DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Mining Programs

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TITLE: Liners and Caps for Coal Refuse Disposal Areas

EFFECTIVE DATE: Upon publication of notice as final in the *Pennsylvania Bulletin*

AUTHORITY: 25 Pa. Code Chapters 86, 88, and 90

POLICY: The Department will ensure coal refuse disposal areas have appropriate barrier layers that are designed and constructed in a manner that prevents precipitation from contacting the coal refuse within coal refuse disposal areas when activity is completed or suspended and prevents adverse impacts to surface and groundwater.

PURPOSE: This guidance explains the procedures that the Department will use in approving liners and caps for facility designs and the criteria for as-built certifications for coal refuse disposal areas.

APPLICABILITY: This guidance applies to coal refuse disposal areas as defined in Chapter 90.

DISCLAIMER: The policies and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements.

The policies and procedures herein are not an adjudication or a regulation. DEP does not intend to give this guidance that weight or deference. This document establishes the framework, within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

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A. BACKGROUND

The Bureau of District Mining Operations (BDMO) issues permits for the construction and operation of coal refuse disposal areas (CRDAs). These facilities may have operating lives of ten years or more and, if not properly constructed, have a high probability to contribute contaminants to the surface water or into groundwater over time as precipitation and groundwater encounter coal refuse. The operator is required to protect the quality of surface and groundwater within the proposed permit and adjacent areas (25 Pa. Code §§ 88.291 and 90.35). CRDAs are required to have a system in place to prevent adverse impacts to surface and groundwater. Furthermore, the systems are required to prevent precipitation from contacting the coal refuse as the portions of the disposal area reach capacity, upon final completion, and during periods of temporary cessation longer than 90 days[*] (25 Pa. Code §§ 88.310, 90.50 and 90.167).

Several regulatory requirements pertain to the construction and performance of coal refuse disposal areas:

Chapter 88 (25 Pa. Code § 88.310(j)) requires that a phased system must be in place for areas of anthracite coal refuse disposal to prevent adverse impacts to surface water and groundwater and to prevent precipitation from encountering the coal refuse material. 25 Pa. Code § 88.310(k) requires that a system to prevent precipitation from contacting the coal refuse material must be installed if a temporary cessation at the site exceeds 90 days in duration[*].

Chapter 90 includes several sections pertaining to pollution prevention for coal refuse disposal: design criteria for groundwater and surface water protection systems (25 Pa. Code § 90.50), requirements that coal refuse disposal prevent adverse impacts and pollution to the surface and groundwater (25 Pa. Code § 90.101), and water quality standards for discharges from facilities (25 Pa. Code § 90.102). 25 Pa. Code § 90.122 is specific to coal refuse sites requiring that the leachate from the coal refuse fill does not degrade the surface or ground waters. This section includes specific requirements for long-term stability, underdrains, a system to prevent precipitation from encountering the refuse material in a completed area, slope protection and diversions to control surface runoff, and placement of the coal refuse. 25 Pa. Code § 90.167(d) requires that a phased system to prevent precipitation from contacting the coal refuse material must be installed if a temporary cessation at the site exceeds 90 days in duration[*].

The three requirements expressed in 25 Pa. Code § 90.50 – (1) to prevent adverse impacts to groundwater, (2) to prevent adverse impacts to surface water and, (3) to prevent precipitation from coming into contact with the coal refuse – can be accomplished with a system of liners and protective capping ("barrier layers"). Liners are used for (1) and (2). Caps are useful for all three requirements, but particularly to prevent precipitation from coming into contact with the coal refuse. This section of the regulations references this document for guidance on the design of the barrier layers system.

[*] Unless the Department approves a longer time period to trigger the precipitation prevention system.

B. REVISION FROM PREVIOUS GUIDANCE

This guidance was previously issued with information for liners for impoundments and stockpiles as well as CRDAs. The guidance was revised to provide additional information for use of barrier layers at CRDAs, specifically, to include caps, in accordance with the intent expressed in 25 Pa. Code § 90.50(c) regarding liners *or caps*. This document is referenced in the regulations and its purpose is to serve as guidance. The intent of this document is to provide methods, practices, procedures, and other information that are acceptable to the Department to achieve compliance with statutory and regulatory requirements.

Technical information regarding liners for all other types of impoundments, treatment ponds, and stockpile areas have been removed from this document and are described in the Engineering Manual for Mining Operations (Chapter 3.0 Sediment Control Impoundments, Section 3.17 Liners (Impoundment and Storage Area) (25 Pa. Code §§ 91.34 and 91.35)). However, some of the information presented here may be useful guidance for operators and permit reviewers for these situations.

The references to "earthen" and "admixed" liners or caps have changed. "Clay or low hydraulic conductivity (HC) soil" replaces "earthen". "Admixed" is removed from the specific barrier layer type description as it is no longer widely used with the exception of "rec mix" for which a description is included. The option of "Other" types is included to cover any materials other than clay/HC soils and synthetic barrier layers that an operator may propose to use.

Applicability for existing facilities

While this technical guidance document (TGD) is not intended to suggest that existing structures must be replaced or retrofitted. A suitable system to prevent adverse impacts to groundwater and surface water is most readily achieved via a liner and cap combination. If an existing site has no liner or a liner that does not meet current standards to prevent groundwater pollution, a robust capping plan may be required. All active sites are subject to the requirement to protect groundwater and surface waters.

C. BARRIER LAYER TYPES

Barrier layers – a liner or a cap – prevent or reduce water migration through the refuse material. Liners generally consist of a low hydraulic conductivity layer of clay soil or synthetic material as an under-liner for coarse coal refuse embankments and synthetic material as an under-liner for fine coal refuse slurry impoundments. Caps over the finished emplacement generally consist of synthetic material or an equivalent system necessary to protect the material from direct contact with precipitation.

For facilities that will experience high hydraulic head conditions (increased water pressure), such as a slurry impoundment constructed on coarse refuse, the liner may include overlying hydraulic head controls such as a pervious layer and a leachate

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collection system above the liner to reduce the head and limit potential migration of the leachate through the underlying liner.

There are two primary types of low permeability/impermeable barrier layers: Low hydraulic conductivity soils (clay) and synthetics.

Low Hydraulic Conductivity Soils ("Clay")

Clay soils may be used if the material is of a specific quality and consistency and the applicant can demonstration its suitability. The applicant should provide documentation for the quality, quantity, and characteristics of clay for the proposed barrier layer. Clay cracks and shrinks in dry conditions creating secondary porosity and pathways for precipitation and plant root penetration that compromises the barrier function. Because it is a natural product that is not homogeneous and is subject to environmental conditions, American Society of Testing Materials (ASTM) tests should be conducted prior to and during the placement of the material as well as additional justifications needed during the application review process. The applicant should consider whether the large volumes of high-quality material needed will be readily available and suitable to meet the requirements for hydraulic conductivity values. Dependence upon imported clay material will likely also increase the bond liability contributing to the economics of liner choice. . Clay liners exposed to hydraulic head pressures can fail so they may be unsuitable for use as barrier layers for impounding structures, particularly fine coal refuse slurry impoundments where use of synthetic layers are encouraged.

Suitable clay soils can be used for liner material in applications including non-impounding coal refuse areas such as coarse (only) refuse facilities, temporary storage areas and outslopes of refuse facilities. These facilities can demonstrate that preferential flow is through or above the construction medium and do not sustain hydraulic head on the clay liner.

Clay can also be used as supplemental earth cover (primary root zone) and as topsoil for revegetation components (that also includes organic matter, lime, fertilizers, and seed mixes, as required).

Synthetic

Synthetic barrier layers include flexible polymeric sheets or flexible membrane liners (FML), which are polymer fabrics or a composite of fabric and other material to enhance impermeability.

Continuous sheets of polyvinyl chloride (PVC), linear low-density polyethylene (LDPE), and high-density polyethylene (HDPE) composition are the most common synthetic material for CRDA barrier layers. These have very low HC, and, therefore, are highly protective when uncompromised and installed to specifications. The sheets are overlapped and fused at the seams thermally or chemically. A protective layer of sand,

soil, or other approved material can be used above and below the membrane to avoid damaging the material.

The use of synthetic material is recommended under high head areas of fine coal slurry impoundment where sustained high pressure head makes clay liner material less reliable.

Synthetic material is recommended by the Department for use as liners and caps for CRDAs to prevent groundwater contamination because of its combination of cost-effectiveness, degree of impermeability, and availability. Synthetic material is currently considered by the Department to be the best and most practical choice to prevent precipitation from coming into contact with the coal refuse to the maximum extent practicable. Specifically, clay material can have a hydraulic conductivity of 1×10^{-7} cm/sec, whereas the synthetic material (≥ 30 mil PVC, LLPE, or HDPE) has a hydraulic conductivity, at a minimum, of 1×10^{-11} cm/sec. The suitability of clay material versus synthetic material is clarified below. Additionally, because synthetic material is a consistent, manufactured product subject to quality controls, less testing is needed than for a clay barrier layer that may incorporate natural heterogeneities.

Synthetic material is not recommended for sloped areas, such as 5H:1V or steeper.

Other

The Department will consider other technologies that can meet or exceed the requirements in its regulations. The applicant can attempt to demonstrate that an alternative to these two options will serve as a barrier layer and will adequately prevent pollution in accordance with the regulatory requirements, but a demonstration must be provided to the Department (25 Pa. Code §90.125(c)). Consideration of an alternative material should be discussed in advance during a pre-application process. Because of a potentially extended timeline for operator demonstration and Department review of an alternate material, the Department does not recommend that alternatives be proposed for a time-sensitive revision or a compliance issue.

Coal ash or low-permeability waste General Permit (GP) materials can be used to provide a safety measure, when used in combination with clay, synthetic, or other approved material, if the applicant can justify their suitability for that use. Coal ash or low-permeability waste GP materials is not suitable for use as the exclusive material for the barrier layer. The applicant will be required to demonstrate there is no presumptive evidence of potential pollution of the waters of this Commonwealth through their proposal (25 Pa. Code § 86.37(a)(3)). These materials will not be allowed if they provide no demonstrable beneficial use other than convenience disposal regardless of any waste approval. See the technical guidance document titled “Beneficial Use of General Permit Materials at Active Coal Mines” No. 563-2112-001.

The Department allows the use of “Rec-Mix” admixture, a coproduct from slag combined with lime, as a protective subbase for the synthetic capping system only if the material does not have the potential to create additional pollutional discharge from the facility.

D. STANDARDS FOR LINERS

The following sections describe thickness standards, testing requirements, and related thresholds for proposed liners when utilized under the given conditions. In instances where site-specific engineering factors result in a need to deviate from the outlined design criteria, the operator must demonstrate to the Department that any alternative liner design is at least as equal and effective in protecting groundwater and surface water from pollution.

When determining the type of liner system to be constructed at a refuse disposal area, the applicant should determine the amount of hydraulic head which occurs on the system in question. Typical situations are as follows:

No Head or Non-Impounding Conditions for Coal Refuse Disposal Areas

No head or non-impounding condition are facilities where the preferential flow allows water to quickly drain for discharge or further treatment.

The Department has accepted suitable clay material where the liner system will not be subject to hydraulic head pressure, such as under temporary stockpile pad areas and coarse coal refuse piles and embankments.

LHC Soils – Clay

Low hydraulic head conditions occur at coarse coal refuse disposal area where preferential flow is towards the leachate system and continual head conditions on the liner system are not present because of the permeability of the coarse material used in construction. These factors allow for the use of clay in a liner system. The following items should be met for utilizing clay as a liner in a coal refuse disposal area.

1. Material

    a. Grain size distribution (ASTM D422) - 95% of the particles with a maximum dimension not greater than one inch where 50% or more must pass through the No. 200 sieve with no particles greater than 2 inches in diameter

    b. Atterberg limits (ASTM D4318) - plasticity index of 10 or greater

    c. Free from roots and debris

    d. Cannot be placed when frozen

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2. Compaction

   a. Standard proctor test (ASTM D698) for maximum dry density and optimum moisture content of clay using nuclear density gauge.

   b. Material compaction of 95% of the maximum dry density as determined by a standard proctor test (ASTM D698) or as required to obtain desired Hydraulic conductivity based on pre-qualification testing of materials.

   c. In-place density determined using a nuclear density gauge (ASTM D6938), non-nuclear density gauges, sand cones (ASTM D1556), or other industry-approved density testing methods.

   d. Hydraulic conductivity of $1x\ 10^{-7}$ cm/sec or less.

3. Thickness

   a. Justification provided for the proposed minimum thickness
   b. Minimum thickness for clay soil is 2.0 feet (0.61 m)
   c. Compacted soil lifts cannot exceed 10.0 inches in thickness

Low Head Conditions

When low head conditions exist, the specific discharge/permeability for a clay-soil lined impoundment should be calculated (and be no greater than 1×10^{-7} cm/sec) in addition to meeting the requirements for utilizing a clay liner in a coarse coal refuse disposal area. To calculate the specific discharge of the clay-soil material, use the following equation.

$$D_s = KI = K\frac{H + L}{L}$$

D_s = specific discharge (cm/sec)
K = hydraulic conductivity of liner (cm/sec)*
I = hydraulic gradient (dimensionless)
H = height of water above liner (length)
L = thickness of liner (length)

*Hydraulic conductivity test (ASTM D5084)

High Head Conditions – Synthetic Liner

High head conditions occur at facilities where water has the potential be held against the system for an extended duration due to confining material or considerable depth of water in an impoundment. The most common example is fine coal refuse slurry impoundments.

When a synthetic liner is proposed, the following manufacturer's information should be submitted with a demonstration of previous similar usage:

1. Certification specifying the material is a minimum of 30 mils
2. Specific discharge rate of 1 x 10^{-7} cm/sec or less
3. Quality Assurance/Quality Control information
4. Liner specifications

The U.S. Department of Labor's Mine Safety and Health Administration (MSHA) Engineering and Design Manual for Coal Refuse Disposal Facilities (Rev. Aug. 2010) is a useful reference for liner design.

Under Drains

To eliminate pressure from surface water, groundwater, or springs on the underside of the liner system, underdrains should be provided as a best management practice. This will create preferential flow to a downgradient drainage pathway rather than causing potential upheaval or degradation to the liner system.

Leachate Drains

Newly constructed CRDAs require a drainage system (leachate collection system) that creates a preferential flow to an appropriate treatment system. This prevents buildup of excessive hydrostatic pressure and aids in system stability. The effluent from the leachate collection system is sent to an appropriate treatment system prior to discharge.

E. STANDARDS FOR CAPS

Regulatory Requirement

25 Pa. Code § 90.50(b) requires the design submitted by an operator in their application to "prevent precipitation from coming into contact with the coal refuse". This language mirrors that of the statute. See 52 P.S. 30.56a(i) ("all new coal refuse disposal areas shall include a system to prevent adverse impacts to surface and ground water and to prevent precipitation from contacting the coal refuse…"). The Department acknowledges the limitations of any system to provide an entirely waterproof barrier and accepts the term "prevent" to mean minimize to extent physically and economically possible. As noted in the Preamble for the rulemaking that established Section 90.50(b) [*Pennsylvania Bulletin*, Vol. 31, No. 28, July 14, 2001 p. 3736]:

> *This statutory requirement was intended to ensure that precipitation contacting the coal refuse is kept to a minimum, thereby reducing the volume of water needing treatment after the site is closed. The system must be designed and installed in a manner that minimizes the amount of time coal refuse is exposed to precipitation.*

Additional Consideration for Caps

Additional capping considerations include erosion prevention, cracking and deterioration from exposure, anticipated activity or construction on the final capped area, settlement, and shifting.

Suitable final capping will reduce or eliminate effluent that can reach the liner or drainage system. Synthetic material is more durable and flexible than clay soils. Because clay soils are susceptible to drying out over time (desiccation) this can allow vegetation root systems to penetrate. Precipitation can more easily infiltrate through these pathways into the refuse resulting in a failure to reduce the post disposal outflow to the maximum extent practicable.

For those existing sites that do not have a robust liner previously installed, in addition to being a barrier to precipitation, the capping material is crucial for meeting the regulatory requirements for final bond release. Where a liner system has not been installed or is determined to be insufficient[1], and the facility remains open to the atmosphere, the operator should demonstrate that the chosen capping system minimizes degradation to the hydrologic balance. The use of clay soils on embankment outslopes may be treated separately from benches, terraces, crest areas, and other mildly graded top surfaces since preferential flow is to the atmosphere and subsequent downstream conveyance structure.

The following sections describe the requirements, standards, testing, and related thresholds for proposed caps when utilized under the given conditions.

Clay

Clay capping material is generally acceptable in the following situations: final coal refuse configuration or out slopes of the coal refuse have an overall slope of 1:2 vertical to horizontal (50%) and preferential flow is to the stormwater conveyance structure.

The following guidelines are for utilizing clay as a cap material, where applicable.

1. Material

    a. Grain size distribution (ASTM D422) - 95% of the particles with a maximum dimension not greater than one inch where 50% or more must pass through the No. 200 sieve with no particles greater than 2 inches in diameter

    b. Atterberg limits (ASTM D4318) - plasticity index of 10 or greater

    c. Free from roots and debris

[1] "Determined to be insufficient" means the Department has evidence that there is pollution occurring to the water of the Commonwealth from this facility.

d. Cannot be placed when frozen

e. The top/final 4.0 feet of the cap is suitable for revegetation as required by 25 Pa. Code § 90.125 – two (2') foot acceptable clay layer and a two (2') foot soil layer are suitable to maintain vegetative cover

2. Compaction

a. Standard proctor test (ASTM D698) for maximum dry density and optimum moisture content of clay using nuclear density gauge

b. Material compaction of 95 percent of the maximum dry density as determined by a standard proctor test (ASTM D698)

c. In-place density determined using a nuclear density gauge (ASTM D6938), non-nuclear density gauges, sand cones (ASTM D1556), or other industry-approved density testing methods

d. Hydraulic conductivity of 1×10^{-7} cm/sec or less

3. Thickness

a. Justification provided for the proposed minimum thickness
b. Minimum thickness for clay soil is 2.0 feet (0.61 m)
c. Compacted soil lifts cannot exceed 10.0 inches in thickness

<u>Synthetic</u>

In most cases, the Department considers use of synthetic material to be the current best management practice to prevent precipitation from contacting the coal refuse to the maximum extent practicable. Synthetic capping material is recommended where the final coal refuse configuration and areas where slope stability are not problematic - maximum allowable slope of 1:20 vertical to horizontal or less than or equal to five percent.

When a synthetic cap is proposed, the following manufacturer's information should be submitted with a demonstration of previous similar usage:

1. Certification specifying the material is a minimum of 30 mils
2. Specific discharge rate of 1×10^{-7} cm/sec or less
3. Quality Assurance/Quality Control information
4. Capping specifications
5. A minimum of 1-foot of topsoil or soil suitable to support vegetation on top of a flexible membrane cap

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6. A protective cover over the cap provided by a geotextile, sand, or soils, or other material that meets requirements established by the manufacturer

Alternative Designs

In instances where site-specific engineering factors result in a need to deviate from the outlined design criteria, any alternative system design should be at least as equal and effective in protecting groundwater and surface water from pollutive discharges. The alternate system should be designed by a qualified engineer with a goal to prevent precipitation from contacting the coal refuse when activity is completed and to prevent adverse impacts to surface and groundwater.
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F. PERMIT APPLICATIONS

The following information should be submitted by the applicant in the permit information:

Liners

1. Drawings showing the location, dimensions, and construction of each facility to be lined. Include type and thickness of liner and depth to groundwater.

2. Description (and analysis, if available) of the fluid or material to be retained by the liner, including a statement concerning the potential presence of oil, grease, solvents, etc. Include a statement regarding the compatibility of the liner and the waste type.

3. Specific discharge rate (D_s) for the liner (as designed).

4. Description of the equipment and procedures used to install the liner, including a construction quality assurance plan.

    a. For clay liners: address the availability of appropriate materials, type of compaction, lift thickness, methods of tying lifts together, installation on sloping surfaces, scarifications, etc., and a detailed description of the borrow area(s) that will serve as the source of the material. Include soil material processing procedures.

    b. For synthetic or other, address the method to be used to seal joints or seams.

5. Description of marker layers or other measures to be used to protect the liner when excavating materials.

6. Procedures and testing methods to be used when the subgrade must be prepared prior to liner placement.

7. Description of the method to be used to test the liner prior to putting it into service.

Caps

1. Drawings showing the location and dimensions of each facility to be capped.

2. Type of capping material and a justification for its suitability.

3. Description of the equipment and procedures to be used to install the cap, including a construction quality assurance plan. For soil cover, address type of compaction, lift thickness, methods of tying lifts together, installation on sloping surfaces, scarifications, etc. For all other types, address the method to be used to seal joints or seams.

4. For non-synthetic capping proposals, a demonstration that the system will prevent precipitation from coming into contact with coal refuse. This can be accomplished using a suitably predictive method of infiltration rate.

G. AS-BUILT TESTING AND ACCEPTANCE REQUIREMENTS

The following are for both liners and caps.

Clay

As part of the acceptance of the final clay liner or cap system, newly installed liners or caps should have in-place testing. All liners and caps should have an in-place density test and moisture determination with a nuclear density gauge at one test/acre/lift.

Testing must include the following (per acre unless specified):

1. Grain size distribution (ASTM D422)
2. Moisture-density relationship (ASTM D698)
3. In-place density (ASTM D6938)
4. Atterberg limits (ASTM D4318)
5. Total thickness verification
6. Permeability testing for impoundments require at one test per side and one on bottom (ASTM D5084)

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Synthetic

Synthetic material should be tested and certified for the intended use. Manufacturer specifications should be followed regarding testing of seams and visual tests for penetration. Manufacturers' specifications and material certification is required for installation of synthetic liners/caps. These items should be reviewed and approved by a qualified professional engineer prior to placement of the material on the liner or covering of the cap and should be reviewed and approved by California District Mining Office (Cal DMO) staff prior to putting the facility into service.

Other

Other material should be tested and certified for the intended use. Manufacturer specifications should be followed regarding testing of the system to ensure compliance with the permitted applicability. Manufacturers' specifications and material certification will be requested by the Department for installation of other material. These items should be reviewed and approved by a qualified professional engineer. Other material certifications should be reviewed and approved by California District Mining Office (Cal DMO) staff prior to putting the facility into service and placement of material on the system. With system certification submission to the Department, the operator should provide photographic documentation and a map showing the testing locations.

Facilities relying on alternative designs or modified testing protocols may be subject to additional in-place testing.

H. TEMPORARY CESSATION

During periods of temporary cessation exceeding 90 days, the operator submits to the Department a notice that includes the timing of the installation of the phased system to prevent precipitation from contacting the refuse. The operator must provide a narrative addressing the temporary cessation that includes plans to establish positive drainage to appropriate controls (25 Pa. Code § 90.167(d) and the hydrologic balance provisions of Subchapter D). The operator must also demonstrate that the clay, synthetic, or approved equivalent materials meet the quality requirements listed under Section C Standards of this guidance. If any deviations from the plan are considered, the operator should notify the Department before proceeding.

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