WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

SOLID AND HAZARDOUS WASTE DIVISION

SOLID WASTE GUIDELINE #13

FINAL COVER SPECIFICATIONS

I. Introduction

Chapter 2, Section 7(g) of the Wyoming Solid Waste Management Rules and Regulations was amended on October 8, 1993, to set final cover specifications for sanitary landfills. These specifications are now defined on a site-by-site basis as a function of the permeability of soils and geologic formations at each landfill. Operators of landfills which are subject to the requirements of Section 7(g) must collect site specific information in order to define a final cover specification for their facility, and then construct the final cover to that specification. Finally, upon completion of closure activities at any landfill, the operator is required to provide a certification from a professional engineer confirming that the provisions of the closure plan have been carried out and that the facility has been closed in compliance with the department's closure standards.

The process of defining the final cover specification, constructing the final cover, and then making the demonstration that the cover has been properly constructed requires a detailed understanding of site conditions and engineering test procedures. The purpose of this guideline, therefore, is to provide a better understanding of the basic regulatory requirements and to identify specific guidance on how to comply with them.

IMPORTANT NOTE : The closure standard specification of Section 7(g) is applicable to all areas which have received wastes <u>after October 9, 1991</u>. Areas which stopped receiving wastes <u>before October 9, 1991</u>, are only required to be covered by two (2) feet of compacted soil and six (6) inches of topsoil.

II. Discussion of Terminology

"Permeability" of a rock or soil is its capacity for transmitting a fluid (in this case water). Permeability is a function of the size, shape and interconnectedness of the pores (i.e., the voids). It is measured by the rate at which a fluid can move a given distance in a given interval of time (units of length per unit time). Permeability of soils and rocks is typically reported in units of centimeters per second (cm/sec).

Conversions : 1×10^{-5} cm/sec = 0.00001 cm/sec = 0.3 in/day = 10 ft/year
1×10^{-7} cm/sec = 0.0000001 cm/sec = 0.003 in/day = 0.1 ft/year

"Density" is the mass or weight of a given substance (in this case soil) in a given volume. Density is a function of the size, shape and variability of the soil grains, and the amount of moisture which is present. Soil density is typically measured in pounds per cubic foot (lbs/ft^3).

III. Regulatory Considerations

The requirement to meet a final cover specification affects numerous regulatory standards. These standards are highlighted below:

A. Chapter 2, Sections 2(b)(iii)(A)(X)(1) and (2)

Site specific soil and geologic conditions must be described in the permit application document. As part of this description, the permeabilities of the natural subsoil or bedrock which is present at the base of the area fill or trenches should be defined by field or laboratory testing. Use of textbook values is discouraged. If textbook values must be used, the most conservative published value (smallest number) should be used.

B. Chapter 2, Sections 2(b)(iii)(A)(XI)(4)

This application standard requires a demonstration that there is sufficient cover material available to properly operate the site through the closure period. Daily and final cover requirements must be considered. At this point in the application, it is prudent to demonstrate that the volume of soil which is to be used for the compacted cover is actually suitable for use as final cover material (i.e., it can be recompacted to the appropriate final cover specification).

C. Chapter 2, Section 2(b)(iii)(A)(XIII)(4)

Permit applications must contain a description of the final soil cover as well as methods to revegetate the site. Detailed information regarding the permeability of the final cover and the associated construction procedures and specifications should be provided. In addition, the application should contain a rationale for the proposed final cover permeability specification.

D. Chapter 2, Sections 7(g) & 4(j)

The closure standard in Section 7(g) states : "The final cover shall have a minimum permeability less than or equal to the permeability of the bottom liner or natural subsoils, or a permeability of 1×10^{-5} cm/sec, whichever is less, or such lower value as specified in the facility permit." The purpose of this standard is to minimize the infiltration of moisture which will migrate through the waste layers and reach the bottom liner or natural subsoils. In theory, if the bottom liner or natural subsoils are less permeable than the final cover, water/leachate will move through the final cover and waste layers faster than it can move through the bottom liner. Leachate will continually accumulate on the less permeable bottom liner, resulting in a "bath tub effect". This effect causes the leachate to stay in contact with the waste longer, which increases the potential for more contaminants to leach out of the waste.

Wyoming receives limited precipitation (generally less than 18 inches/year) and has very high evapotranspiration potentials (generally more than 22 inches/year). In consideration of these facts, the department has conducted computer simulations using the Hydrologic Evaluation of Landfill Performance (HELP) Model (Version 2) to simulate and evaluate the performance of low permeability landfill covers. In summary, the department found that a compacted soil cover with a permeability of 1×10^{-7} cm/sec is almost as effective in preventing infiltration as one with a permeability of 1×10^{-9} cm/sec. Due to the extremely high costs and the insignificant gain in performance of a very low permeability final cover, the department has concluded that in most cases where underlying soil or bedrock has a permeability which is less than 1×10^{-7} cm/sec, a final cover specification of 1×10^{-7} cm/sec should be adequate to prevent infiltration, generation of leachate, and a "bath-tub effect" in the landfill. It should be noted than 1×10^{-7} cm/sec is the department's permeability specification for engineered containment systems.

In consideration of the discussion above, there are three possible scenarios for complying with the intent of the final cover specifications of Section 7(g):

- The bottom liner or natural subsoils are more permeable than 1×10^{-5} cm/sec (e.g., 1×10^{-3} cm/sec). In this case, the final cover specification would be set at 1×10^{-5} cm/sec.

- The bottom liner or natural subsoils are less permeable than 1×10^{-5} cm/sec (e.g., 1×10^{-6} cm/sec). In this case, the final cover specification would be set at 1×10^{-6} cm/sec, the permeability of the bottom liner or natural subsoils.

- The bottom liner or natural subsoils are less permeable than the 1×10^{-7} cm/sec permeability specification for engineered containment (e.g., 1×10^{-9} cm/sec). In this case, the final cover specification would be set at 1×10^{-7} cm/sec, the permeability specification for engineered containment systems.

E. Chapter 2, Section 5(y)(ii)(H)

This operating standard requires operators to maintain a record of the dates when trenches are completed and their contents. This information must be maintained in the facility's operating record through the active life of the site and to the end of the post-closure period. Due to the fact that the final cover specification requirements of Section 7(g) apply only to those areas which received waste after October 9, 1991, it is very important to document when a trench or area is completed.

F. Chapter 2, Section 5(y)(ii)(I)

This operating standard requires operators to maintain closure and post-closure plans, and any monitoring, testing and analytical data which are required. This information must be maintained in the facility's operating record through the active life of the site and to the end of the post-closure period. Any testing data which are collected for the purpose of demonstrating that final cover specifications (see section III.G below) have been met are subject to this recordkeeping requirement.

G. Chapter 1, Section 2(h)(ii)

At closure, landfill operators are required to provide a certification from a professional engineer confirming that the provisions of the closure plan have been carried out and that the facility has been closed in compliance with the department's closure standards. In order to provide this certification, field data must be collected to demonstrate that the final cover specification has been met. These data are collected most efficiently at the time that the final cover is being installed. However, these data may be collected after the final cover is installed.

IV. Logistical Considerations

Operators of existing landfills should define the Section 7(g) final cover specifications for their facilities as soon as possible, especially if reclamation is conducted on an ongoing basis. Defining these specifications and monitoring construction activities is necessary to insure that the final cover is properly constructed. If the final cover is not properly constructed to the appropriate specifications, it is possible that the final cover would have to be reworked to achieve the required specifications.

Operators of landfills which are still in the permit application review process may want to postpone placement of the compacted cover pending departmental approval of their application. If placement of the compacted cover is postponed, however, Chapter 2, Section 5(p) requires operators to place six (6) inches of daily cover and twelve (12) inches of intermediate cover to any area where wastes will not be disposed of for a period of 180 days. As provided in Chapter 2, Section 7(g), two (2) feet of final cover must then be constructed over any intermediate cover already in place.

V. Permeability Test Methods

A. Direct Measurement Methods

The permeability of soils or bedrock can be measured directly in the field or in a laboratory. In general, field permeability tests are thought to provide more accurate information than laboratory tests. However, field permeability tests cannot be conducted unless saturated conditions exist.

If the underlying soils or bedrock formation is saturated at depth, the permeability of the unit can be measured in the field by conducting tests on the water bearing zone. A variety of pumping tests are useful for measuring the permeability of higher yield aquifers (Driscoll, 1989). In lower-yield aquifers or small-diameter wells, bail or slug tests (Hvorslev, 1951) are appropriate for measuring permeability. Direct measurement of permeability in the field is only useful in evaluating the permeability of underlying soils or bedrock. If the aquifer material is not representative of the soils or bedrock at the base of the disposal area or trench (which is often the case), this method is not appropriate for measuring the permeability of the soils or bedrock at the base of the disposal area or trench.

Permeability can also be measured directly by collecting undisturbed field samples for laboratory analysis. The two most common laboratory methods for measuring permeability are the constant head permeability test (ASTM, 1988, Test Method D-2434) and the falling head permeability test (Bowles, 1970). In general, the constant head permeability test is most appropriate for coarse-grained soils (sands), while the falling head test is most appropriate for fine-grained soils (silts and clays). These laboratory methods can be used to measure both the permeability of underlying soils or bedrock, and the permeability of final cover material which has already been placed.

B. Indirect Measurement Methods

The permeability of compacted soils (liner or cover material) can be indirectly measured in the field by directly measuring the moisture content and density of the compacted soil. This approach involves some preliminary laboratory analysis of recompacted soil samples. The relationship of moisture content and density is first determined in the laboratory using the Standard Proctor test (ASTM, 1988, Test Method D 698). Constant or falling head permeability laboratory tests are then conducted at various recompacted densities to determine what percentage of the maximum dry density (and corresponding moisture content) will provide the desired permeability specification. In the field, soil moisture content is monitored during construction and adjusted to insure that the soils are compacted within some percentage of the optimum moisture content (typically 2-5%, depending on the characteristics of the soil). In-place densities are then measured using nuclear equipment (ASTM, 1988, Test Method 2922) or the sand-cone method (ASTM, 1988, Test Method D 1566) to verify that the soil has been adequately compacted to the necessary density (i.e., permeability) specification.

VI. Sampling Strategies

A. Underlying Soils and Bedrock

A sufficient number of sampling points should be analyzed to fully evaluate subsurface variations in soil and bedrock types and in the associated permeabilities. The goal of this sampling and analysis effort is to define a single permeability which accurately represents the soil or bedrock at the base of the landfill units. In some extreme cases where subsurface conditions vary significantly throughout a site, it may be more reasonable to identify different permeabilities for the different areas.

If field methods are used to measure permeability, the results of each individual test should be reported. Slug or bail tests should be conducted on all available piezometers.

If field samples are collected for laboratory analysis, it is extremely important to collect samples at the elevation (depth) which represents the base of the landfill trenches or area fill. If subsurface soil or bedrock

conditions vary across a particular site, samples should be collected to represent the various soil types and lithologies. At a minimum, the department recommends that five (5) samples be collected and analyzed at each landfill. For facilities which have significant variability in subsurface conditions or which encompass more than 40 acres, a larger sample population may be appropriate. In these situations, a sampling program should be proposed (with a basis for justification) to the department before the samples are collected.

B. Compacted Final Cover

The department recommends that final cover specifications be documented by first defining the relationship between permeability, moisture content and density in the laboratory, and then monitoring moisture content and density in the field during construction. Undisturbed samples can also be collected in the field once the final cover is installed, and then analyzed in the laboratory to determine the permeability. Running permeability tests on undisturbed samples, however, is quite costly and time-consuming. Additional costs may also be incurred if the laboratory permeability measurements indicate that the final cover specifications have not been achieved and heavy equipment must be remobilized to the site to rework the final cover.

The department recommends analyzing at least one (1) sample for each foot of cover for every five (5) acres. At a 40-acre facility, this would result in a total of 16 samples (8 from the upper one-foot of cover, 8 from the lower one-foot of cover). For facilities which use heterogeneous final cover material, a larger sample population may be appropriate. In these situations, a sampling program should be proposed (with a basis for justification) to the department before the samples are collected. If small portions (less than 5 acres) of a landfill are being covered and reclaimed on an ongoing basis, the department recommends that at least three (3) samples be collected and analyzed for each one (1) foot of compacted cover within the area being reclaimed.

C. Other Approaches

As an alternative to the sampling strategies outlined above, ASTM Method E-122 "Standard Recommended Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process", can be used to determine a statistically valid sampling strategy.

VII. Data Reporting and Evaluation

Permeability values should always be reported in units of centimeters per second (cm/sec). When more than one test is conducted on a specific medium (e.g., underlying bedrock, final cover material, etc.) the results of each individual test and the mean, variance and standard deviation of each independent population should be reported.

The mean of the permeability data for the underlying soil or bedrock should be used as a "target specification" for the final cover material. Once the final cover is installed and tested, the means of each independent population (e.g., the underlying soils/bedrock and the final cover material) should be compared to determine if the populations can be differentiated. The following describes three possible scenarios and the respective procedures to determine whether or not the final cover permeability is adequate.

<u>SCENARIO #1</u> - The mean of the permeability data of the final cover material is the **same or less than** the mean of the permeability of the underlying soils/bedrock.

No further analyses or calculations are required, and it can be concluded that an adequate final cover system has been constructed to the necessary specifications.

<u>SCENARIO #2</u> - The mean of the permeability data of the final cover material is **greater than** the mean of the permeability of the underlying soils/bedrock.

The department recommends that the two independent data sets be further evaluated using a statistical test. The Students t-test for hypothesis at the 95% confidence interval is an acceptable statistical method which compares the means of each data set to determine whether the final cover and the underlying soils/bedrock permeabilities may be from the same population. If the result of the t-test indicates the two data sets cannot be distinguished, then it can be concluded that the final cover permeability meets necessary specifications. However, if the result of the t-test indicates the two data sets are **not** from the same population, then it can be concluded the final cover permeability is inadequate and additional work to meet specifications is required.

SCENARIO #3 - The underlying soil/bedrock is more permeable than 1×10^{-5} cm/sec.

In the situation where the underlying soil or bedrock is more permeable than 1×10^{-5} cm/sec (e.g., 1×10^{-3} cm/sec), the mean of the permeability data for the final cover material should be compared to the minimum final cover specification . If the mean of these data, minus one standard deviation, is less than 1×10^{-5} cm/sec, the department will be satisfied that an adequate final cover system has been constructed to the necessary specifications.

VIII. Further Information

Additional information on this subject can be found in "Soil Properties, Classification, and Hydraulic Conductivity Testing" (EPA, 1984) and "Covers for Uncontrolled Hazardous Waste Sites" (EPA, 1985).

Please be advised that the procedures and guidelines outlined above for determining and demonstrating final cover specifications are only recommendations from the department. Other procedures may be reasonable and appropriate for the purpose of complying with these regulatory requirements. Operators should be cautioned that the cost of determining and demonstrating final cover specifications can be quite high. Therefore, if an operator wishes to use procedures other than those outlined in this guideline, a proposal and justification should be submitted to the department for review and prior approval.

Further information can also be obtained from the following Solid and Hazardous Waste Division offices. Comments and suggestions for improvements are always appreciated.

Casper : (307) 473-3450 / Cheyenne : (307) 777-7752 / Lander : (307) 332-6924

Signed

_____ March 2, 1995

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Date

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