endosulfan II
- Endosulfan sulfate
- Isodrin
- Mirex
- Methoxychlor
- PCNB
- Perthane
- Strobane
- Trifluralin
- Toxaphene

Polychlorinated Biphenyls :
- PCB-1016
- PCB-1232
- PCB-1242
- PCB-1248
- PCB-1254

Demand :
- Chemical Oxygen Demand

Nitrosoamines :
- N-Nitrosodi-n-propylamine

Phthalate Esters (ALL)

Polynuclear Aromatics :
- Acenaphthene
- Anthracene
- Acenaphthylene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(ghi)perylene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Fluorene
- Indeno(1,2,3-cd)pyrene
- Naphthalene
- Phenanthrene
- Pyrene

Wastewater Metals I :
- Silver, Total
- Barium, Total
- Chromium, Total
- Iron, Total
- Nickel, Total
- Lead, Total

Wastewater Metals III :
- Gold, Total
- Cobalt, Total
- Platinum, Total
- Tin, Total

Wastewater Metals II :
- Chromium VI
- Mercury, Total

Residue :
- Solids, Total

Priority Pollutant Phenols :
- 2,4,6-Trichlorophenol
- 2,4-Dichlorophenol
- 2,4-Dimethylphenol
- 2,4-Dinitrophenol
- 2-Chlorophenol
- 2-Methyl-4,6-dinitrophenol
- 2-Nitrophenol
- 4-Chloro-3-methylphenol
- Phenol
- Pentachlorophenol

Wastewater Miscellaneous :
- Color
- Corrosivity
- Phenols
- Oil & Grease Total Recoverable
- Hydrogen Ion (pH)
- Specific Conductance
- Sulfide (as S)
- Surfactant (MBAS)

Mineral :
- Acidity
- Alkalinity
- Calcium Hardness
- Chloride
- Hardness, Total

Purgeable Aromatics :
- 1,3-Dichlorobenzene
- Benzene
- Chlorobenzene

Acrolein and Acrylonitrile (ALL)
Chlorinated Hydrocarbons (ALL)

Serial No.: 022359

Wadsworth Center for Laboratories and Research

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DOH-3317 (12/92)

NEW YORK STATE DEPARTMENT OF HEALTH

MARK R. CHASSIN, M.D., M.P.P., M.P.H. *COMMISSIONER*

Expires 12:01 AM April 1, 1994
ISSUED August 16, 1993
REVISED September 23, 1993

INTERIM CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

Lab ID No.: 10903

Director: MR. CARMINE FIORIGLIO
Lab Name: MDS LABORATORIES
Address : 4418 POTTSVILLE PIKE
READING PA 19605

is hereby APPROVED as an Environmental Laboratory for the category

ENVIRONMENTAL ANALYSES/ POTABLE WATER

All approved subcategories and/or analytes are listed below:

Drinking Water Non-Metals :
Color
Corrosivity

Drinking Water Metals I :
Lead, Total

D.W. Miscellaneous :
Asbestos

Serial No.: 022360

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ENVIRONMENTAL ANALYSES/AIR AND EMISSIONS

All approved subcategories and/or analytes are listed below:

Miscellaneous Air :
Asbestos
Fibers

Fuels (ALL)

Metals I (ALL)

Serial No.: 022361

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READING PA 19605

is hereby APPROVED as an Environmental Laboratory for the category

ENVIRONMENTAL ANALYSES/SOLID AND HAZARDOUS WASTE

All approved subcategories and/or analytes are listed below:

Characteristic Testing :
- Corrosivity
- Ignitability
- Reactivity

Miscellaneous :
- Asbestos in Friable Material
- Hydrogen Ion (pH)
- Sulfide (as S)

Acrolein and Acrylonitrile (ALL)
Chlorinated Hydrocarbons (ALL)
Phthalate Esters (ALL)

Chlorophenoxy Acid Pesticides (ALL)
Haloethers (ALL)

Serial No.: 022362

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DOH-3317 (12/92)

APPENDIX E

ASTM FIELD METHODS

Designation: D 1452 - 80 (Reapproved 1990)[ε1]

Standard Practice for Soil Investigation and Sampling by Auger Borings[1]

This standard is issued under the fixed designation D 1452; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

[ε1] NOTE—Section 6 was added editorially in July 1990.

1. Scope

1.1 This practice covers equipment and procedures for the use of earth augers in shallow geotechnical exploration. This practice does not apply to sectional continuous flight augers.

1.2 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Significance and Use

2.1 Auger borings often provide the simplest method of soil investigation and sampling. They may be used for any purpose where disturbed samples can be used and are valuable in connection with ground water level determination and indication of changes in strata and advancement of hole for spoon and tube sampling. Equipment required is simple and readily available. Depths of auger investigations are, however, limited by ground water conditions, soil characteristics, and the equipment used.

3. Apparatus

3.1 *Hand-Operated Augers*:

3.1.1 *Helical Augers*—Small lightweight augers generally available in sizes from 1 through 3 in. (25.4 through 76.2 mm).

3.1.1.1 *Spiral-Type Auger*, consisting of a flat thin metal strip, machine twisted to a spiral configuration of uniform pitch; having at one end, a sharpened or hardened point, with a means of attaching a shaft or extension at the opposite end.

3.1.1.2 *Ship-Type Auger*—Similar to a carpenter's wood bit. It is generally forged from steel and machined to the desired size and configuration. It is normally provided with sharpened and hardened nibs at the point end and with an integral shaft extending through its length for attachment of a handle or extension at the opposite end.

3.1.2 *Open Tubular Augers*, ranging in size from 1.5 through 8 in. (38.1 through 203.2 mm) and having the common characteristic of appearing essentially tubular when viewed from the digging end.

3.1.2.1 *Orchard-Barrel Type*, consisting essentially of a tube having cutting lips or nibs hardened and sharpened to penetrate the formation on one end and an adaptor fitting for an extension or handle on the opposite end.

3.1.2.2 *Open-Spiral Type*, consisting of a flat thin metal strip that has been helically wound around a circular mandrel to form a spiral in which the flat faces of the strip are parallel to the axis of the augered hole. The lower helix edges are hard-faced to improve wear characteristics. The opposite end is fitted with an adaptor for extension.

3.1.2.3 *Closed-Spiral Type*—Nearly identical to the open-spiral type except, the pitch of the helically wound spiral is much less than that of the open-spiral type.

3.1.3 *Post-Hole Augers*, generally 2 through 8 in. (50.8 through 203.2 mm), and having in common a means of blocking the escape of soil from the auger.

3.1.3.1 *Clam-Shell Type*, consisting of two halves, hinged to allow opening and closing for alternately digging and retrieving. It is not usable deeper than about 3.5 ft (1.07 m).

3.1.3.2 *Iwan Type*, consisting of two tubular steel segments, connected at the top to a common member to form a nearly complete tube, but with diametrically opposed openings. It is connected at the bottom by two radial blades pitched to serve as cutters which also block the escape of contained soil. Attachment of handle or extension is at the top connector.

3.2 *Machine-Operated Augers*:

3.2.1 *Helical Augers*, generally 8 through 48 in. (203.2 through 1219 mm), consisting essentially of a center shaft fitted with a shank or socket for application of power, and having one to three complete 360° (6.28-rad) spirals for conveyance and storage of cut soil. Cutter bits and pilot bits are available in moderate and hard formation types and normally replaceable in the field. They are normally operated by heavy-duty, high-torque machines, designed for heavy construction work.

3.2.2 *Stinger Augers*, generally 6 through 30 in. (152.4 through 762 mm), are similar to the helical auger in 3.2.1, but lighter and generally smaller. They are commonly operated by light-duty machines for post and power pole holes.

3.2.3 *Disk Augers*, generally 10 through 30 in. (254 through 762 mm), consisting essentially of a flat, steel disk with diametrically opposed segments removed and having a

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved June 12, 1980. Published August 1980. Originally published as D 1452 - 57 T. Last previous edition D 1452 - 65 (1972).

shank or socket located centrally for application of power. Replaceable cutter bits, located downward from the leading edges of the remaining disk, dig and load soil that is held on the disk by valves or shutters hinged at the disk in order to close the removed segments. The disk auger is specifically designed to be operated by machines having limited vertical clearance between spindle and ground surface.

3.2.4 *Bucket Auger*, generally 12 through 48 in. (304.8 through 1219 mm), consisting essentially of a disk auger, without shank or socket, but hinge-mounted to the bottom of a steel tube or bucket of approximately the same diameter as the disk auger. A socket or shank for power application is located in the top center of the bucket diametral cross piece provided for the purpose.

3.3 *Casing* (when needed), consisting of pipe of slightly larger diameter than the auger used.

3.4 *Accessory Equipment*—Labels, field log sheets, sample jars, sealing wax, sample bags, and other necessary tools and supplies.

4. Procedure

4.1 Make the auger boring by rotating and advancing the desired distance into the soil. Withdraw the auger from the hole and remove the soil for examination and test. Return the empty auger to the hole and repeat the procedure. Continue the sequence until the required depth is reached.

4.2 Casing is required in unstable soil in which the bore hole fails to stay open and especially when the boring is extended below the ground-water level. The inside diameter of the casing must be slightly larger than the diameter of the auger used. The casing shall be driven to a depth not greater than the top of the next sample and shall be cleaned out by means of the auger. The auger can then be inserted into the bore hole and turned below the bottom of the casing to obtain a sample.

4.3 The soil auger can be used both for boring the hole and for bringing up disturbed samples of the soil encountered. The structure of a cohesive soil is completely destroyed and the moisture may be changed by the auger. Seal all samples in a jar or other airtight container and label appropriately. If more than one type of soil is picked up in the sample, prepare a separate container for each type of soil.

4.4 *Field Observations*—Record complete ground water information in the field logs. Where casing is used, measure ground water levels, both before and after the casing is pulled. In sands, determine the water level at least 30 min after the boring is completed; in silts, at least 24 h. In clays, no accurate water level determination is possible unless pervious seams are present. As a precaution, however, water levels in clays shall be taken after at least 24 h.

5. Report

5.1 The data obtained in boring shall be recorded in the field logs and shall include the following:

5.1.1 Date of start and completion of boring,

5.1.2 Identifying number of boring,

5.1.3 Reference datum including direction and distance of boring relative to reference line of project or other suitable reference points,

5.1.4 Type and size of auger used in boring,

5.1.5 Depth of changes in strata,

5.1.6 Description of soil in each major stratum,

5.1.7 Ground water elevation and location of seepage zones, when found, and

5.1.8 Condition of augered hole upon removal of auger, that is, whether the hole remains open or the sides cave, when such can be observed.

6. Keywords

Auger borings; sampling; soil investigations

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: D 1556 - 90[ε1]

Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method[1]

This standard is issued under the fixed designation D 1556; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

[ε1] NOTE—The title was corrected editorially in November 1991.

1. Scope

1.1 This test method may be used to determine the in-place density and unit weight of soils using a sand cone apparatus.

1.2 This test method is applicable for soils without appreciable amounts of rock or coarse materials in excess of 1½ in. (38 mm) in diameter.

1.3 This test method may also be used for the determination of the in-place density and unit weight of undisturbed or *in situ* soils, provided the natural void or pore openings in the soil are small enough to prevent the sand used in the test from entering the voids. The soil or other material being tested should have sufficient cohesion or particle attraction to maintain stable sides on a small hole or excavation, and be firm enough to withstand the minor pressures exerted in digging the hole and placing the apparatus over it, without deforming or sloughing.

1.4 This test method is not suitable for organic, saturated, or highly plastic soils that would deform or compress during the excavation of the test hole. This test method may not be suitable for soils consisting of unbound granular materials that will not maintain stable sides in the test hole, soils containing appreciable amounts of coarse material larger than 1½ in. (38 mm), and granular soils having high void ratios.

1.5 When materials to be tested contain appreciable amounts of particles larger than 1½ in. (38 mm), or when test hole volumes larger than 0.1 ft^3 (2830 cm^3) are required, Test Method D 4914 or D 5030 are applicable.

1.6 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and a unit of force (lbf). This implicitly combines two separate systems of units, that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. This test method has been written using the gravitational system of units when dealing with the inch-pound system. In this system the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft^3 should not be regarded as non-conformance with this test method.

1.7 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terms and Symbols Relating to Soil and Rock[2]

D 698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (304.8-mm) Drop[2]

D 1557 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 3584 Practice for Indexing Papers and Reports on Soil and Rock for Engineering Purposes[2]

D 4253 Test Method for Maximum Index Density of Soils Using a Vibratory Table[2]

D 4254 Test Method for Minimum Index Density of Soils and Calculation of Relative Density[2]

D 4643 Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method[2]

D 4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles[2]

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing[2]

D 4914 Test Method for Density and Unit Weight of Soil and Rock in Place by the Sand Replacement Method[2]

D 4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method[2]

D 4959 Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method[2]

D 5030 Test Methods for Density and Unit Weight of Soil and Rock in Place by the Water Replacement Method[2]

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

3. Terminology

3.1 *Definitions*—All definitions are in accordance with Terminology D 653.

4. Summary of Test Method

4.1 A test hole is hand excavated in the soil to be tested and all the material from the hole is saved in a container. The hole is filled with free flowing sand of a known density, and the volume is determined. The in-place wet density of the soil is determined by dividing the wet mass of the removed material by the volume of the hole. The water content of the material from the hole is determined and the dry mass of the material and the in-place dry density are calculated using the wet mass of the soil, the water content, and the volume of the hole.

5. Significance and Use

5.1 This test method is used to determine the density of compacted soils placed during the construction of earth embankments, road fill, and structural backfill. If often is used as a basis of acceptance for soils compacted to a specified density or percentage of a maximum density determined by a test method, such as Test Methods D 698 or D 1557.

5.2 This test method can be used to determine the in-place density of natural soil deposits, aggregates, soil mixtures, or other similar material.

5.3 The use of this test method is generally limited to soil in an unsaturated condition. This test method is not recommended for soils that are soft or friable (crumble easily) or in a moisture condition such that water seeps into the hand excavated hole. The accuracy of the test may be affected for soils that deform easily or that may undergo a volume change in the excavated hole from vibration, or from standing or walking near the hole during the test (see Note 1).

NOTE 1—When testing in soft conditions or in soils near saturation, volume changes may occur in the excavated hole as a result of surface loading, personnel performing the test, and the like. This can sometimes be avoided by the use of a platform that is supported some distance from the hole. As it is not always possible to detect when a volume change has taken place, test results should always be compared to the theoretical saturation density, or the zero air voids line on the dry density versus water content plot. Any in-place density test on compacted soils that calculates to be more than 95 % saturation is suspect and an error has probably occurred, or the volume of the hole has changed during testing.

6. Apparatus

6.1 *Sand-Cone Density Apparatus*, consisting of the following:

6.1.1 An attachable jar or other sand container having a volume capacity in excess of that required to fill the test hole and apparatus during the test.

6.1.2 A detachable appliance consisting of a cylindrical valve with an orifice approximately ½ in. (13 mm) in diameter, attached to a metal funnel and sand container on one end, and a large metal funnel (sand-cone) on the other end. The valve will have stops to prevent rotating past the completely open or completely closed positions. The appliance will be constructed of metal sufficiently rigid to prevent distortion or volume changes in the cone. The walls of the cone will form an angle of approximately 60 % with the base to allow uniform filling with sand.

6.1.3 A metal base plate or template with a flanged center hole cast or machined to receive the large funnel (cone) of the appliance described in 6.1.2. The base plate may be round or square and will be a minimum of 3 in. (75 mm) larger than the funnel (sand-cone). The plate will be flat on the bottom and have sufficient thickness or stiffness to be rigid. Plates with raised edges, ridges, ribs, or other stiffners of approximately ⅜ to ½ in. (10 to 13 mm) high may be used.

6.1.4 The mass of the sand required to fill the apparatus and base plate will be determined in accordance with the instructions in Annex A1 prior to use.

6.1.5 The details for the apparatus shown in Fig. 1 represents the minimum acceptable dimensions suitable for testing soils having maximum particle sizes of approximately 1½ in. (37.5 mm) and test hole volumes of approximately 0.1 ft (2830 cm). When the material being tested contains a small amount of oversize and isolated larger particles are encountered, the test should be moved to a new location. Larger apparatus and test hole volumes are needed when particles larger than 1½ in. (37.5 mm) are prevalent. The apparatus described here represents a design that has proven satisfactory. Larger apparatus, or other designs of similar proportions may be used as long as the basic principles of the sand volume determination are observed. When test hole volumes larger than 0.2 ft^3 (5660 cm^3) are required Test

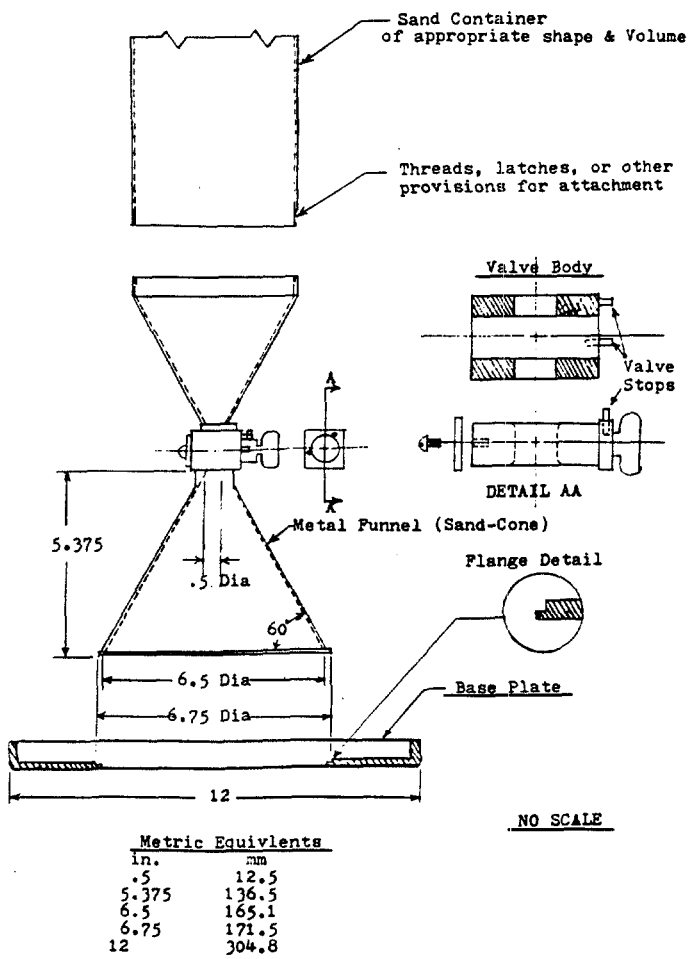

FIG. 1 Density Apparatus

Method D 4914 should be utilized.

6.2 *Sand*—Sand must be clean, dry, uniform in density and grading, uncemented, durable, and free-flowing. Any gradation may be used that has a uniformity coefficient ($C_u = D_{60}/D_{10}$) less than 2.0, a maximum particle size smaller than 2.0 mm (No. 10 sieve), and less than 3 % by weight passing 250 µm (No. 60 sieve). Uniformly graded sand is needed to prevent segregation during handling, storage, and use. Sand free of fines and fine sand particles is required to prevent significant bulk-density changes with normal daily changes in atmospheric humidity. Sand comprised of durable, natural subrounded, or rounded particles is desirable. Crushed sand or sand having angular particles may not be free-flowing, a condition that can cause bridging resulting in inaccurate density determinations (see Note 2). In selecting a sand from a potential source, a gradation and five separate bulk-density determinations in accordance with the procedure in Annex A2 should be made on each container or bag of sand. To be an acceptable sand, the bulk-density variation between any one determination shall not be greater than 1 % of the average. Before using sand in density determinations, it shall be dried, then allowed to reach an air-dried state in the general location where it is to be used (see Note 3). Sand shall not be re-used without removing any contaminating soil, checking the gradation, drying and redetermining the bulk-density (see Note 4). Bulk-density tests of the sand will be made at time intervals not exceeding 14 days, always after any significant changes in atmospheric humidity, before reusing, and before use of a new batch from a previously approved supplier (see Note 5).

NOTE 2—Some manufactured (crushed) sands such as blasting sand have been successfully used with good reproducibility. The reproducibility of test results using angular sand should be checked under laboratory controlled testing situations before selecting an angular sand for use.

NOTE 3—Many organizations have found it beneficial to store sands in moisture resistant containers. Sand should be stored in dry areas protected from weather. The use of a lighted bulb or other heat source in, or adjacent to the storage containers has also been found to be beneficial in areas of high humidity.

NOTE 4—As a general rule, reclaiming sand after testing is not desirable.

NOTE 5—Most sands have a tendency to absorb moisture from the atmosphere. A very small amount of absorbed moisture can make a substantial change in bulk-density. In areas of high humidity, or where the humidity changes frequently, the bulk-density may need to be determined more often than the 14 day maximum interval indicated. The need for more frequent checks can be determined by comparing the results of different bulk-density tests on the same sand made in the same conditions of use over a period of time.

6.3 *Balances or Scales*—Meeting Specification D 4753, with 50 g readability, or better, to determine the mass of sand and excavated soils. A balance or scale having a minimum capacity of 20 kg and 5.0 gm readability is suitable for determining the mass of the sand and the excavated soil when apparatus with the dimensions shown in Fig. 1 is used.

6.4 *Drying Equipment*—Equipment corresponding to the method used for determining water content as specified in Test Methods D 2216, D 4643, D 4959, or D 4944.

6.5 *Miscellaneous Equipment*—Knife, small pick, chisel, small trowel, screwdriver, or spoons for digging test holes, large nails or spikes for securing the base plate; buckets with lids, plastic-lined cloth sacks, or other suitable containers for retaining the density samples, moisture sample, and density sand respectively; small paint brush, calculator, notebook or test forms, etc.

7. Procedure

7.1 Select a location/elevation that is representative of the area to be tested, and determine the density of the soil in-place as follows:

7.1.1 Inspect the cone apparatus for damage, free rotation of the valve, and properly matched baseplate. Fill the cone container with conditioned sand for which the bulk-density has been determined in accordance with Annex A2, and determine the total mass.

7.1.2 Prepare the surface of the location to be tested so that it is a level plane. The base plate may be used as a tool for striking off the surface to a smooth level plane.

7.1.3 Seat the base plate on the plane surface, making sure there is contact with the ground surface around the edge of the flanged center hole. Mark the outline of the base plate to check for movement during the test, and if needed, secure the plate against movement using nails pushed into the soil adjacent to the edge of the plate, or by other means, without disturbing the soil to be tested.

7.1.4 In soils where leveling is not successful, or surface voids remain, the volume horizontally bounded by the funnel, plate and ground surface must be determined by a preliminary test. Fill the space with sand from the apparatus, determine the mass of sand used to fill the space, refill the apparatus, and determine a new initial mass of apparatus and sand before proceeding with the test. After this measurement is completed, carefully brush the sand from the prepared surface (see Note 6).

NOTE 6—A second calibrated apparatus may be taken to the field when this condition is anticipated (instead of refilling and making a second determination). The procedure in 7.1.4 may be used for each test when the best possible accuracy is desired, however, it is usually not needed for most production testing where a relatively smooth surface is obtainable.

7.1.5 Dig the test hole through the center hole in the base plate, being careful to avoid disturbing or deforming the soil that will bound the hole. Test hole volumes are to be as large as practical to minimize errors and will in no case be smaller than the volumes indicated in Table 1 for the maximum size of soil particle removed from the test hole. The sides of the hole should slope slightly inward and the bottom should be reasonably flat or concave. The hole should be kept as free as possible of pockets, overhangs, and sharp obtrusions since these affect the accuracy of the test. Soils that are essentially granular require extreme care and may require digging a conical-shaped test hole. Place all excavated soil, and any soil loosened during digging, in a moisture tight container that is marked to identify the test number. Take care to avoid losing any materials. Protect this material from any loss of moisture

TABLE 1 Minimum Test Hole Volumes Based on Maximum Size of Included Particle

Maximum Particle Size		Minimum Test Hole Volumes	
in.	(mm)	cm^3	ft^3
½	(12.5)	1420	0.05
1	(25.0)	2120	0.075
2	(50)	2830	0.1

until the mass has been determined and a specimen has been obtained for a water content determination.

7.1.6 Clean the flange of the base plate hole, invert the sand-cone apparatus and seat the sand-cone funnel into the flanged hole at the same position as marked during calibration (see Annex A1). Eliminate or minimize vibrations in the test area due to personnel or equipment. Open the valve and allow the sand to fill the hole, funnel, and base plate. Take care to avoid jarring or vibrating the apparatus while the sand is running. When the sand stops flowing, close the valve.

7.1.7 Determine the mass of the apparatus with the remaining sand, record, and calculate the mass of sand used.

7.1.8 Determine and record the mass of the moist material that was removed from the test hole. When oversized material corrections are required, determine the mass of the oversized material on the appropriate sieve and record, taking care to avoid moisture losses. When required, make appropriate corrections for the oversized material using Practice D 4718.

7.1.9 Mix the material thoroughly, and either obtain a representative specimen for water content determination, or use the entire sample.

7.1.10 Determine the water content in accordance with Test Method D 2216, D 4643, D 4944, or D 4959. Correlations to Method D 2216 will be performed when required by other test methods.

7.2 Water content specimens must be large enough and selected in such a way that they represent all the material obtained from the test hole. The minimum mass of the water content specimens is that required to provide water content values accurate to 1.0 %.

8. Calculation

8.1 Calculations shown are for mass in grams and volumes in cubic centimetres. Other units are permissible provided the appropriate conversion factors are used to maintain consistency of units throughout the calculations. See 1.6 for additional comments on the usage of inch-pound units.

8.2 Calculate the volume of the test hole as follows:

$$V = (M_1 - M_2)/\rho_1$$

where:

V = volume of the test hole, cm^3,
M_1 = mass of the sand used to fill the test hole, funnel and base plate, g (from 7.1.7),
M_2 = mass of the sand used to fill the funnel and base plate (from Annex A1.2.2.6), g, and
ρ_1 = bulk density of the sand (from Annex A2.3.5), g/cm^3.

8.3 Calculate the dry mass of material removed from the test hole as follows:

$$M_4 = 100\ M_3/(w + 100)$$

where:

w = water content of the material removed from test hole, %, (from 7.1.10),
M = moist mass of the material from test hole, g, (from 7.1.8), and
M = dry mass of material from test hole, g, or multiply by 0.002205 for lb.

8.4 Calculate the in-place wet and dry density of the material tested as follows:

$$\rho_m = M_3/V$$
$$\rho_d = M_4/V$$

where:

V = volume of the test hole, cm^3 (from 8.2),
M_3 = moist mass of the material from the test hole, g, (from 7.1.8),
M_4 = dry mass of the material from the test hole, g, (from 8.3),
ρ_m = wet density of the tested material g/cm^3 or its wet unit weight, y_m in lb/ft^3 where $y_m = \rho_m \times 62.43$, and
ρ_d = dry density of the tested material, g/cm^3 or its dry unit weight, γ_d in lb/ft^3 where $\gamma_d = \rho_d \times 62.43$.

8.5 It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory densities determined in accordance with Test Method D 698, D 1557, D 4253 or D 4254. This relation can be determined by dividing the in-place density by the laboratory density and multiplying by 100. Calculations for determining relative density are provided in Test Method D 4254. Corrections for oversize material, if required, should be performed in accordance with Practice D 4718.

9. Report

9.1 Report, as a minimum, the following information:

9.1.1 Test location, elevation, thickness of layer tested, or other pertinent data to locate or identify the test.

9.1.2 Test hole volume, cm^3 or ft^3.

9.1.3 In-place wet density, g/cm^3 or lb/ft^3.

9.1.4 In-place dry density, ρ_d, g/cm^3.

9.1.5 In-place dry unit weight, KN/m^3 ($\rho_d \times 9.807$), or lb/ft^3 ($\rho_d \times 62.43$), expressed to the nearest .1 KN/m^3, or 1.0 for lb/ft^3.

9.1.6 In-place water content of the soil expressed as a percentage of dry mass, and the test method used.

9.1.7 Test apparatus identity and calibrated volume.

9.1.8 Bulk density of the sand used, g/cm^3, or lb/ft^3.

9.1.9 Visual description of the soil or material designation.

9.1.10 Mass and percentage of oversized particles and the size sieve used, if performed.

9.1.11 Comments on the test, as applicable.

9.1.12 If the in-place dry density or unit weight is expressed as a percentage of another value, include the following:

9.1.12.1 The laboratory test method used.

9.1.12.2 The comparative dry density or unit weight value and water content used.

9.1.12.3 Correction for oversized material and details, if applicable.

9.1.12.4 The comparative percentage of the in-place material to the comparison value.

9.1.13 If the in-place density, unit weight, or water content are to be used for acceptance, include the acceptance criteria applicable to the test.

10. Precision and Bias

10.1 *Statement of Precision*—Due to the nature of the soil or rock materials tested by the method it is either not feasible or too costly at this time to produce multiple specimens that

have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory testing variation. Subcommittee D18.08 welcomes proposals that would allow for development of a valid precision statement.

10.2 *Statement of Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10.3 While no formal round-robin testing has been completed, it is estimated by Subcommittee D18.08 from available data that the results of two properly conducted tests performed by a skilled operator on the same material at a given time and location should not differ by more than approximately 2 lb/ft^3 (3.2 Kg/m^3). Tests performed by unskilled operators on the same material would be expected to yield substantially greater differences.

11. Keywords

11.1 The following keywords are applicable to this test method in accordance with Practice D 3584: acceptance tests; compaction tests; degree of compaction; density tests; earthfill; embankments; field control density; field tests; inplace density; inplace dry density; *in situ* density; relative density; sand cone; soil compaction; soil tests; unit weight.

ANNEXES

(Mandatory Information)

A1. CALIBRATION OF SAND CONE APPARATUS

A1.1 Scope

A1.1.1 This annex describes the procedure for determining the mass of sand contained in the funnel and base plate of the sand-cone apparatus.

A1.1.2 The mass of sand contained in the apparatus and base plate is dependent on the bulk-density of the sand. Consequently, this procedure must be performed for each apparatus whenever there are changes in the sand bulk-densities.

A1.2 Calibration Procedure

A1.2.1 Calibration of the apparatus can be accomplished by either of two methods:

A1.2.1.1 *Method A*—By determining the mass of calibrated sand that can be contained in each funnel and base plate set, or

A1.2.1.2 *Method B*—By determining the volume of sand needed to fill each funnel and base plate set and applying this volume constant whenever new sand bulk-densities are calculated.

A1.2.1.3 Since the mass of sand contained in the apparatus funnel and base plate is dependent on the bulk density of the sand, if Method A is used, it must be repeated whenever the bulk-density of the sand changes.

A1.2.2 All determinations of mass are to be made to the nearest 1 g.

A1.2.3 *Method A:*

A1.2.3.1 Fill the apparatus with sand that is dried and conditioned to the same state anticipated during use in testing.

A1.2.3.2 Determine the mass of the apparatus filled with sand, g.

A1.2.3.3 Place the base plate on a clean, level, plane surface. Invert the container/apparatus and seat the funnel in the flanged center hole in the base plate. Mark and identify the apparatus and base plate so that the same apparatus and plate can be matched and reseated in the same position during testing.

A1.2.3.4 Open the valve fully until the sand flow stops, making sure the apparatus, base plate, or plane surface are not jarred or vibrated before the valve is closed.

A1.2.3.5 Close the valve sharply, remove the apparatus and determine the mass of the apparatus and remaining sand. Calculate the mass of sand used to fill the funnel and base plate as the difference between the initial and final mass.

A1.2.3.6 Repeat the procedure a minimum of three times. The maximum variation between any one determination and the average will not exceed 1 %. Use the average of the three determinations for this value in the test calculations.

A1.2.4 *Method B (Optional):*

A1.2.4.1 When large numbers of tests and batches of sand are anticipated, it may be advantageous to determine the volume of each apparatus and base plate. Baring damage to the apparatus or mismatching of the base plates, this volume will remain constant, and will eliminate the need to repeat Method A when the sand bulk-density changes (see Note A1.1). If this alternative is chosen, the calculations in the field test must be altered to determine the total volume of the sand in the field test hole and apparatus. The volume of the apparatus is then subtracted to determine the volume of the test hole.

A1.2.4.2 Determine the mass of sand required to fill the apparatus funnel and base plate in accordance with A1.2.3, following steps A1.2.3.1 through A1.2.3.6 for each batch of sand.

A1.2.4.3 Calculate the volume of the funnel and base plate by dividing the bulk-density of the sand (as determined in Annex A2) by the mass of sand found in A1.2.3.6. Perform a minimum of three determinations and calculate an average value. The maximum volume variation between any one determination and the average will not exceed 1 %. Use the average of the values when performing test calculations.

NOTE A1.1—The sand-cone apparatus should be routinely inspected for damage that may affect the volume of the cone. Dings, out-of-round, or other damage will affect the volume and will necessitate a redetermination of the volume (if repairable).

A2. CALIBRATION OF DENSITY SAND

A2.1 Scope

A2.1.1 This annex is used for determining the bulk-density (calibration) of the sand for use in this test method.

A2.1.2 The calibration determines an average density of the sand for use in calculating the volume of the test hole.

A2.2 Equipment Required

A2.2.1 *Container*—Select a container of known volume that is approximately the same size and allows the sand to fall approximately the same distance as the hole excavated during a field test. The 1/30 ft^3 (944 cm^3) and 1/13.33 ft^3 (2124 cm^3) molds specified in Test Methods D 698, or the 0.1 ft^3 (2830 cm^3) mold specified in Test Method D 4253 are recommended. Alternatively, cast duplicates of actual test holes may be used. This is accomplished by forming plaster of paris negatives in actual test holes over a range of test volumes, and using these as forms for portland cement concrete castings. These should be cast against a flat plane surface, and after the removal of the negative, sealed water tight and the volume determined in accordance with the procedure in Test Method D 4253.

A2.2.1.1 Determine the container volume to 1 % using water in accordance with the procedures described in Test Method D 4253.

A2.2.2 *Sand-Cone Apparatus*—Use a sand cone apparatus of the same size and design as will be used during field testing.

A2.2.2.1 Flow characteristics through different value assemblies have been shown to cause different bulk-density values. Bulk-density determinations will be required for each apparatus set unless other assemblies are determined to provide the same results.

A2.2.3 *Balance or Scale*—A balance or scale having a sufficient capacity to determine the mass of the calibration container filled with sand. For 0.500 ft^3 (14 200 cm^3) containers, a balance having a minimum capacity of 50 lb (20 kg) and meeting the requirements of Specification D 4753 for 0.01 lb (5 g) readability is required.

A2.2.4 *Metal Straightedge*, about 2 in. (50 cm) wide, at least ⅛ in. (3 mm) thick, and length approximately 1.5 times the diameter of the calibration container.

A2.3 Bulk-Density Determination

A2.3.1 Fill the assembled apparatus with sand. The sand is to be dried and conditioned to the same state anticipated during use.

A2.3.2 Determine and record the mass of the calibration container when empty.

A2.3.3 *Method A (Preferred):*

A2.3.3.1 When the calibration container has the same diameter as the flanged center hole in the base plate, invert and center the sand filled apparatus and base plate on the calibration container.

A2.3.3.2 Fully open the valve and allow the sand to fill the container. When the sand flow stops, close the valve.

A2.3.3.3 Determine the mass of the apparatus and remaining sand. Calculate the net mass of sand in the calibration container by subtracting the mass of sand contained in the cone and base plate (as determined in Annex A1) and record.

A2.3.4 *Method B (Alternative):*

A2.3.4.1 Invert and support the apparatus over the calibration container so that the sand falls approximately the same distance and location as in a field test, and fully open the valve.

A2.3.4.2 Fill the container until it just overflows and close the valve. Using a minimum number of strokes and taking care not to jar or densify the sand, carefully strike off excess sand to a smooth level surface. Any vibration or jarring during the bulk-density determination will result in settling and densifying the sand, leading to erroneous results.

A2.3.4.3 Clean any sand from the outside of the calibration container. Determine the mass of the container and sand. Record the net mass of the sand by subtracting the mass of the empty container.

A2.3.5 Perform at least three bulk-density determinations and calculate the average. The maximum variation between any one determination and the average will not exceed 1 %. Repeated determinations not meeting these requirements indicates nonuniform sand density, and the sand source should be re-evaluated for suitability. The average value obtained is to be used in the test calculations.

A2.4 Calculation

A2.4.1 Calculate the bulk-density of the sand as follows:

$$\rho_1 = M_5/V_1$$

where:

ρ_1 = bulk-density of the sand, g/cm^3, (multiply by 9.807 for KN/m^3, or 62.43 for lb/ft^3),

M_5 = mass of the sand to fill the calibration container, g, (from A2.3.4.3), and

V_1 = volume of the calibration container, cm^3 (from A2.2.1.1).

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: D 2922 – 91

Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)[1]

This standard is issued under the fixed designation D 2922; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

These methods have been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers the determination of the total or wet density of soil and soil-rock mixtures by the attenuation of gamma radiation where the source and detector(s) remain on the surface (Backscatter Method) or the source or detector is placed at a known depth up to 300 mm (12 in.) while the detector(s) or source remains on the surface (Direct Transmission Method).

1.2 The density in mass per unit volume of the material under test is determined by comparing the detected rate of gamma radiation with previously established calibration data.

1.3 The values tested in SI units are to be regarded as the standard. The inch-pound equivalents may be approximate.

1.4 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and a unit of force (lbf). This implicitly combines two separate systems of units; that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. This standard has been written using the gravitational system of units when dealing with the inch-pound system. In this system the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft^3 should not be regarded as nonconformance with this standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific Hazard statements, see Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*

D 698 Test Method for Moisture-Density Relations of Soil and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[2]

D 1556 Test Method for Density of Soil In-Place by the Sand-Cone Method[2]

D 1557 Test Method for Moisture-Density Relations of Soil and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop[2]

D 2167 Test Method for Density of Soil In-Place by the Rubber-Balloon Method[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2937 Test Method for Density of Soil In-Place by the Drive-Cylinder Method[2]

D 3017 Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)[2]

D 4253 Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table[2]

D 4643 Method for Determination of Water Content by the Microwave Oven Method[2]

D 4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles[2]

D 4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method[2]

D 4959 Test Method for Determination of Water (Moisture) Content by Direct Heating Method[2]

3. Significance and Use

3.1 The test method described is useful as a rapid, nondestructive technique for the in-place determination of density of soil and rock.

3.2 The test method is suitable for quality control and acceptance testing for construction and for research and development applications.

3.3 The nondestructive nature of the test allows repetitive measurements to be made at a single test location.

4. Interferences

4.1 The chemical composition of the sample may affect the measurement; and adjustments may be necessary.

4.2 The test method exhibits spatial bias in that the instrument is more sensitive to the density of the material in close proximity to the surface (Backscatter Method only).

NOTE 1—The nuclear gauge density measurements are somewhat biased to the surface layers of the soil being tested. This bias has largely been corrected out of the direct transmission method and any remaining bias is insignificant. The backscatter method is still more sensitive to the material within the first several inches from the surface.

[1] These test methods are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

4.3 Oversize rocks or large voids in the source-detector path may cause higher or lower density determination. Where lack of uniformity in the soil due to layering, rock or voids is suspected, the test volume site should be dug up and visually examined to determine if the test material is representative of the full material in general and if rock correction (see 9.6) is required.

4.4 The sample volume is approximately 0.0028 m^3 (0.10 ft^3) for the Backscatter Method and 0.0057 m^3 (0.20 ft^3) for the Direct Transmission Method when the test depth is 15 cm (6 in.). The actual sample volume is indeterminate and varies with the apparatus and the density of the material. In general, the higher the density the smaller the volume.

5. Apparatus

5.1 *Nuclear Gauge*—An electronic counting instrument, capable of being seated on the surface of the material under test, and which contains:

5.1.1 A sealed source of high energy gamma radiation such as cesium or radium.

5.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).

5.2 *Reference Standard*—A block of material used for checking instrument operation and to establish conditions for a reproducible reference count rate.

5.3 *Site Preparation Device*—A plate, straightedge, or other suitable leveling tool which may be used for planning the test site to the required smoothness, and in the Direct Transmission Method, guiding the drive pin to prepare a perpendicular hole.

5.4 *Drive Pin*—A pin of slightly larger diameter than the rod in the Direct Transmission Instrument, used to prepare a hole in the material under test for inserting the rod.

5.5 *Drive Pin Extractor*—A tool that may be used to remove the drive pin in a vertical direction so that the pin will not distort the hole in the extraction process.

5.5.1 A slide hammer, with a drive pin attached, may also be used both to prepare a hole in the material to be tested and to extract the pin without distortion to the hole.

6. Hazards

6.1 This equipment utilizes radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of this equipment must become familiar with applicable safety procedures and government regulations.

6.2 Effective user instructions together with routine safety procedures, such as source leak tests, recording and evaluation of film badge data, etc., are a recommended part of the operation and storage of this instrument.

7. Calibration

7.1 Calibration of the instrument will be in accordance with Annex A1.

8. Standardization and Reference Check

8.1 Nuclear gauges are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and material density. To offset this aging, the gauge may be calibrated as the ratio of the measured count rate to a count rate made on a reference standard or to an air-gap count (for the backscatter air-gap technique, see 9.5.1.3). The reference count rate should be of the same order of magnitude as the measured count rate over the useful density range of the instrument.

8.2 Standardization of the gauge shall be performed at the start of each day's work, and a permanent record of these data shall be retained. Perform the standardization with the gauge located at least 8 m (25 ft) away from other sources of radioactive material, and clear of large masses or other items which may affect the reference count rate.

8.2.1 If recommended by the instrument manufacturer to provide more stable and consistent results: (1) turn on the gauge prior to use to allow it to stabilize, (2) leave the power on during the use of the gauge for that day.

8.2.2 Using the reference standard, take at least four repetitive readings at the normal measurement period and determine the mean. If available on the gauge, one measurement period of four or more times the normal period is acceptable. This constitutes one standardization check.

8.2.3 If the value obtained above is within the limits stated below, the gauge is considered to be in satisfactory condition, and the value may be used to determine the count ratios for the day of use. If the value is outside these limits, allow additional time for the gauge to stabilize, make sure the area is clear of sources of interference, and then conduct another standardization check. If the second standardization check is within the limits, the gauge may be used, but if it also fails the test, the gauge shall be adjusted or repaired as recommended by the manufacturer. The limits are as follows:

$$|N_s - N_o| \leq 2.0 \sqrt{N_o/F}$$

where:

N_s = value of current standardization count,

N_o = average of the past four values of N_s taken for prior usage, and

F = value of prescale. [The prescale value (F) is a divisor which reduces the actual value for the purpose of display. The manufactor will supply this value if other than 1.0.] Some instruments may have provisions to compute and display these values.

8.2.3.1 If the instrument standardization has not been checked within the previous three months, perform at least four new standardization checks, and use the mean as the value for N_o.

8.3 Use the value of N_s to determine the count ratios for the current day's use of the instrument. If for any reason the measured density becomes suspect during the day's use, perform another standardization check.

9. Procedure for Field Use

9.1 Standardize the gauge. (See Section 8.)

9.2 Select a test location. If the gauge will be closer than 250 mm (10 in.) to any vertical mass that might influence the result, such as in a trench or alongside a pipe, follow the manufacturer's correction procedure.

9.3 Remove all loose and disturbed material. Remove additional material as necessary to reach the material that represents a valid sample of the zone or stratum to be tested. Surface drying and spatial bias should be considered in

determining the depth of material to be removed.

9.4 Plane or scrape a smooth horizontal surface so as to obtain maximum contact between the gauge and the material being tested. The placement of the gauge on the surface of the material to be tested is always important, but is especially critical to the successful determination of density when using the *backscatter* method. The optimum condition in all cases, is total contact between the bottom surface of the gauge and the surface of the material being tested. To correct for surface irregularities, use of native fines or fine sand as a filler may be necessary. The depth of the filler should not exceed approximately 3 mm (⅛ in.) and the total area filled should not exceed 10 % of the bottom area of the instrument. The maximum depth of any void beneath the gauge that can be tolerated without filling shall not exceed approximately 3 mm (⅛ in.). Several trial seatings may be required to achieve these conditions.

9.5 Proceed with the test in the following manner:

9.5.1 *Backscatter Procedure:*

9.5.1.1 Seat the gauge firmly on the prepared test site.

9.5.1.2 Keep all other radioactive sources away from the gauge to avoid affecting the measurement so as not to affect the readings.

9.5.1.3 Secure and record one or more readings for the normal measurement period in the backscatter position.

NOTE 2—When using the backscatter air-gap procedure, follow the instrument manufacturers instructions regarding apparatus set up. Take the same number of readings for the normal measurement period in the air-gap position as in the standard backscatter position. Determine the air-gap ratio by dividing counts per minute obtained in the air-gap position by counts per minute obtained in standard backscatter position.

9.5.1.4 Determine the ratio of the reading to the standard count or to the air gap count. From this count ratio and the appropriate calibration and adjustment data, determine the in-place wet density.

9.5.2 *Direct Transmission Procedure:*

9.5.2.1 Make a hole perpendicular to the prepared surface using the guide and the hole-forming device 5.4, or by drilling if necessary. The hole shall be of such depth and alignment that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area. The depth of the hole must be deeper than the depth to which the probe will be placed. The guide shall be the same size as the base of the gauge, with the hole in the same location on the guide as the probe on the gauge. The corners of the guide are marked by scoring the surface of the soil. The guide plate is then removed and any necessary repairs are made to the prepared surface.

9.5.2.2 Proceed with testing in the following manner:

9.5.2.3 Set the gauge on the soil surface, carefully aligning it with the marks on the soil so that the probe will be directly over the pre-formed hole.

9.5.2.4 Insert the probe in the hole.

9.5.2.5 Seat the gauge firmly by rotating it about the probe with a back and forth motion.

9.5.2.6 Pull gently on the gauge in the direction that will bring the side of the probe against the side of the hole that is closest to the detector (or source) location in the gauge housing.

9.5.2.7 Keep all other radioactive sources away from the gauge to avoid affecting the measurement.

9.5.2.8 Secure and record one or more readings for the normal measurement period.

9.5.2.9 Determine the ratio of the reading to the standard count. From this count ratio and the appropriate calibration and adjustment data, determine the in-place wet density.

NOTE 3—Some instruments have built-in provisions to compute the ratio, wet density, and to enter an adjustment bias. Additionally some instruments may have provisions to measure and compute moisture content, and dry density.

9.6 If the volume tested as defined in 4.4 has excess oversize material with respect to the limitations in the appropriate Test Methods D 698, D 1557 or D 4253, then a correction for wet density (unit weight) and water content must be applied. This correction will be done in accordance with Practice D 4718. This test method requires sampling from the actual test volume.

9.6.1 If samples of the measure material are to be taken for purposes of correlation with other test methods or rock correction, the volume measured can be approximated by a 200 mm (8 in.) diameter cylinder located directly under the center line of the radioactive source and detector(s). The height of the cylinder to be excavated will be the depth setting of the source rod when using the Direct Transmission method or approximately 75 mm (3 in.) when using the Backscatter Method.

9.6.2 An alternative to the correction for oversize particles, that can be used with mass density methods or minimal oversize situations, involves multiple tests. Tests may be taken at adjacent locations and the results averaged to get a representative value. Comparisons need to be made to evaluate whether the presence of a single large rock or void in the soil is producing unrepresentative values of density. Whenever values obtained are questionable, the test volume site should be dug up and visually examined.

10. Calculation of Results

10.1 The in-place wet density is determined as outlined in 9.5. If dry density is required, the in-place water content shall be determined using either gravimetric samples and laboratory determination of water content (Test Methods D 2216, D 4643, D 4959, D 4944), or an instrument which determines water content by neutron thermalization (Test Method D 3017).

10.1.1 If the water content is determined by nuclear methods, Test Method D 3017, subtract the kg/m^3 (lbf/ft^3) of moisture from the kg/m^3 (lbf/ft^3) of wet density, and obtain dry density in kg/m^3 (lbf/ft^3).

10.1.2 If the water content is determined by other methods, and is in the form of percent, proceed as follows:

$$\rho_d = \frac{100\rho_m}{100 + W}$$

where:

ρ_d = dry density in kg/m^3 (lbf/ft^3),
ρ_m = wet density in kg/m^3 (lbf/ft^3), and
W = water as a percent of the dry mass.

11. Report

11.1 The report shall include the following:

11.1.1 Standardization and adjustment data for the date of the tests.

11.1.2 Make, model and serial number of the test instrument.

11.1.3 Name of the operator(s).

11.1.4 Test site identification.

11.1.5 Visual description of material tested.

11.1.6 Test mode (backscatter or direct transmission) and test depth (if applicable).

11.1.7 Wet and dry densities in kg/m^3 or unit weights in lb/ft^3.

11.1.8 Water content in percent of dry mass or dry unit weight.

12. Precision and Bias

12.1 *Precision:*

12.1.1 Data are being evaluated to determine the precision of this test method. In addition, Subcommittee D18.08 is seeking pertinent data from users of the test method.

12.1.2 An instrument count precision of 8 kg/m^3 (0.5 lbf/ft^3) for the Backscatter Method and 4 kg/m^3 (0.25 lbf/ft^3) Direct Transmission Method are typical on a material of approximately 2000 kg/m^3 (125 lbf/ft^3) density, with a measurement time of one minute.

12.1.2.1 Instrument count precision is defined as the change in density that occurs corresponding to a one standard deviation change in the count due to the random decay of the radioactive source. The density of the material and the time period of the count must be stated. It may be determined from a series of 20 or more counts taken without moving the instrument, or alternately from the calibration data using the assumption that σ is equal to the $\sqrt{\text{count}}$ at that density. The count must be the true instrument count corrected for any pre-scaling (see 8.2.3).

$$P = \frac{\sigma}{S}$$

where:

P = instrument precision in density (kg/m^3 or lbf/ft^3)

σ = one standard deviation of the count

S = the slope of the calibration curve at the defined density value.

12.2 *Bias:*

12.2.1 There is no accepted reference value for this test method, therefore, bias cannot be determined.

13. Keywords

13.1 density; field density; nuclear methods

ANNEX

(Mandatory Information)

A1. CALIBRATION

A1.1 Verify or re-establish calibration curves, tables, or equation coefficients at least once every 12–18 months and after all major repairs which may affect the instrument geometry.

A1.2 The instrument shall be calibrated in such a way as to produce a calibration response within ± 16 kg/m^3 (± 1.0 lbf/ft^3) on blocks of materials (standards) of established densities. (This calibration may be done by the manufacturer, the user, or an independent vendor.) Nuclear instrument response is influenced by the chemical composition of measured material. This response must be taken into account in establishing the assigned standard block density. The densities of materials used to establish or verify the calibration should extend through a range representative of the density of the materials to be tested. The density of these material standards shall be determined to an accuracy of ± 0.2 %.

A1.3 Sufficient data shall be taken on each density standard to ensure an instrument count precision of at least one-half the instrument count precision required for field use. The data may be presented in the form of a graph, table, equation coefficients, or stored in the gauge, to allow covering the count rate data to material density.

A1.4 The method and test procedures used in establishing the calibration count rate data shall be the same as those used for obtaining the field count rate data.

A1.5 The material type, actual density and assigned standard block density of each calibration standard used to establish or verify the instrument calibration shall be stated as part of the calibration data.

A1.6 The standards shall be of sufficient size to not change the count rate if enlarged in any dimension. Minimum surface dimensions of approximately 610 mm long by 430 mm wide (24 × 17 in.) have proven satisfactory. For the Backscatter Method a minimum depth of 230 mm (9 inches) is adequate; for the Direct Transmission Method the depth shall be at least 50 mm (2 in.) deeper than the deepest rod depth. A larger surface area may be required for the Backscatter Air-Gap technique. Minimum surface dimensions may be reduced slightly if the standards are adjacent to a dense material.

A1.7 The most successful standards that have been established for accurate calibration have been made of aluminum, magnesium, aluminum/magnesium, granite and limestone. These standards have been used in combination with each other and with historical curve information to produce accurate and reliable calibration.

A1.7.1 Standards of soil, rock, and concrete that have the characteristics of reproducible uniformity are difficult to prepare. These standards may be of use for some special calibration or field calibration where local site material chemistry or background situation require special adaptation.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: D 3017 – 88

Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)[1]

This standard is issued under the fixed designation D 3017; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers the determination of water content of soil and rock by the thermalization or slowing of fast neutrons where the neutron source and the thermal neutron detector both remain at the surface.

1.2 The water content in mass per unit volume of the material under test is determined by comparing the detection rate of thermalized or slow neutrons with previously established calibration data.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound equivalents may be approximate.

1.3.1 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two systems of units, that is, the absolute system and the gravitational system. This standard has been written using the absolute system for water content (kilograms per cubic metre) in SI units. Conversion to the gravitational system of unit weight in lbf/ft^3 may be made by multiplying by 0.06243 or in kN/m^3 by multiplying by 9.807. The recording of water content in pound-force per cubic foot should not be regarded as non-conformance with this standard although the use is scientifically incorrect.

1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1556 Test Method for Density of Soil in Place by the Sand-Cone Method[2]

D 2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2922 Test Methods for Density of Soil and Soil Aggregate and Rock in Place by Nuclear Methods (Shallow Depth)[2]

D 2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method[2]

D 4643 Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method[2]

D 4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles[2]

3. Significance and Use

3.1 The test method described is useful as a rapid, nondestructive technique for the in-place determination of water content of soil and rock.

3.2 The test method is used for quality control and acceptance testing of compacted soil and rock for construction and for research and development. The non-destructive nature allows repetitive measurements at a single test location and statistical analysis of the results.

3.3 The fundamental assumptions inherent in the test method are that the hydrogen present is in the form of water as defined by Method D 2216, and that the material under test is homogeneous.

3.4 Test results may be affected by chemical composition, sample heterogeneity, and, to a lesser degree, material density and the surface texture of the material being tested. The technique also exhibits spatial bias in that the apparatus is more sensitive to water contained in the material in close proximity to the surface and less sensitive to water at deeper levels.

4. Interferences

4.1 The chemical composition of the sample may dramatically affect the measurement and adjustments may be necessary. Hydrogen in forms other than water, as defined by Method D 2216, and carbon will cause measurements in excess of the true value. Some chemical elements such as boron, chlorine, and minute quantities of cadmium will cause measurements lower than the true value.

4.2 The water content determined by this test method is not necessarily the average water within the volume of the sample involved in the measurement. The measurement is heavily influenced by the water content of the material closest to the surface. The volume of soil and rock represented in the measurement is indeterminate and will vary with the water content of the material. In general, the greater

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

the water content of the material, the smaller the volume involved in the measurement. At 160 kg/m^3 (10 lbf/ft^3), approximately 50 % of the typical measurement results from the water content of the upper 50 to 75 mm (2 to 3 in.).

4.2.1 If samples of the measured material are to be taken for purposes of correlation with other test methods or rock correction, the volume measured can be approximated by a 200-mm (8 in.) diameter cylinder located directly under the center line of the fast neutron source and thermal neutron detector. The height of the cylinder to be excavated is approximated by:

Moisture Content		Cylinder Height		Volume	
kg/m^3	lbf/ft^3	mm	in.	m^3	ft^3
80	5	250	10	0.0079	0.29
160	10	200	8	0.0063	0.23
240	15	150	6	0.0047	0.17
320	20	125	5	0.0039	0.15
400	25	112	4.5	0.0035	0.13
480	30	100	4	0.0031	0.12

NOTE 1—The volume of field compacted material sampled by the test can effectively be increased by repeating the test at immediately adjacent (vertically or horizontally) locations and averaging the results.

4.3 Other neutron sources must not be within 8 m (25 ft) of equipment in operation.

5. Apparatus

5.1 While exact details of construction of the apparatus may vary, the system shall consist of:

5.1.1 *Fast Neutron Source*—A sealed mixture of a radioactive material such as americium or radium and a target material such as beryllium.

5.1.2 *Slow Neutron Detector*—Any type of slow neutron detector such as boron trifluoride or helium-3 proportional counter.

5.1.3 *Readout Device*—A suitably timed scaler(s). Usually the readout device will contain the high-voltage supply necessary to operate the detector, and low-voltage power supply to operate the readout and accessory devices.

5.1.4 *Housing*—The source, detector, readout device, and power supply shall be in housings of rugged construction which shall be water and dust resistant.

5.1.5 *Reference Standard*—A block of hydrogeneous material for checking equipment operation and to establish conditions for a reproducible count rate.

5.1.6 *Site Preparation Device*—A steel plate, straightedge, or other suitable leveling tools which may be used to plane the test site to the required smoothness.

5.2 Calibrate apparatus in accordance with Annex A1.

5.3 Determine the precision of the apparatus in accordance with Annex A2.

6. Hazards

6.1 This equipment utilizes radioactive materials which may be hazardous to the health of the users unless proper precautions are taken.

6.2 Effective operator instruction together with routine safety procedures such as source leak tests, recording and evaluation of film badge data, use of survey meters, etc., are a recommended part of the operation of equipment of this type.

7. Standardization

7.1 All nuclear water content instruments are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and water content. To offset this aging, instruments are calibrated as a ratio of the measurement count rate to a count rate made on a reference standard. The reference count rate should be in the same or higher order of magnitude than the range of measurement count rates over the useful water range of the equipment.

7.2 Standardization of equipment on the reference standard is required at the start of each day's use and a permanent record of these data shall be retained. The standardization shall be performed with the equipment located at least 8 m (25 ft) away from other gages and clear of large masses of water or other items which may affect the gage readings.

7.2.1 Turn on the instrument and allow for stabilization in accordance with the manufacturer's recommendations. If the instrument is to be used either continuously or intermittently during the day, it is generally best to leave it in the "power on" condition to prevent having to repeat the stabilization. This will provide more stable, consistent results.

7.2.2 Using the reference standard take at least four repetitive readings at the normal measurement period and obtain the mean. If available on the instrument, one measurement at a period of four or more times the normal period is acceptable. This constitutes one standardization check.

7.2.3 If the value obtained above is within the limits stated below, the equipment is considered to be in satisfactory condition and the value may be used to determine the count ratios for the day of use. If the value obtained is outside these limits, another standardization check should be made. If the second standardization check is within the limits, the equipment may be used, but if it also fails the test, the equipment shall be adjusted or repaired as recommended by the manufacturer.

$$N_s \leqq N_o + \frac{2.0\sqrt{N_o}}{\sqrt{F}} \quad (1)$$

and

$$N_s \geqq N_o - \frac{2.0\sqrt{N_o}}{\sqrt{F}} \quad (2)$$

where:

N_s = value of current standardization check (7.2.2) on the reference standard,

N_o = average of the past four values of N_s taken for prior usage, and

F = value of prescale (A2.2.1).

7.3 The value of N_s will be used to determine the count ratios for the current day's use of the equipment. If, for any reason, measured water content becomes suspect during the day's use, perform another standardization.

8. Procedure

8.1 Standardize the instrument (Section 7).

8.2 Select a location for test where the instrument in test position will be at least 250 mm (10 in.) away from any vertical projection.

8.3 Prepare the test site in the following manner:

8.3.1 Remove all loose and disturbed material, and remove additional material as necessary to reach the top of the vertical interval to be tested. Surface drying and the spatial bias should be considered in determining the depth at which the instrument is to be seated.

8.3.2 Prepare a horizontal area, sufficient in size to accommodate the instrument, by planing to a smooth condition so as to obtain maximum contact between the instrument and material being tested. If the instrument base is to be placed below the surrounding surface, the horizontal area shall be at least twice the area of the base of the instrument. If the depression is greater than 25 mm (1 in.), the condition in 8.2 must be met by clearing a larger area.

8.3.3 The placement of the instrument on the surface of the material to be tested is critical to the successful determination of water. The optimum condition is total contact between the bottom surface of the instrument and the surface of the material being tested. The maximum void beneath the instrument shall not exceed approximately 3 mm (1/8 in.). Use native fines of similar water content or dry quartz sand to fill voids and level the excess with a rigid plate or other suitable tool. The total area filled shall not exceed 10 % of the bottom area of the instrument.

8.4 Proceed with the test in the following manner:

8.4.1 Seat the instrument firmly, place the source in the proper position and take a count for the normal measurement period.

8.4.2 Determine the ratio of the reading to the standard count (Section 7). From this ratio and the calibration and adjustment data, determine the in-place water content per unit volume (Note 2).

NOTE 2—Some instruments have built-in provisions to compute the ratio, the water content per unit volume with adjustments, the dry density, and the water content in percent of dry density (or dry unit weight).

8.5 If the volume tested as defined in 4.2.1 is insufficient for the size of rock contained in the soil (refer to Test Method D 4718), take additional tests at adjacent locations and average the results (Note 3).

NOTE 3—The water content value obtained should be compared to other water contents obtained for similar soils and conditions. The presence of a large rock particle or void in the soil being tested may give an unrepresentative value of water content. If the value is unusually high or low, another determination of water content should be performed. To avoid preparation of another test site, the gage may be repositioned (such as rotating the gage 90°) at the original site.

9. Calculation

9.1 Calculate the water content, w, in percent of dry density (or dry unit weight) of soil as follows:

$$w = \frac{M_m \times 100}{\rho_d} \tag{3}$$

or

$$w = \frac{M_m \times 100}{\rho - M_m} \tag{4}$$

where:

w = water content, percent of dry density,
M_m = water content, kg/m^3 (lbf/ft^3),
ρ_d = dry density of soil (kg/m^3) or dry unit weight (lbf/ft^3), and
ρ = wet (total) density of soil (kg/m^3) or wet unit weight (lbf/ft^3).

10. Report

10.1 The report shall include the following:

10.1.1 Make, model, and serial number of the test device,

10.1.2 Standard count and adjustment data for the date of the tests,

10.1.3 Name of the operator,

10.1.4 Test site identification,

10.1.5 Visual description of material tested,

10.1.6 Count rate for each reading, if applicable,

10.1.7 Water content in kg/m^3 or lbf/ft^3,

10.1.8 Wet and dry densities in kg/m^3 or unit weights in lbf/ft^3,

10.1.9 Water content in percent of dry density or dry unit weight.

11. Precision and Bias

11.1 The precision and bias of this test method has not been determined. While the instrument precision (repeatability on the same sample) of 4 kg/m^3 (0.25 lbf/ft^3) is required and the procedure provides a means of removing the bias, no methods are available that provide sufficiently accurate values of the water content of in-place soil and rock against which the precision and bias for the procedure and operator variance can be determined.

ANNEXES

(Mandatory Information)

A1. CALIBRATION

A1.1 *Calibration Curves*—Calibration curves, tables, or equations shall be established or verified once each year by determining by test the nuclear count rate of at least two samples of different known water content. This data may be plotted or equations determined to create tables or computer programs for conversion of count data to water content. The method and test procedures used in obtaining the count rate (or ratio as defined in Section 7) to establish the calibration relationship must be the same as those used for measuring the water content of the material to be tested. The water content of materials used to establish the calibration must vary through a range to include the water content of

materials to be tested and be in the density range of 1600 to 2240 kg/m^3 (100 to 140 lbf/ft^3). Due to the effect of chemical composition, the calibration supplied by the manufacturer with the apparatus will not be applicable to all materials. It shall be accurate for mixes of silica sand and water; therefore, the calibration must be checked and adjusted, if necessary, in accordance with A1.3.

A1.2 *Calibration Standards*—Calibration standards may be established using any of the following methods. Prepared containers or standards must be large enough to not change the observed count rate (or ratio as defined in Section 7) if made larger in any dimension.

NOTE A1.1—Dimensions of approximately 610 mm long by 460 mm wide by 360 mm deep (approximately 24 by 18 by 14 in.) have proven satisfactory.

A1.2.1 Prepare a homogeneous standard of hydrogenous materials having an equivalent water content determined by comparison (using a nuclear instrument) with a saturated silica sand standard prepared in accordance with A1.2.2. A metallic density standard as defined in Test Methods D 2922 is a convenient zero water content standard.

A1.2.2 Prepare containers of compacted material with a percent water content determined by oven dry (Method D 2216) and a wet density calculated from the mass of the material and the inside dimensions of the container. The water content may be calculated as follows:

$$M_m = \frac{\rho \times w}{100 + w} \quad \text{(A1.1)}$$

where:

M_m = water content, kg/m^3 or lbf/ft^3,
w = water content, percent of dry mass, and
ρ = wet (total) density, kg/m^3 or lbf/ft^3.

A1.2.3 Where neither of the previous calibration standards are available, the instrument may be calibrated by using a minimum of four selected test sites in an area of a compaction project where a homogenous material has been placed at several different water contents. The test sites shall represent the range of water contents over which the calibration is to be used. At least four replicate nuclear measurements shall be made at each test site. The density at each site shall be measured by making four closely spaced determinations with calibrated equipment in accordance with Test Methods D 2922, Test Method D 1566, Test Method D 2167, or Test Method D 2937. The water content of each of the density tests shall be determined by Method D 2216. Use the mean value of the replicate readings as the calibration point value for each site.

A1.3 *Calibration Adjustments:*

A1.3.1 The calibration of newly acquired or repaired instruments shall be verified and adjusted prior to use. Calibration curves shall be checked prior to performing tests on materials that are distinctly different from material types previously used in obtaining or adjusting the calibration. Sample materials may be selected by either A1.3.1.1 or A1.3.1.2. The amount of water shall be within ±2 % of the water content established as optimum for compaction. Determine the water content in kg/m^3 or lbf/ft^3 by Eq. A1.1. A microwave oven or direct heater may be utilized for drying materials which are not sensitive to temperature, in addition to the methods listed in A1.2.3. A minimum of four comparisons is required and the mean of the observed differences used as the correction factor.

A1.3.1.1 Container(s) of compacted material taken from the test site may be prepared in accordance with A1.2.2.

A1.3.1.2 Test site(s) on the compacted material may be selected in accordance with A1.2.3.

A1.3.2 The method and test procedures used in obtaining the count rate (or ratio as defined in Section 7) to establish the error must be the same as those used for measuring the water content of the material to be tested.

A1.3.3 The mean value of the difference between the moisture content of the test samples as determined in A1.3.1.1 or A1.3.1.2 and the values measured with the instrument shall be used as a correction to measurements made in the field. Some instruments utilizing a microprocessor may have provision to input a correction factor that is established by the relative values of water content as a percentage of dry density, thus eliminating the need to determine the difference in mass units of water.

A2. DETERMINING PRECISION OF APPARATUS

A2.1 The precision of the apparatus at a water content of 160 kg/m^3 (10 lbf/ft^3) shall be better than 4 kg/m^3 (0.25 lbf/ft^3) at the manufacturer's stated period of time for the measurement (Note A2.1). Other timing periods may be available (usually multiples of four of the normal period) which may be used where higher or lower precisions are desired for statistical purposes. The precision shall be determined by the procedure defined in 5.2.1 or 5.2.2.

NOTE A2.1—While 1 min is the usual timing period and may be used for the comparison of various apparatus, the intent of the test method is to require a measurement period that produces the stated precision for all acceptance testing.

A2.2 The precision of the apparatus is determined from the slope of the calibration response and the statistical deviation of the count (detected neutrons) for the period of measurement, as follows:

$$P = \frac{\sigma}{S}$$

where:

P = apparatus precision in water content (kg/m^3 or lbf/ft^3),
σ = standard deviation in counts per measurement period, and
S = slope in change in counts per measurement period divided by the change in water content (kg/m^3 or lbf/ft^3).

A2.2.1 The count per measurement period shall be the total number of thermal neutrons detected during the timed period. The displayed value must be corrected for any prescaling which is built into the apparatus. The prescale value (F) is a divisor which reduces the actual value for the purpose of display. The manufacturer will supply this value if other than 1.0.

A2.2.2 The standard deviation in counts per measurement period shall be obtained as follows:

$$\sigma = \frac{\sqrt{C}}{\sqrt{F}}$$

where:

σ = standard deviation in counts per measurement period,

C = counts per measurement period (before prescale correction) at a water content of 160 kg/m^3 (10 lbf/ft^3), and

F = value of prescale (A2.2.1).

A2.2.3 The counts per measurement period (before prescale correction) shall be obtained form the calibration curve, tables or equation.

A2.2.4 The slope of calibration response in counts per measurement period (before prescale correction) at a water content of 160 kg/m^3 (10 lbf/ft^3) shall be determined from the calibration curve, tables, or equation.

A2.3 The precision shall be computed by determining the standard deviation of at least 20 repetitive measurements (instrument not moved after the first measurement) on material having a water content of 130 to 190 kg/m^3 (8.1 to 11.9 lbf/ft^3). In order to perform this procedure, the resolution of the count display, calibration response, or other method of displaying water content must be equal to or better than ±1 kg/m^3 or 0.1 lbf/ft^3.

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Designation: D 4220 - 89

Standard Practices for Preserving and Transporting Soil Samples[1]

This standard is issued under the fixed designation D 4220; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These practices cover procedures for preserving soil samples immediately after they are obtained in the field and accompanying procedures for transporting and handling the samples.

1.2 *Limitations*—These practices are not intended to address requirements applicable to transporting of soil samples known or suspected to contain hazardous materials.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

D 420 Practice for Investigating and Sampling Soil and Rock for Engineering Purposes[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

3. Terminology

3.1 Terminology in these practices is in accordance with Terminology D 653.

4. Summary of Practices

4.1 The various procedures are given under four groupings as follows:

4.1.1 *Group A*—Samples for which only general visual identification is necessary.

4.1.2 *Group B*—Samples for which only water content and classification tests, proctor and relative density, or profile logging is required, and bulk samples that will be remolded or compacted into specimens for swell pressure, percent swell, consolidation, permeability, shear testing, CBR, stabilimeter, etc.

4.1.3 *Group C*—Intact, naturally formed or field fabricated, samples for density determinations; or for swell pressure, percent swell, consolidation, permeability testing and shear testing with or without stress-strain and volume change measurements, to include dynamic and cyclic testing.

4.1.4 *Group D*—Samples that are fragile or highly sensitive for which tests in Group C are required.

4.2 The procedure(s) to be used should be included in the project specifications or defined by the designated responsible person.

5. Significance and Use

5.1 Use of the various procedures recommended in these practices is dependent on the type of samples obtained (Practice D 420), the type of testing and engineering properties required, the fragility and sensitivity of the soil, and the climatic conditions. In all cases, the primary purpose is to preserve the desired inherent conditions.

5.2 The procedures presented in these practices were primarily developed for soil samples that are to be tested for engineering properties, however, they may be applicable for samples of soil and other materials obtained for other purposes.

6. Apparatus

6.1 The type of materials and containers needed depend upon the conditions and requirements listed under the four groupings A to D in Section 4, and also on the climate and transporting mode and distance.

6.1.1 *Sealing Wax*, includes microcrystalline wax, paraffin, beeswax, ceresine, carnaubawax, or combinations thereof.

6.1.2 *Metal Disks*, about 1/16 in. (about 2 mm) thick and having a diameter slightly less than the inside diameter of the tube, liner, or ring and to be used in union with wax or caps and tape, or both.

6.1.3 *Wood Disks*, prewaxed, 1 in. (25 mm) thick and having a diameter slightly less than the inside diameter of the liner or tube.

6.1.4 *Tape*, either waterproof plastic, adhesive friction, or duct tape.

6.1.5 *Cheesecloth*, to be used in union with wax in alternative layers.

6.1.6 *Caps*, either plastic, rubber or metal, to be placed over the end of thin-walled tubes (Practice D 1587), liners and rings (Practice D 3550), in union with tape or wax.

6.1.7 *O'ring (Sealing End Caps)*, used to seal the ends of samples within thin-walled tubes, by mechanically expanding an O'ring against the tube wall.

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[1] These practices are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

NOTE 1—Plastic expandable end caps are preferred. Metal expandable end caps seal equally well; however, long-term storage may cause corrosion problems.

6.1.8 *Jars*, wide mouthed, with rubber-ringed lids or lids lined with a coated paper seal and of a size to comfortably receive the sample, commonly ½ pt (250 mL), 1 pt (500 mL) and quart-sized (1000 mL).

6.1.9 *Bag*, either plastic, burlap with liner, burlap or cloth type (Practice D 1452).

6.1.10 *Packing Material*, to protect against vibration and shock.

6.1.11 *Insulation*, either granule (bead), sheet or foam type, to resist temperature change of soil or to prevent freezing.

6.1.12 *Sample Cube Boxes*, for transporting cube (block) samples. Constructed with ½ to ¾ in. (13 to 19 mm) thick plywood (marine type).

6.1.13 *Cylindrical Sample Containers*, somewhat larger in dimension than the thin-walled tube or liner samples, such as cylindrical frozen food cartons.

6.1.14 *Shipping Containers*, either box or cylindrical type and of proper construction to protect against vibration, shock, and the elements, to the degree required.

NOTE 2—The length, girth and weight restrictions for commercial transportation must be considered.

6.1.15 *Identification Material*—This includes the necessary writing pens, tags, and labels to properly identify the sample(s).

7. Precautions

7.1 Special instructions, descriptions, and marking of containers must accompany any sample that may include radioactive, chemical, toxic, or other contaminant material.

7.2 Interstate transportation containment, storage, and disposal of soil samples obtained from certain areas within the United States and the transportation of foreign soils into or through the United States are subject to regulations established by the U.S. Department of Agriculture, Animal, and Plant Health Service, Plant Protection and Quarantine Programs, and possibly to regulations of other federal, state, or local agencies.

7.2.1 Samples shipped by way of common carrier or U.S. Postal Service must comply with the Department of Transportation Hazardous Materials Regulation, 49CRF Part 172.

7.3 Sample traceability records (see Fig. 1) are encouraged and should be required for suspected contaminated samples.

7.3.1 The possession of all samples must be traceable, from collection to shipment to laboratory to disposition, and should be handled by as few persons as possible.

7.3.2 The sample collector(s) should be responsible for initiating the sample traceability record; recording the project, sample identification and location, sample type, date, and the number and types of containers.

7.3.3 A separate traceability record shall accompany each shipment.

7.3.4 When transferring the possession of samples the person(s) relinquishing and receiving the samples shall sign, date, record the time, and check for completeness of the traceability record.

8. Procedure

8.1 *All Samples*—Properly identify samples with tags, labels, and markings prior to transporting them as follows:

8.1.1 Job name or number, or both,

8.1.2 Sampling date,

8.1.3 Sample/boring number and location,

8.1.4 Depth or elevation, or both,

8.1.5 Sample orientation,

8.1.6 Special shipping or laboratory handling instructions, or both, including sampling orientation, and

8.1.7 Penetration test data, if applicable (Test Method D 1586).

8.1.8 Subdivided samples must be identified while maintaining association to the original sample.

8.1.9 If required, sample traceability record.

8.2 *Group A*—Transport samples in any type of container by way of available transportation. If transported commercially, the container need only meet the minimum requirements of the transporting agency and any other requirements necessary to assure against sample loss.

8.3 *Group B:*

8.3.1 Preserve and transport these samples in sealed, moistureproof containers. All containers shall be of sufficient thickness and strength to ensure against breakage and moisture loss. The container types include: plastic bags or pails, glass or plastic (provided they are waterproof) jars, thin walled tubes, liners, and rings. Wrap cylindrical and cube samples in suitable plastic film or aluminum foil, or both, (Note 3) and coat with several layers of wax, or seal in several layers of cheesecloth and wax.

8.3.2 Transport these samples by any available transportation. Ship these samples as prepared or placed in larger shipping containers, including bags, cardboard, or wooden boxes or barrels.

NOTE 3—Some soils may cause holes to develop in aluminum foil, due to corrosion. Avoid direct contact where adverse affects to sample composition are a concern.

8.3.3 *Plastic Bags*—Place the plastic bags as tightly as possible around the sample, squeezing out as much air as possible. They shall be 3 mil or thicker to prevent leakage.

8.3.4 *Glass-Plastic Jars*—If the jar lids are not rubber ringed or lined with new waxed paper seals, seal the lids with wax.

8.3.5 *Plastic Pails*—If the plastic pail lids are not air tight, seal them with wax or tape.

8.3.6 *Thin-Walled Tubes:*

8.3.6.1 *Expandable Packers*—The preferred method of sealing sample ends within tubes is with plastic, expandable packers.

8.3.6.2 *Wax With Disks*—For short-term sealing, paraffin wax is acceptable. For long term sealing (in excess of 3 days) use microcrystalline waxes or combine with up to 15 % beeswax or resin, for better adherence to the wall of the tube and to reduce shrinkage. Several thin layers of wax are preferred over one thick layer. The minimum final thickness shall be 0.4 in. (10 mm).

8.3.6.3 *End Caps*—Seal metal, rubber, or plastic end caps with tape. For long term storage (longer than 3 days), also dip them in wax, applying two or more layers of wax.

8.3.6.4 *Cheesecloth and Wax*—Use alternating layers (a minimum of two each) of cheesecloth and wax to seal each end of the tube and stabilize the sample.

NOTE 4—Where necessary, spacers or appropriate packing materials, or both, must be placed prior to sealing the tube ends to provide proper confinement. Packing material must be nonabsorbent and must maintain its properties to provide the same degree of continued sample support.

8.3.7 *Liners and Rings*—Refer to 8.3.6.3 or 8.3.6.4.

8.3.8 *Exposed Samples:*

8.3.8.1 *Cylindrical, Cubical or Other Samples Wrapped in Plastic*, such as polyethylene and polypropylene, or foil should be further protected with a minimum of three coats of wax.

8.3.8.2 *Cylindrical and Cube Samples Wrapped in Cheesecloth and Wax*, shall be sealed with a minimum of three layers of each, placed alternatively.

8.3.8.3 *Carton Samples (Frozen Food Cartons)*—Samples placed in these containers must be situated so that wax can be poured completely around the sample. The wax should fill the void between the sample and container wall. The wax should be sufficiently warm to flow, but not so hot that it penetrates the pores of the soil. Generally, the samples should be wrapped in plastic or foil before being surrounded with wax.

8.4 *Group C:*

8.4.1 Preserve and seal these samples in containers as covered in 8.3. In addition, they must be protected against vibration and shock, and protected from extreme heat or cold.

8.4.2 Samples transported by the sampling or testing agency personnel on seats of automobiles and trucks need only be placed in cardboard boxes, or similar containers into which the sealed samples fit snugly, preventing bumping, rolling, dropping, etc.

8.4.3 For all other methods of transporting samples, including automobile trunk, bus, parcel services, truck, boat, air, etc., place the sealed samples in wood, metal, or other type of suitable shipping containers that provide cushioning or insulation, or both, for each sample and container. Avoid transporting by any agency whose handling of containers is suspect.

8.4.4 The cushioning material (sawdust, rubber, polystyrene, urethane foam, or material with similar resiliency) should completely encase each sample. The cushioning between the samples and walls of the shipping containers should have a minimum thickness of 1 in. (25 mm). A minimum thickness of 2 in. (50 mm) shall be provided on the container floor.

8.4.5 When required, the samples should be shipped in the same orientation in which they were sampled. Otherwise, special conditions shall be provided such as freezing, controlled drainage, or sufficient confinement, or a combination thereof, to maintain sample integrity.

8.5 *Group D:*

8.5.1 The requirements of 8.4 must be met, in addition to the following:

8.5.1.1 Samples should be handled in the same orientation in which they were sampled, including during transportation or shipping, with appropriate markings on the shipping container.

8.5.1.2 For all modes of private or commercial transportation, the loading, transporting and unloading of the shipment containers should be supervised as much as possible by a qualified person.

NOTE 5—A qualified person may be an engineer, geologist, soil scientist, soils technician or responsible person designated by the project manager.

8.6 *Shipping Containers* (see Figs. 2 to 7 for typical containers):

8.6.1 The following features should be included in the design of the shipping container for Groups C and D.

8.6.1.1 It should be reuseable,

8.6.1.2 It should be constructed so that the samples can be maintained, at all times, in the same position as when sampled or packed, or both,

8.6.1.3 It should include sufficient packing material to cushion or isolate, or both, the tubes from the adverse effect of vibration and shock, and

8.6.1.4 It should include sufficient insulating material to prevent freezing, sublimation and thawing, or undesirable temperature changes.

8.6.2 *Wood Shipping Containers:*

8.6.2.1 Wood is preferred over metal. Outdoor (marine) plywood having a thickness of ½ and ¾ in. (13 to 19 mm) may be used. The top (cover) should be hinged and latched, or fastened with screws.

8.6.2.2 The cushioning requirements are given in 8.4.4.

8.6.2.3 For protection against freezing or extreme temperature variation, the entire shipping container should be lined with a minimum insulation thickness of 2 in. (50 mm).

8.6.3 *Metal Shipping Containers*—The metal shipping containers must incorporate cushioning and insulation material to minimum thicknesses in accordance with 8.6.2, although slightly greater thicknesses would be appropriate. Alternatively, the cushion effect could be achieved with a spring suspension system, or any other means that would provide similar protection.

8.6.4 *Styrene Shipping Containers*—Bulk styrene with slots cut to the dimensions of the sample tube or liner. A protective outer box of plywood or reinforced cardboard is recommended.

8.6.5 *Other Containers*—Containers constructed with laminated fiberboard, plastic or reinforced cardboard outer walls, and properly lined, may also be used.

9. Reporting

9.1 The data obtained in the field shall be recorded and should include the following:

9.1.1 Job name or number, or both,

9.1.2 Sampling date(s),

9.1.3 Sample/boring number(s) and location(s),

9.1.4 Depth(s) or elevation(s), or both,

9.1.5 Sample orientation,

Sample Identification/Traceability Record
(Controlled Document)

Project: _____ W.O. # _____
Shipped by: _____
Shipped to: _____ Attention of:
Comments: _____ Hazardous materials suspected? (yes/no)

Sampling Point	Location	Field ID #	Date	Sample Type	No. of Containers	Analysis/Test Required	(optional) Lab ID

Sampler(s) (signature) _____

Field ID	Relinquished by: (signature)	Date/Time		Received by: (signature)	Date/Time		Comments

Shipment prepared by: (signature) _____ Date/Time _____ Shipment method: _____
Received for Lab by: (signature) _____ Date/Time _____ Comments _____
Receiving Laboratory: Please return original form after signing for receipt of samples.

FIG. 1 Example Layout of Record Form

9.1.6 Groundwater observation, if any,
9.1.7 Method of sampling, and penetration test data, if applicable,
9.1.8 Sample dimensions,
9.1.9 Soil description (Practice D 2488),
9.1.10 Names of technician/crewman, engineer, project chief, etc.,
9.1.11 Comments regarding contaminated or possible contaminated samples,
9.1.12 If used, a copy of traceability records,
9.1.13 Weather conditions, and
9.1.14 General remarks.

10. Precision and Bias

10.1 This practice provides qualitative and general information only. Therefore, a precision and bias statement is not applicable.

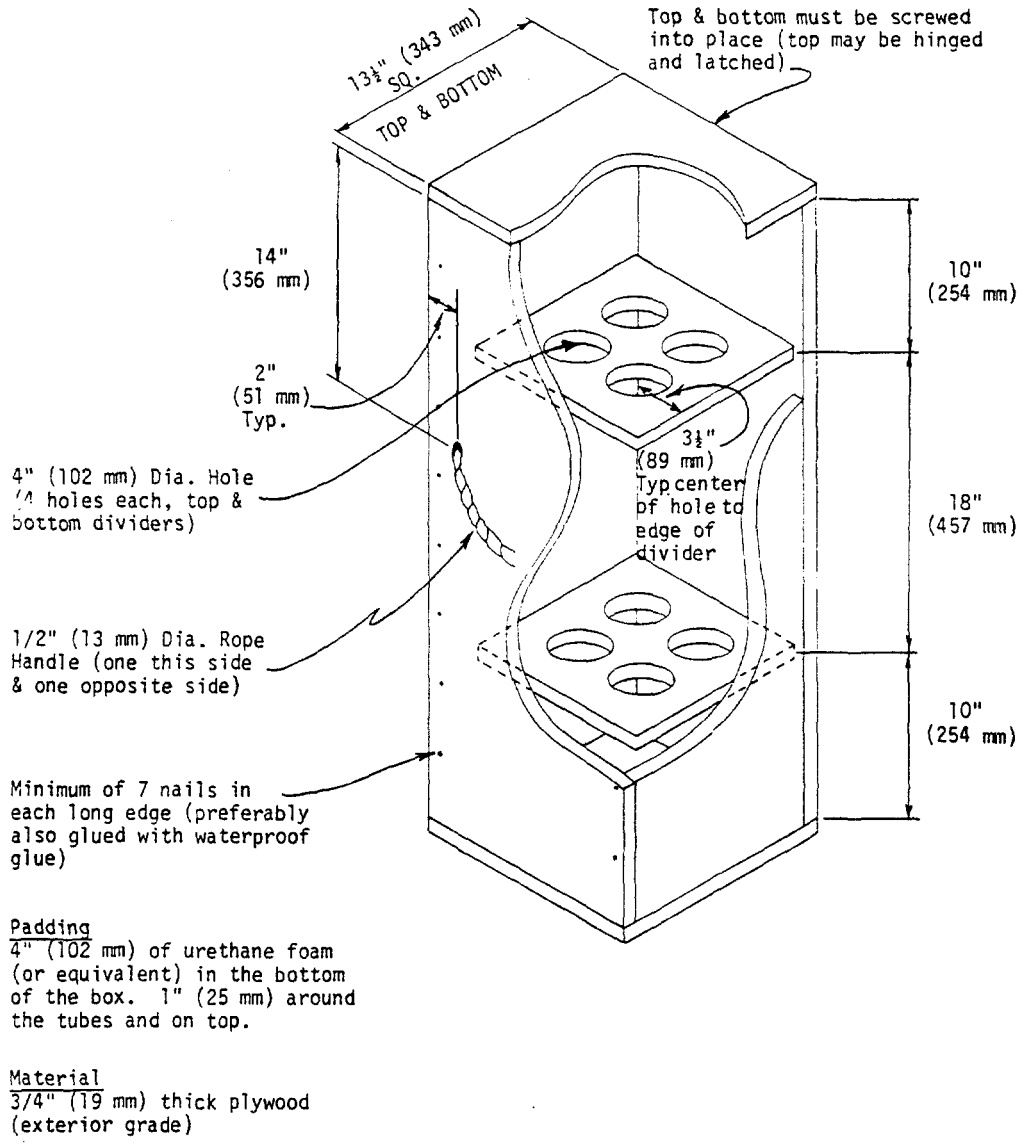
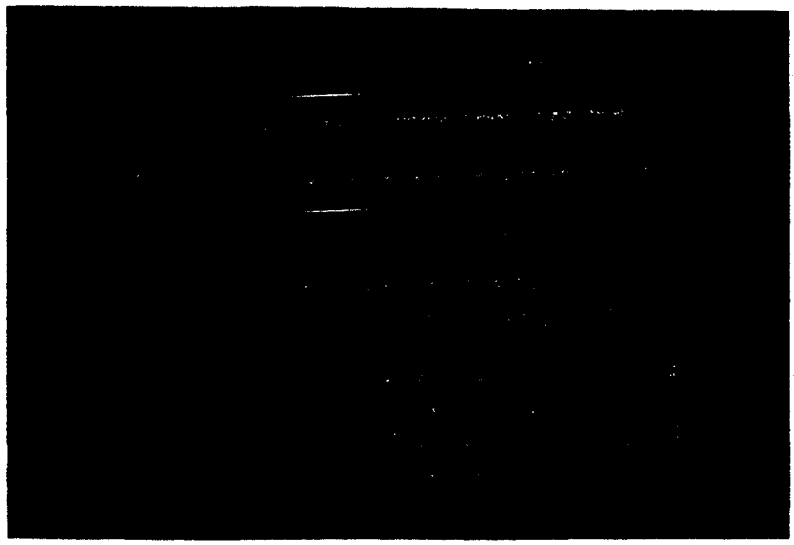
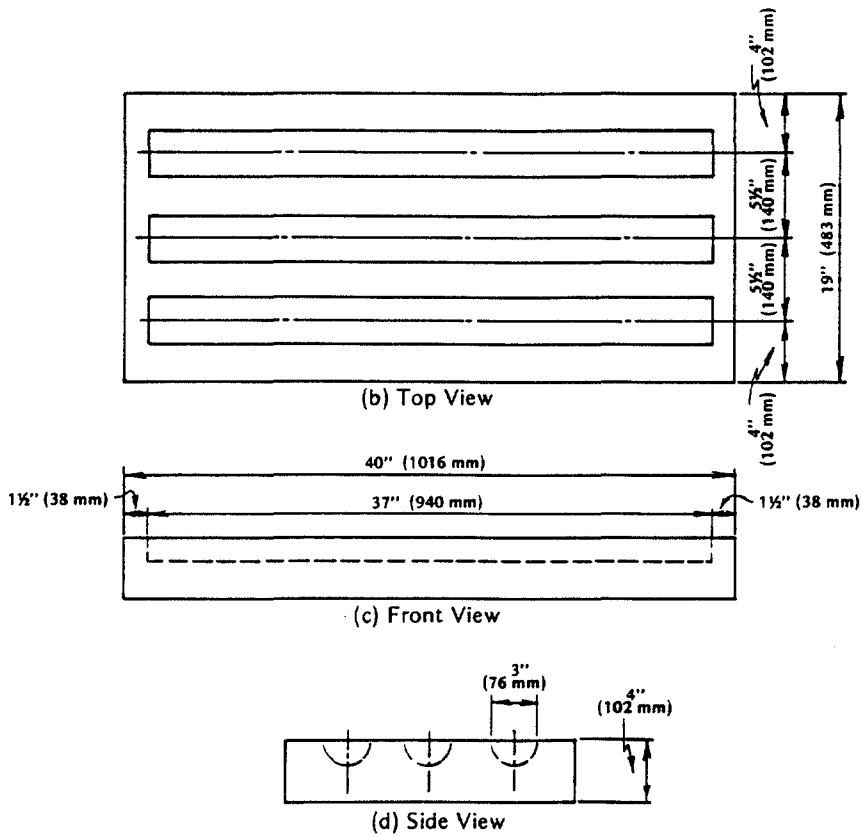


FIG. 2 Shipping Box for 3-in. (76-mm) Thin-Walled Tubes

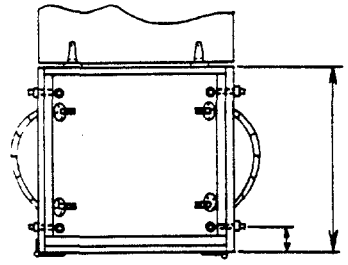


(a) Photo of Open Box For 5" (127 mm) Tubes

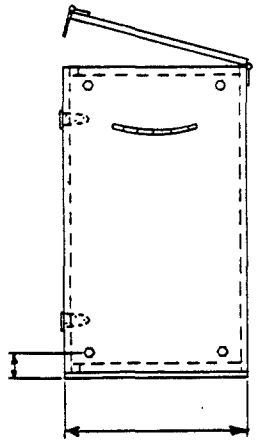


NOTE—Top and bottom halves are identical.

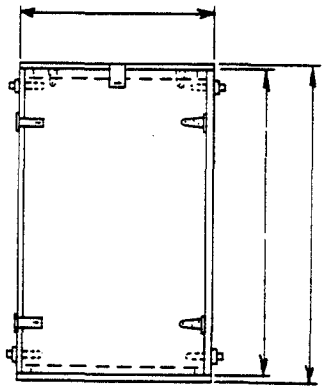
FIG. 3 Styrene Shipping Container for 3-in. (76-mm) Thin-Walled Tubes



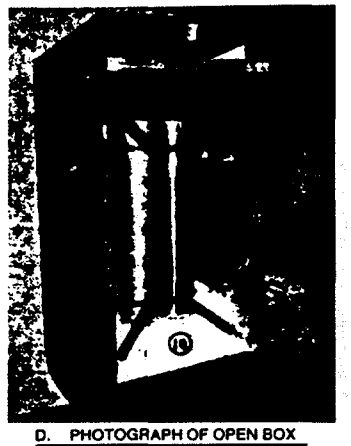
A. TOP VIEW
(lid open)



C. SIDE VIEW



B. FRONT VIEW



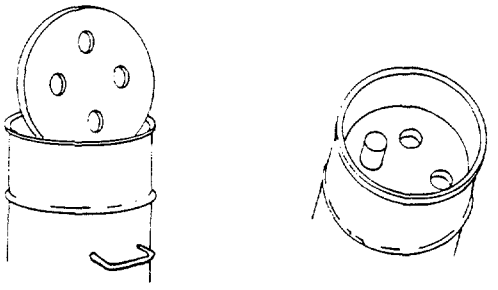
D. PHOTOGRAPH OF OPEN BOX

BILL OF MATERIALS

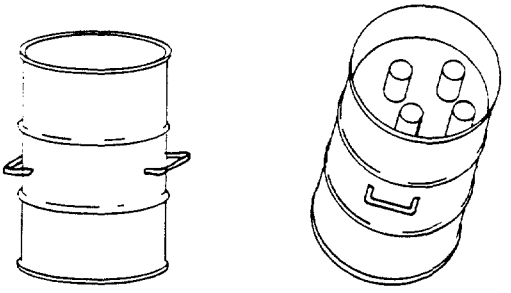
Item No.	Description of Item	Quantity
1	*Plywood*, 4 ft by 8 ft by ¾ in. (1220 mm by 2440 mm by 19.1 mm) exterior, Grade AC	1 Sheet
2	*Hinge*, strap, 4 in. (102 mm), heavy duty with screws	4 Each
3	*Hasp*, hinged, 4½ in. (114 mm), with screws	3 Each
4	*Screw, Wood, Steel, Flathead*, No. 10 by 1¾ in. (44.5 mm)	72 Each
5	*Bolt, Machine*, ⅜ in. (9.5 mm), with nut to secure hasps	3 Each
6	*Washer*, flat, ⅜ in. (9.5 mm)	3 Each
7	*Eye Bolt*, ½ by 2 in. (6.4 mm by 51 mm), zinc-plated, with nut	8 Each
8	*Washer*, flat, ¼ in. (6.4 mm), for hasp bolt	8 Each
9	*S Hooks*, 2 in. (51 mm), open, zinc-plated	8 Each
10	*Clamp*, adjustable, hose, steel, worm screw adjustment	2 Each
11	*Spring*, expansion	8 Each
12	*Adhesive*, woodworking	1 lb (454 g)
13	*Rope*, nylon, ½-in. (12.7-mm) diameter, solid braided	5 ft (1524 mm)
14	*Cushioning Material*, expanded polystyrene foam	10 ft^3 (0.28 m^3)

NOTES—(a) All wooden components can be sawed from one sheet of plywood.
(b) This shipping box will accommodate approximately three 3-in. (76-mm) diameter tubes or two 5-in (127-mm) diameter tubes up to 30 in. (762 mm) in length. For longer tubes the inside height of the box must be a minimum of 6-in. (152 mm) greater than the length of the tube.
(c) All joints to be glued and fastened with screws.
(d) Stencil all sides as follows (See Views B and C).
TO PROTECT FROM FREEZING
(e) After suspending samples as indicated above, all void space must be filled with a suitable resilient packing material.

FIG. 4 Suspension System Container for Thin-Walled Tubes



(a) 55-gallon (0.21 m^3) oil barrels with sections of styrofoam insulation; welded handles on each side.



(b) Same as (a) showing barrel ready for shipment. Steel lids bolted on to provide tight seal.

NOTE—Two in. (51 mm) of foam rubber covers 2 in. of styrofoam at the base. One in. (25 mm) of foam rubber overlays the top of the tubes, and the remaining space to the lid is filled with styrofoam.

FIG. 5 Shipping Barrel for Thin-Walled Tubes

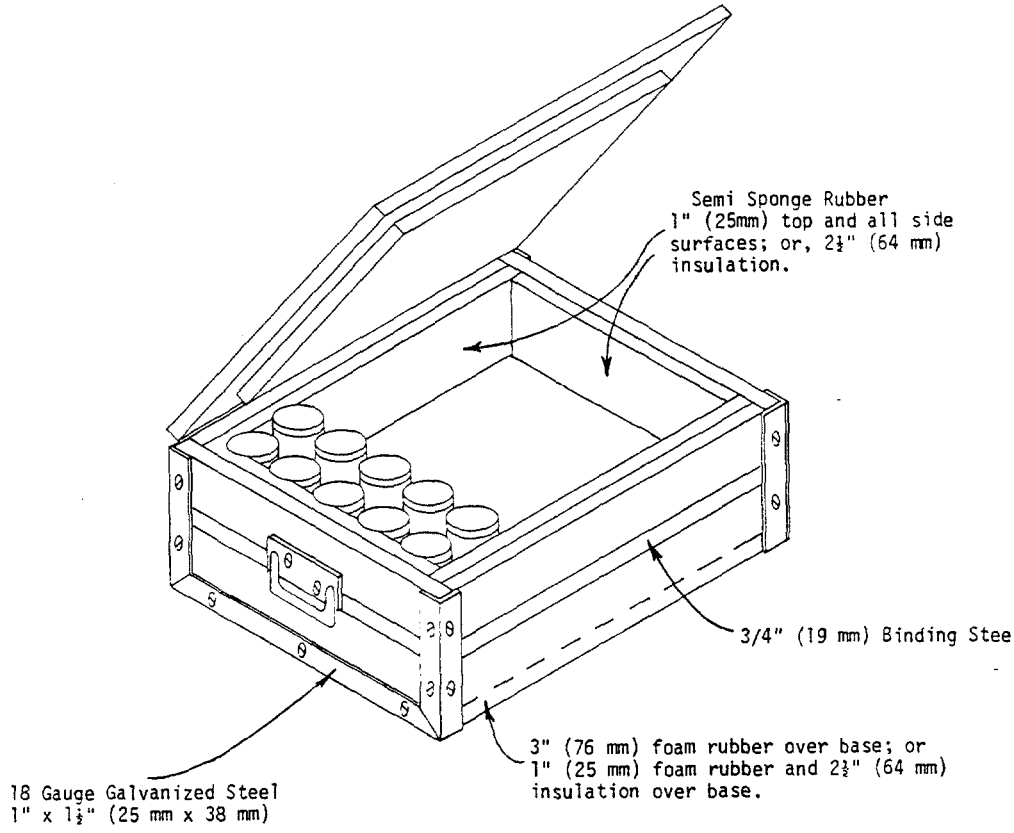
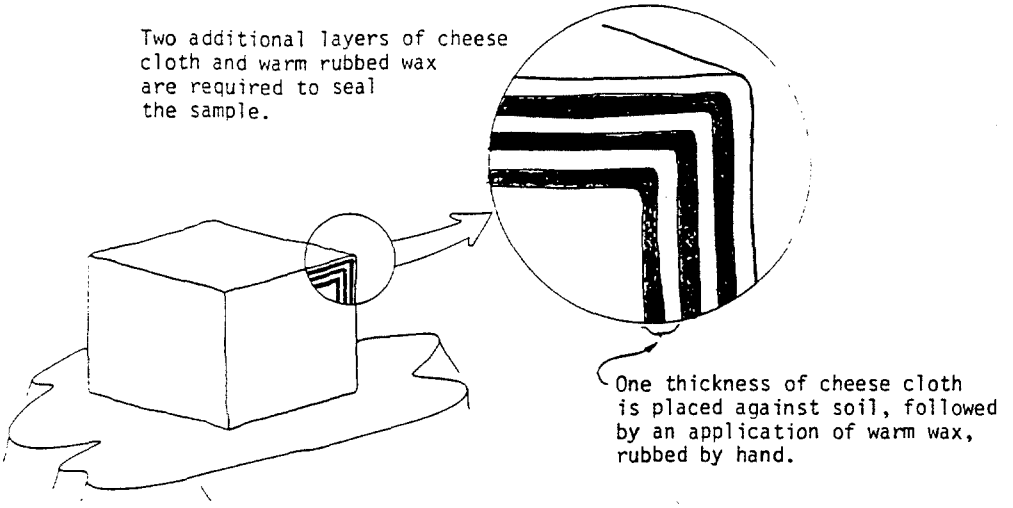
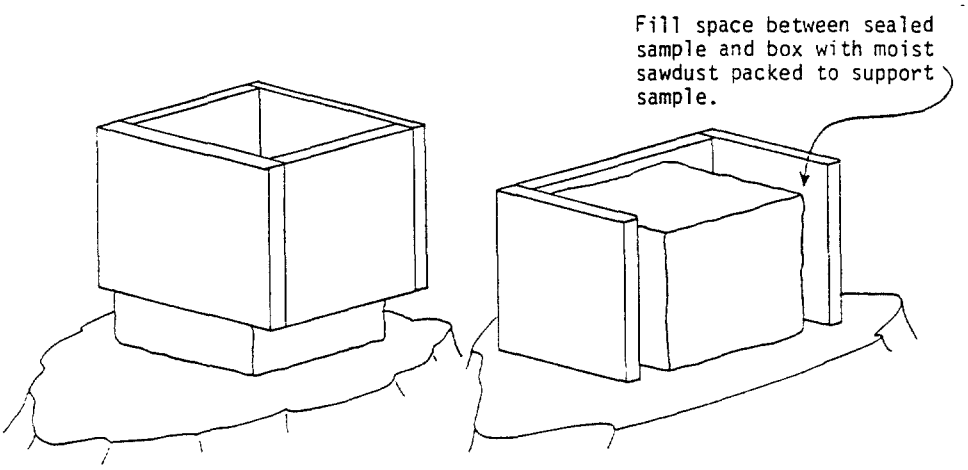


FIG. 6 Shipping Box for Liner (Short Tube) or Ring Samples



A. METHOD FOR SEALING HAND-CUT UNDISTURBED SAMPLES



B. ENCASE EASILY DISTURBED SAMPLES IN BOX PRIOR TO CUTTING

Box constructed with 1/2"-3/4" (13 - 19 mm) exterior plywood.

FIG. 7 Preparing and Packaging a Block Sample

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: D 4959 - 89

Standard Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating Method[1]

This standard is issued under the fixed designation D 4959; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers procedures for determining the water (moisture) content of soils by drying with direct heat, such as using a hotplate, stove, blowtorch, etc.

1.2 This test method is not intended as a replacement for Method D 2216 but rather as a substitute when more rapid and less accurate results are acceptable or desired to expedite other phases of testing. Method D 2216 is to be used as the method to compare for accuracy checks and correction.

1.3 When questions of accuracy between this test method and Method D 2216 arise, Method D 2216 shall be the referee method.

1.4 This test method is applicable for most soil types. For some soils, such as those containing significant amounts of halloysite, mica, montmorillonite, gypsum, or other hydrated materials, highly organic soils or soils that contain dissolved solids, (such as salt in the case of marine deposits), this test method may not yield reliable water content values.

1.5 The values stated in SI units are to be regarded as standard.

1.6 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing[2]

3. Terminology

3.1 *Definitions*—All definitions are in accordance with Terms and Symbols D 653.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *direct heating*—a process by which the soil is dried by conductive heating from the direct application of heat in excess of 110°C to the specimen container, such as provided by a hot plate, gas stove or burner, heatlamps, or other heat sources. Direct application of heat by flame to the specimen is not appropriate.

3.2.2 *water (moisture) content*—the ratio, expressed as a percentage, of the mass of water in a given mass of soil to the mass of the solid particles.

4. Summary of Test Method

4.1 A moist soil specimen is placed in a suitable container and its mass is determined. It is then subjected to drying by the application of direct heat until dry by appearance, removed from the heat source, and its new mass is determined. This procedure is repeated until the mass becomes constant within specified limits.

4.2 The difference between the masses of the moist specimen and the dried specimen is used as the mass of water contained in the specimen. The water content (expressed as a percentage) is determined by dividing the mass of water by the dry mass of soil, multiplied by 100. For a given soil type and specimen size, the time to achieve a constant dry mass can be noted and used to estimate drying time for subsequent tests of the same soil type using the same size specimen and drying apparatus.

5. Significance and Use

5.1 The water content of a soil is used throughout geotechnical engineering practice both in the laboratory and in the field. The use of Method D 2216 for water content determination can be time consuming and there are occasions when a more expedient method is desirable. Drying by direct heating is one such method. Results of this test method have been demonstrated to be of satisfactory accuracy for use in field control work, such as in the determination of water content, and in the determination of in-place dry unit weight of soils.

5.2 The principal objection to the use of the direct heating for water content determination is the possibility of overheating the soil, thereby yielding a water content higher than would be determined by Method D 2216. While not eliminating this possibility, the incremental drying procedure in this test method will minimize its effects. Some heat sources have settings or controls that can also be used to reduce overheating. Loose fitting covers or enclosures can also be used to reduce overheating while assisting in uniform heat distribution.

5.3 The behavior of a soil when subjected to direct heating is dependent on its mineralogical composition, and as a result, no one procedure is applicable for all types of soils or heat sources. The general procedure of this test method

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

Current edition approved June 30, 1989. Published October 1989.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

applies to all soils, but test details may need to be tailored to the soil being tested.

5.4 When this test method is to be used repeatedly on the same or similar soil from a given site, a correction factor can usually be determined by making several comparisons between the results of this test method and Method D 2216. A correction factor is valid when the difference is consistent for several comparisons, and is reconfirmed on a regular specified basis.

5.5 This test method may not be appropriate when precise results are required, or when minor variations in water content will affect the results of other test methods, such as borderline situations where small variations in the measured water content could affect acceptance or rejection.

5.6 This test method is not appropriate for specimens known to contain flammable organics or contaminants, and other test methods should be utilized in these situations.

6. Interferences

6.1 When testing sand and gravel size particles, additional care must be taken to avoid the possibility of particle shattering.

6.2 Due to the localized high temperatures in the soil during testing, the physical characteristics of the soil may be altered. Degradation of individual particles may occur, along with vaporization, chemical transition, or loss of organics. Therefore, specimens used in this test method should not be used for other tests subsequent to drying (see Note 1).

NOTE 1—The subsequent use of specimens dried by direct heating in other test methods is discouraged.

7. Apparatus

7.1 *Direct Heat Source*—Any source or heat that can be directed to the soil specimen to raise the specimen temperature to or above 110°C. Commonly used sources include electric, gas, butane or oil-fired stoves, and hotplates, blowtorches, heat lamps, hair driers, space heaters, etc. Heat sources that directly apply open flame to the specimen may cause extreme degradation of the specimen along with oxidation of and depositing of soot in the specimen and should not be used.

7.2 *Balances*—A balance having a minimum capacity of 2 Kg, and meeting the requirements of Specification D 4753 for a balance of 0.1 gram readability.

7.3 *Specimen Containers*—Suitable containers made of material resistant to corrosion and a change in mass upon repeated heating, cooling, and cleaning. One container is needed for each water content determination.

7.4 *Container Handling Apparatus*—Gloves or suitable holder for moving hot containers after drying.

7.5 *Miscellaneous (as needed)*—Mixing tools such as spatulas, spoons, etc.; eye protection, such as safety glasses or goggles; cigarette papers, and knives.

8. Hazards

8.1 Container holders or gloves are recommended for handling hot containers. Some soil types can retain considerable heat, and serious burns could result from improper handling.

8.2 Suitable eye protection such as safety glasses or goggles is recommended due to the possibility of particle shattering during heating, mixing, or mass determinations.

8.3 Highly organic soils, and soils containing oil or other contaminants may ignite during drying with direct heat sources. Means for smothering flames to prevent operator injury or equipment damage should be available during testing. Fumes given off from contaminated soils or wastes may be toxic, and should be vented accordingly.

8.4 Due to the possibility of steam explosions, or thermal stress shattering of porous or brittle aggregates, a vented covering over the sample container may be appropriate to prevent operator injury or equipment damage. This also prevents scattering of the test specimen during the drying cycle while aiding in uniform heating of the specimen.

9. Samples

9.1 Perform the water content determination as soon as practical after sampling to prevent water loss and damage to potentially corrodible containers.

9.2 Prior to testing, store samples in non-corrodible airtight containers at a temperature between approximately 3 and 30°C and in an area that prevents direct exposure to sunlight.

10. Test Specimens

10.1 Select a representative portion of the total sample. If a layered soil or more than one soil type is encountered, select an average portion or individual portions of each, and note which portion(s) were tested in the report of the results.

10.1.1 For bulk samples, select the test specimen from the material after it has been thoroughly mixed. The mass of moist material selected shall be in accordance with Table 1.

10.1.2 For small samples, select a representative portion in accordance with the following procedure:

10.1.2.1 For cohesionless soils, mix the material thoroughly, then select a test specimen having a mass of moist material in accordance with Table 1.

10.1.2.2 For cohesive soils, remove about 3 mm of material from the exposed periphery of the sample and slice the remaining specimen in half (to check if the material is layered), prior to selecting the test specimen. If the soil is layered, see 10.1. Breaking or cutting of cohesive samples to approximately 6 mm particles speeds drying and prevents crusting or overheating the surface while drying the interior.

10.2 Using a test specimen smaller than the minimum mass indicated in Table 1 requires discretion, though it may be adequate for the purpose of the test. Note a specimen having a mass less than the previously indicated value in the report of results.

NOTE 2—When working with a small sample containing a relatively large coarse-grained particle, it may be appropriate not to include this particle in the test specimen, depending on the use of test results. If this is done, such exclusion should be noted in the report of the results.

TABLE 1 Test Specimen Masses

Sieve Size Retaining More Than 10 % of Sample, mm	Minimum Mass of Moist Specimen, g[A]
2.0 (No. 10)	200 to 300
4.75 (No. 4)	300 to 500
19.0 (No. ¾)	500 to 1000

[A] Larger specimens may be used and are encouraged. Generally, inherent test inaccuracies are minimized by using specimens with as large a mass as practical.

10.3 When the result of a water content determination by the use of this test method is to be compared to the results of another method, such as Method D 2216, obtain a second specimen during selection of the specimen for this comparison. Take precautions to obtain a specimen that represents the same water content as closely as possible. Protect the comparison specimens from water loss by transporting and storing the specimens in sealed containers. A correction factor can be determined for use on subsequent water content determinations on the same soil types from the same site when the difference is relatively constant using several comparisons. Check the correction factor on a regular, specified basis. Recognize that different technicians, heat sources, and such may result in different correction factors.

11. Conditioning

11.1 Prepare, process, and test all specimens as quickly as possible to minimize unrecorded moisture loss.

11.2 Cut or break up the soil into small size aggregations to aid in obtaining more uniform drying of the specimen, taking care to avoid any loss of soil.

11.3 If the specimens are not being tested immediately, place the specimens in containers that can be closed and stored in an area not exposed to direct sunlight, to prevent loss of moisture prior to initial mass determinations.

12. Procedure

12.1 Determine the mass of a clean, dry container, and record.

12.2 Place the soil specimen in the container, and immediately determine and record the mass of the soil and container.

12.3 Apply heat to the soil specimen and container, taking care to avoid localized overheating. Continue heating while stirring the specimen to obtain even heat distribution. Continue application of heat until the specimen first appears dry. A comparatively uniform color should result. Avoid localized burnt or darkened appearance of any part of the soil by intermittent mixing and stirring.

12.3.1 Experience with a particular soil type indicates when shorter or longer initial drying periods can be used without overheating.

NOTE 3—A piece of dry, light-weight paper or tissue, such as cigarette paper, placed on the surface of the apparently dry soil will curl or ripple if the soil still contains significant water.

12.4 After an initial heating period has been completed (soil appears dry), remove the container and soil from the heat source and cool to allow handling and prevent damage to the balance. Determine and record the mass of the soil and container.

12.5 Return the container and soil to the heat source for an additional application of heat.

12.6 With a small spatula or knife, carefully stir and mix the soil, taking care not to lose any soil.

12.7 Repeat 12.3 through 12.5 until the change between two consecutive mass determinations would have an insignificant effect on the calculated water content. A change of 0.1 % or less of the dry mass of the soil for the last two determinations should be acceptable for most specimens.

12.8 Use the final dry mass determination in calculating the water content.

12.9 When routine testing of similar soils is contemplated, the drying times and number of cycles may be established and correlated for each heat source and used for subsequent determinations. When pre-determined drying times and cycles are utilized, periodic verification in accordance with the procedure in 12.7 should be performed to assure that the results of the final dry mass determination are equivalent.

13. Calculation

13.1 Calculate the water content of the soil as follows:

$$w = [(M_1 - M_2)/(M_2 - M_c)] \times 100 = M_w/M_s \times 100$$

where:

w = water content, %,
M_1 = mass of container and moist specimen, g,
M_2 = mass of container and dried specimen, g,
M_c = mass of container, g,
M_w = mass of water, g, and
M_s = mass of solid particles, g.

14. Report

14.1 Report the following information:

14.1.1 Identification of the sample (material) being tested, by location (boring number, sample number, test number, etc.),

14.1.2 Water content of the specimen to the nearest 1 %,

14.1.3 Indication of the test specimen mass, including a note if less than the minimum indicated in Table 1,

14.1.4 Indication of test specimens containing more than one soil type (layered, and the like),

14.1.5 Indication of any material (size and amount) excluded from the test specimen,

14.1.6 Initial mass of test specimen prior to drying, and the mass after the incremental drying periods,

14.1.7 Identification of the type of direct heat source, drying settings, drying times, and number of cycles used, when standardized drying is utilized, and

14.1.8 Identification of comparison test(s) if performed, the method of test utilized and any correction factors applied (see Note 4).

NOTE 4—Water content determinations conducted in accordance with Method D 2216 or other methods may be recorded on the same report. This is not a mandatory requirement, but may be convenient when the results of the two methods are to be compared.

15. Precision and Bias

15.1 The precision and bias of this test method has not been determined. Limited data are being evaluated to determine the precision of this test method. Subcommittee D18.08 is seeking pertinent data from users of this test method.

15.2 The accuracy of this test method is operator dependent, and is a function of the care exercised in performing the steps of the procedure, giving particular attention to careful control and systematic repetition of the procedures used.

16. Keywords

16.1 rapid method; direct heating; acceptance tests; compaction control; density; laboratory moisture tests; moisture content; moisture control; quality control; soil moisture; test procedures

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