Attachment: U. S. EPA "Summary - Quality Assurance and Quality Control for Waste Containment Facilities."

I. Foreword

Quality Assurance (QA) procedures are necessary to assure proper construction of solid waste landfills and surface impoundments. The purpose of this document is to provide detailed recommendations to field personnel, engineers and permit applicants regarding the minimum quality assurance procedures for the construction of facilities and to ensure documentation of construction. These QA recommendations do not in any way reduce the responsibilities of individual contractors or permittees to achieve facility design or performance specifications.

Quality assurance refers to the function of the owner or owner's representative, usually an independent testing company, to monitor construction activity and review construction data and reports from contractors, manufacturers and suppliers. Contractors, manufacturers and suppliers must supply Quality Control (QC) information for their products and equipment. The information becomes part of the project quality assurance/documentation report that is often submitted to the Department.

A specific sequence of procedures is necessary for the construction of liners. These procedures are usually provided with an application for a permit and occasionally required by a permit. Documentation of each procedure becomes necessary to demonstrate that design or performance specifications have been achieved. Visual inspection, survey, field and laboratory testing will be undertaken as appropriate. Recommendations for certifications are listed, including testing frequencies and product specifications. A qualified QA inspector and/or surveyor, independent of the owner or owner's representative, can provide oversight to certify proper construction.

This document has been prepared by the Department for the purpose of assisting owners and operators to fulfill regulatory and permit requirements. Questions and comments are welcome, and can be addressed to the Division of Waste Management, North Dakota Department of Health, PO Box 5520, Bismarck, ND 58506-5520, telephone 701-328-5166.

II. Soil Investigation

The soil material to be used for the construction or installation of any backfill or subliner, subbase, clay liner, drainage layer, or landfill cap must be clearly identified and described in a soil investigation to be submitted to the Department with any permit application or as deemed necessary (NDAC 33-20-03.1-02, subsection 6). The soil investigation should include a map and a description of borings along with a determination of soil parameters for any material to be used during construction. Appropriate soil parameters for a soil investigation include, but are not limited to:

1. In-place moisture-density
2. Atterberg limits
3. Grain-size distribution
4. Laboratory moisture-density relationship (ASTM D698 or D1557)
5. Coefficient of permeability

III. Backfill or Subliner Installation

For some landfills in strip mined areas, it is necessary to raise the bottom elevation of the disposal units. The earthen materials used for backfill must be selected and placed to ensure proper stability for the landfill and the liners and to help minimize leachate constituent migration. The backfill placement should be documented as follows:

1. A grid pattern should be established at the base and sides of the excavation, generally 100-foot spacing. Survey points should be taken and recorded on drawings to be submitted to the Department in the QA report.

2. Minimum one (1) standard or modified proctor test for every 10,000 cubic yards with an additional test for any change in the major soil type.

3. Grain-size distribution and soil classification of backfill tested, at minimum, once each 5000 cubic yards, with any changes in the major soil type.

4. Suitability of backfill, at minimum each twelve inches, tested as follows:

    a. Visual check of soil characteristics as the material is placed.

    b. Density test. Meet 90 percent modified or 95 percent standard proctor density, one test per 100-foot grid.

Location method of all tests should be documented for reports.

IV. Subbase Preparation

Construction of appropriate berms, embankments and subbase preparation will occur prior to liner installation. A survey of the subgrade area is necessary prior to the start of liner

construction. The subgrade surface should be smooth and free from material prior to the start of liner construction. The subgrade should be documented as follows:

1. A grid pattern should be established with additional points placed at the toe of all slopes and at the low point in each cell. Survey points should be taken and recorded on drawings for inclusion with reports.

2. Tests of the top six inches of the subgrade are needed as follows:

    a. Minimum one (1) standard or modified proctor test (minimum 5 point curve) with an additional test for any change in major soil type.

    b. Density and in-place moisture testing. Determine in-place moisture content and meet, at minimum, 90 percent modified proctor or 95 percent standard proctor density, one test per 100-foot grid.

    c. Soil classification. Atterberg limits and grain-size distribution once per 1000 cubic yards of subgrade surface area, at a minimum, and with any change in the major soil type.

    d. Location method of all tests should be documented for reports.

V. Lysimeter Installation

Lysimeters should be installed in accordance with appropriate design details. The subgrade elevations and pipe invert elevations should be addressed in permit applications or as may be required by the Department. All values should be entered in appropriate tables. The lysimeter construction should be visually inspected during installation.

VI. Clay Liner Specifications

For clay liner (and clay caps), the selection and placement of clay soils is critical to meet the required hydraulic conductivity of 1×10^{-7} centimeters per second or less. The condition and moisture level of the soil material has to be monitored closely. Processing of the soil is very important. If the material consists of a claystone, a rock crusher and screen may be utilized to pulverize the material to an adequate consistency.

Appropriate precautions are needed to avoid rocks and gravel larger than 3/4 inch in the liner materials. At minimum, for clay liner soils placed within two feet of the top of the clay liner surface (the upper two feet of the liner), rocks and gravel larger than 3/4 inch must be screened or removed from the soil. A road reclaimer or tillage equipment may be used to break up soil clods. The addition of water or, if necessary, any drying of the soil must be provided for. Placement of the clay soil should be as follows:

1. The clay soils should be placed to achieve a maximum thickness of six inches per compacted lift and compacted to a minimum 90 percent modified proctor or 95 percent standard proctor density. Additional compaction effort may be necessary based on the moisture-density relationship and permeability information.

2. The clay should be compacted 2 to 5 percent wetter than the moisture content at maximum proctor density.

3. Placement and/or compaction of frozen soils is not recommended. Therefore, if frozen soils are identified, they should be removed from the liner. Special precautions to prevent freezing of the clay liner will be necessary. These methods may include soil cover and/or insulation.

4. Proper compaction equipment and methods are necessary. The tamp foot or sheeps foot compactor should weigh, at minimum, 30,000 pounds. However, equipment in the range of 60,000 to 70,000 pounds is better. It is necessary that field equipment properly breaks clay lumps and kneads the clay materials together. At minimum, four to six passes of the compaction equipment per lift of soil are necessary to assure structural improvement of the soil.

5. Visual control to eliminate unacceptable material is necessary. Appropriate testing and documentation during clay liner and clay cap construction is necessary. The soil testing and documentation recommendations follow:

    a. Density and as-placed moisture content tests, as discussed in item No. 1 above, one (1) density and as-placed moisture content test per 100-foot grid pattern on the base of the cell on every lift and offset on each subsequent lift. Nuclear density testing may be utilized rather than sandcone; however, some limited sandcone testing should be utilized to verify nuclear testing methods. Use of a twelve (12) inch probe could allow for reduced frequency of testing since the probe will effectively monitor two (2) lifts per test. Nuclear density testing holes must be filled with clay or bentonite. Greater testing frequency should be utilized in confined areas, small facilities, or where thinner liners are allowed.

    b. Moisture-density (Proctor) testing (minimum 5 point curve), at minimum, on every 5000 cubic yards or less of material used and with any change in the major soil type with a minimum of one test per lift of soil. Modified proctor density testing is preferred over standard proctor testing.

    c. Laboratory determination of as-placed moisture content, dry density and Atterberg limits at a minimum frequency of one (1) test per every 5000 cubic yards of material used.

    d. Soil classification tests for grain-size distribution and soil classification at a frequency of, at minimum, one (1) test per every 5000 cubic yards of clay placed or at a frequency of one (1) test per acre and with any change in the major soil type.

    e. Hydraulic conductivity testing of the liner at a frequency equivalent to every third grain-size sample required under item No. 3 above with a minimum of three tests per site or construction phase. Laboratory testing methods utilizing a shelby tube or on hand carved samples from the liners are inferior and have been documented to under represent actual hydraulic conductivities by a factor of 900 to 1300. Some in situ testing of liner and cap construction utilizing single or double ring devices is preferable to verify lab testing results. Landfill leachate may be used instead of water in the liner tests.

f. Porosity should be calculated in conjunction with permeability tests.

VII. Clay Side Liner Specifications

Clay side liners may be constructed parallel to the sidewall in instances where side slopes are not overly steep. Problems could arise in achieving adequate compaction and uniform thickness on steeper slopes. Where slopes are steeper (especially steeper than 2.5 to 3 H:l V) liners should be built in horizontal lifts with a horizontal thickness equivalent to the scraper width. Horizontal lifts should be tied together and should not contain layers of coarse material. More permeable zones in horizontal lifts could result in seepage. Side/liner construction and testing should be similar to that for the requirements for bottom liners, except for horizontal lifts, where the density and as-placed moisture content testing requirement should be completed on each 200 lineal feet of sidewall for each lift and the testing should be offset on each subsequent lift.

When the trench is open for use, liners should be protected to minimize the damaging effects of desiccation (drying), freezing, erosion and traffic on the liners. Recompaction or reconstruction of damaged liners may be necessary.

VIII. Synthetic Liner Installation

Installation procedures for synthetic liners should be fully described in the permit application. All synthetic liner installation must be performed under the daily supervision of a master seamer. All personnel performing seaming operations should be qualified by experience or by successfully passing seaming tests. The experience record of each of the installer's technicians should be given to the QA inspector prior to the start of synthetic liner placement. No seamer should be allowed to work until their qualifications have been reviewed by the inspector.

The manufacturer shall provide quality control (QC) certification forms with results of plant testing of the geomembrane. These forms must certify that the geomembrane rolls shipped to the site meet or exceed the material property requirements of the project specifications. These QC certification forms should be received by the QA inspector prior to any synthetic liner installation.

A pre-construction meeting is necessary prior to synthetic liner placement to discuss schedule, responsibilities, testing frequencies and to review the installers panel layout drawing.

The geomembrane rolls must be inspected upon arrival to ensure that the materials meet the project specifications. The QA inspector should record all roll numbers to verify rolls as shipped and note in a daily field report any damage to the rolls.

Prior to the placement of the liner, both installer and the QA inspector must inspect the clay liner for any uneven areas, rocks, foreign objects, etc. that may damage the liner. The installer should sign an acceptance form accepting the clay liner condition prior to synthetic liner placement. During the deployment of the liner, the inspector should be present to observe deployment, record roll numbers and panel numbers, and mark any areas with visible damage on the liner. A panel placement form should be filled out by the inspector detailing weather conditions, etc. during deployment.

Before seaming begins, trial welds must be taken, tested and recorded. The frequency of trial welds should be specified in the permit application. If a trial weld fails, the seamer must be required to make another complete trial seam. If this additional test fails, the seaming apparatus or seamer should not be accepted until the deficiencies are corrected and two consecutive passing trial seams are made.

Continuity (non-destructive) testing should be performed using a vacuum box unit or appropriate pressure testing methods over the entire length of each seam. This process should be observed by the QA inspector and any leaks noted, repaired and retested. This testing should follow along the seaming process, not at the completion of all seaming.

Destructive test samples must be taken at the minimum frequency of one test per every 500 feet of seam length. These samples should be taken on a daily basis and sent to an independent laboratory for testing. The locations of these tests should be recorded and included on the as-built panel placement drawing.

IX. Cap and Liner Protection and Repair

Damage to both synthetic and clay liners and caps may occur due to exposure to wind, rain, freezing, drying, equipment traffic and other factors. The owner/operator of a landfill should address liner protection, maintenance and repair in the permit application. The owner/operator or his representative should perform regular inspections of the cap or liner condition and repair damaged areas.

Caps and lines should be protected from damage during freezing conditions. All lined areas should have at least six feet of solid waste in place on the liner by December 15 of each year. No disposal should take place on uncovered areas after December 15 without testing the liner integrity; Department approval may be necessary.

X. Drainage Layer or Blanket Placement

Installation of the granular drainage material must be performed in a manner that prevents equipment from coming in direct contact with the liner. Placement should start at the edge of the cell and proceed by pushing the material out over the liner surface. Placement of drainage material on sidewalls should be completed by pushing the material up. Placement of drainage material around, adjacent or over leachate collection pipe and leachate collection pipe trenches should be carefully monitored.

Documentation and testing for the drainage blanket construction must include:

1. Hydraulic Conductivity. One test, at minimum, for every 2000 cubic yards of material with a minimum of one test per borrow area. At minimum, every site must be tested for at least four samples.

2. Gradation. Minimum of one (1) gradation to a 200 mesh sieve per 1000 cubic yards placed, with a minimum of one per borrow area.

3. Porosity. Calculated in conjunction with the hydraulic conductivity tests.

Lab hydraulic conductivity of the drainage blanket must be of a sample remolded to in-place density. Constant head permeability tests (D 2434) are appropriate for this material. The

Department may require that leachate be used in the tests and may require both chemical and physical durability be tested. Appropriate survey control should be used to document drainage layer thickness.

XI. Leachate Collection Transmission Pipes

Pipes must be placed in locations and elevations as shown on plans provided with the permit application. Transmission line joints and PVC pipes should be sealed with solvent based glue. Slip joints for leachate collection lines may be approved if calculations suggest that substantial subsidence may occur. Pipes should be properly supported to prevent movement and concentration of loads. The coarse aggregate used as pipe bedding and cover should be tested for gradation and compared with gradation of drainage blanket at a frequency of twice per cell. Geomembrane, granular filters or filter fabric placed around the pipe bedding should be appropriately specified, based on results of material gradations, and properly placed. Deflection testing of the collection pipe should be conducted using a mandrel. The cable should be strung through the pipe sections as they are installed. The mandrel should be attached and pulled through the pipe following placement of the granular drainage layer.

XII. Landfill Caps

Construction of the landfill cap should be completed in a manner similar to the construction of landfill clay liners. Special precautions are necessary to assure the disposed waste will support the landfill cap as constructed.

XIII. Quality Assurance/Construction Documentation Report

Authorization to utilize a new facility is usually contingent upon Departmental review and approval of a quality assurance/construction documentation report.

An acceptable report includes, at a minimum, the following information:

1. As built engineering drawings depicting the following information:

    a. Completed subbase elevations.

    b. Final liner grades.

    c. Top of drainage blanket grades.

    d. Leachate collection lines, clean-outs and manholes with spot elevation every 100 feet along the lines and at all manhole entrances and exits.

    e. Drainage features.

    f. All monitoring devices.

    g. Spot elevations at all breaks and slope and on approximate 100-foot centers.

    h. All test locations.

    i. Other site information as appropriate.

2. Engineering cross sections, a minimum of one east-west and one north-south through the completed area.

3. A comprehensive narrative explaining how construction of the project was accomplished along with an analysis of the soil, liner and any other testing data. This report should also include an appendix containing all the raw data from the field and laboratory testing.

4. A series of 35mm color prints documenting all major aspects of the site construction.

5. Construction of the site should be certified by a registered professional engineer to have been completed in accordance with the approved plans. Any deviations from the plan should be noted and explained.

The Department reserves the right to require any measures necessary to assure proper construction and documentation of the landfill or disposal cell.

XIV. References

Daniel, David. 1989. Landfill liner case studies, presentation at "Sanitary Landfill Design" course, University of Wisconsin.

Mitchell, Gene. 1989. Implementing leachate control systems and liners, presentation at "Sanitary Landfill Design" course, University of Wisconsin.

U. S. Environmental Protection Agency. 1986. Draft Technical Resource Document, Design, Construction and Evaluation of Clay Liners for Waste Management Facilities.

Daniel, David. 1985. Summary of testimony before Illinois Pollution Control Board. Day, Steven R. and Daniel, David E. 1985. Hydraulic Conductivity of Two Prototype Clay Liners.

U. S. Environmental Protection Agency. 1983. "Lining of Waste Impoundment in Disposal Facilities," EPA-SW-870, 448 pp.

Day, Steven R. and Daniel, David E. 1985. Field permeability test for clay liners, "Hydraulic Barriers in Soil and Rock," American Society of Testing and Materials (ASTM) 04-874004-38.

Parametrix, Incorporated. 1987. Solid Waste Landfill Design Manual, Washington State Department of Ecology: Belview, Washington, 578 pp.