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Project Summary

Manual of Procedures and Criteria for Inspecting the Installation of Flexible Membrane Liners in Hazardous Waste Facilities

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Under the Hazardous and Solid Waste Amendments (HSWA) of 1984, certain landfills and surface impoundments are required to assure proper containment of wastes by the use of liner systems. Proper installation procedures for the flexible membrane liner (FML) system must be followed to ensure containment of wastes. This manual is intended to assist an inspector in performing all aspects of a proper FML installation inspection.

Four types of FMLs are addressed in this manual: PVC, CSPE, CPE, and HDPE. The manual covers seven installation operations. These operations include unloading and storage of FML, preparation and maintenance of supporting surface (both earth and other supporting surfaces), placement of FML on the supporting surface, seaming operations, anchoring and sealing (anchoring in earth and to concrete, piping, etc.), testing (both the seams and the integrity of the entire FML installation), and covering the FML (earth, concrete, geotextiles, or drainage nets).

The manual describes each operation and sub-operation, and gives recommended inspection procedures, inspection frequencies, and interpretations. The types of documentation necessary for each inspection are also discussed. Where appropriate, alternatives to recommended inspection procedures are provided. Inspection checklists are included for each operation to aid the inspector in the field.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH , to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

One of the major problems associated with hazardous waste landfills and surface impoundments has been hazardous leachate and associated groundwater contamination. Controlling leachate with flexible membrane liners (FMLs) is a function of proper liner selection, good design, and proper installation. Poor performance in any one of these three areas can cause an FML system to fail.

In terms of FML installation, defective field seaming, improper subgrade preparation, and bad seals around penetrations into the liner (such as drainage pipes) can be considered to be the most frequent causes, but there are several other factors which must also be considered. Poor weather conditions during installation, steep side slopes, vegetation growing through the liner, worker inexperience, insufficient anchoring, lack of protective cover, etc., may all contribute to liner failure. However, until this manual there were no set guidelines

which FML installers could follow for testing and inspecting these areas.

This manual is intended for use by engineering firms, dischargers of wastes to land, operators, and regulatory officials. The manual is intended to provide criteria and procedures for inspecting and testing FML installations in land-based waste containment facilities.

Throughout the inspection process, the inspector will work with representatives of the various participants including the general contractor, the subcontractor(s), and the design engineer. It is the responsibility of the inspector to ensure that installation design plans and specifications are followed. The inspector has the authority to reject the work until *noncomplying items (e.g., improper* seaming) are corrected or until field conditions (e.g., ambient temperature is too low/high) warrant resumption. It is essential that the inspector maintain a cooperative attitude toward FML installers while assuring proper FML installation.

Procedures

The information in this manual was derived from two principal sources—the published literature and interviews. An extensive literature review was conducted to identify various FML installation procedures in use or recommended by liner suppliers and installers. The bibliography of the manual contains over 130 references.

Secondly, a number of researchers and liner industry personnel who are involved in FML installation were contacted and interviewed. The combined literature search and interview process resulted in:

- An understanding of why inspections are important.
- Identification of areas needing inspection.
- Identification of tests, test frequency, and sample size.
- Identification of acceptance criteria.

Manual Contents

The manual is limited to discussion of the four FMLs most commonly used for waste containment:

- Polyvinyl chloride (PVC)
- High-density polyethylene (HDPE)
- Chlorosulfonated polyethylene (CSPE)
- Chlorinated polyethylene (CPE)

The manual is organized in seven chapters that sequentially cover each FML installation procedure, as follows:

- On-site unloading/storage of FML.
- Preparation and maintenance of the FML supporting surface.
- Placement of FML on supporting surface.
- FML seaming operations.
- FML anchors/attachments.
- FML testing, including seam testing and testing of the integrity of the entire FML installation.
- FML cover operations.

On-Site Unloading/Storage

The initial step of FML inspection is to make sure the specified FML type and accessories are delivered to the job site undamaged. This is primarily the responsiblity of the installation supervisor. However, the inspector should also make spot checks.

Once the FML is accepted as undamaged, it is important it be carefully unloaded onto a surface that is relatively level and smooth, free of rocks, holes and debris to prevent damage to the FML.

FML materials and accessories are best kept out of direct weather conditions to prevent possible damage from sun, wind, or moisture. Often the storage area is in the same location as the unloading area. If this is the case, the area must be large enough so that unloading, storage, and transport can operate smoothly. If the storage area is in a building, proper accessibility and maneuverability are of great value. If the storage area is open it should generally be fenced for security.

Specific sections and subsections in the manual that address inspection criteria and procedures for on-site unloading/storage are listed below.

- Material check:
  - —FML.
  - —Accessories.
- Unloading and handling equipment.
- Unloading area:
  - —Accessibility.
  - —Type.
  - —Location.
  - —Unloading and handling.
- Storage area:
  - —Type.
  - —Location.
  - —Climatic conditions.
  - —Other factors.

Preparation and Maintenance of Supporting Surface

For purposes of the manual, a supporting surface is defined as the surface on which the FML will be placed. For a single FML system, the supporting surface will probably consist of compacted earth, concrete, asphalt, or other material. If a second FML is specified (a double FML system), the supporting surface for the top FML will generally consist of a drainage net, a granular soil layer, and/or a geotextile fabric.

Whether a single or double FML system, it is assumed that the supporting surface has been brought to final grade, and that the soil subgrade (if applicable) has been compacted and is structurally sound.

If the supporting surface is soil, the inspector should be aware that the soil type will effect the installation procedure. For example, clayey soils form surface cracks when dried, and sandy soils form depressions under foot and vehicular traffic. A table containing soil characteristics pertinent to FML installations is included in the manual.

A soil supporting surface should be free of all vegetative growth prior to final preparation. Burrowing animals (e.g., gophers and ground squirrels) should also be removed and/or their tunnels destroyed. Final preparation consists of removing all clods, pebbles, etc., filling voids, and rolling/compacting the surface.

After the supporting surface has been accepted for FML placement, it is important to maintain its integrity by mitigating or correcting damage caused by wind or storm water erosion, and saturation or ponding by storm water.

Supporting surfaces other than soil (e.g., concrete and asphalt) must also be inspected to assure that they are smooth, free of surface voids or depressions, and that there are no abrupt changes in abutting surface elevations.

The specific sections and subsections as they appear in the manual are as follows:

- Soil supporting surfaces:
  - —Type of soil.
  - —Vegetation removal.
  - —Burrowing animals, ants, and other pests.

—Preparation of finished earth supporting surface
—Maintenance of earth supporting surface.
- Other supporting surfaces:
—Concrete.
—Asphaltic supporting surfaces.
—Geotextile fabric.
—Drainage layers.

Placement of FML on Supporting Surface

Placement of FML on the supporting surface includes: transporting the FML to the working area; removing the FML from its packaging; and spreading the FML sheets in their appropriate locations, making sure each FML is not damaged (e.g., has no holes, etc.) and is ready for seaming.

Prior to commencing placement of the FML, the inspector should first ensure that placement equipment is on site and in working order; a sufficient number of qualified placement personnel are on site, and weather conditions are suitable.

Specific sections and subsections in the manual discussing placement inspection criteria and procedures are listed below.

- Placement equipment.
- Personnel
- Weather conditions.
- FML layout:
—Type of FML
—Thickness of FML.
—Accessibility.
—Placement on slopes.
—Placement around penetrations.

Seaming Operations

FML seams can be prepared either in the factory or in the field. Factory seams are manufactured in a controlled environment, and seam quality is generally superior to field seams. Since the field inspector is not responsible for observing the making of factory seams, only a brief summary of factory seaming techniques is provided in the manual as background. However, the overall quality assurance/quality control program should require factory inspections.

The primary thrust of the manual is to discuss field seaming operations and the inspection thereof However, the discussion is necessarily general because each FML manufacturer/fabricator has specific (and often proprietary) seaming equipment and seaming procedures.

Prior to the start of FML seaming operations, the manufacturer should provide the inspector with precise specifications on the equipment and procedures that will be used to seam their material in the factory and field. In addition, the inspector should meet with the manufacturer's/fabricator's representative for an explanation and demonstration of the seaming equipment and procedures to be used on the job.

Seaming methods described include liquid applied solvent or adhesive methods; thermal methods; vulcanizing tapes and adhesives; and tape and mechanical seaming methods.

Specific sections and subsections in manual discussing seaming inspection criteria and procedures are listed below.

- Seaming methods
—Factory seams.
—Field seams.
- Equipment.
- Personnel.
- Environmental conditions.
- Seaming.

Liner Anchors/Attachments

One of the most common areas of failure in an FML installation is the attachment of the FML to another surface. In general, these attachments consist of perimeter anchors or attachments to structures, such as pipes or columns, within the facility.

The manual provides the inspector with guidance on specific types of anchors/attachments, and also delineates several general practices and procedures that should be followed. These include ensuring that placement equipment is on site, in working order, and that a sufficient number of qualified placement personnel are on site

Specific sections and subsections in the manual discussing liner anchors/attachments inspection criteria and procedures are listed below.

- Placement equipment.
- Personnel
- Anchors/attachments.
—Earth anchor trenches.
—Inspection procedures.
—Concrete and piping.
—Concrete.
—Battens and bolts.
—Reglets.
—Piping.

FML Testing

This chapter of the manual introduces the inspector to methods that are used to test factory and field seams and patches. These test methods can be destructive and/or nondestructive. Nondestructive tests are performed in the field on in-place FML. Testing is performed by the contractor and should be observed by the inspector. This type of test retains the integrity of the FML seam or sheet being tested. Destructive tests are performed in either the field or laboratory. The intent is to determine the strength characteristics of a seam sample by stressing the sample until either the seam or the FML sheeting fails. Only tests performed in the field should be observed by the inspector; however, the inspector should review laboratory test results to ensure acceptable results were obtained.

Destructive tests can be performed on samples taken from either in-place FML seams, sheets, and patches (destructive sampling), or on samples of representative FML seams and patches fabricated by the seaming/patching crew from the same material, and using the same seaming methods as those being used to make the in-place seams and patches (nondestructive sampling). The inspector should verify that the type of samples used are those specified in the quality assurance/quality control plan.

Field test methods described in the manual are probe, air lance, vacuum box, ultrasonic pulse echo, ultrasonic impedance plane, spark, pressurized dual seam, electrical resistivity, hydrostatic, seam strength peel, and seam strength shear tests. Laboratory test methods described are the bonded seam strength shear and bonded seam strength peel tests.

Specific sections and subsections in the manual discussing FML testing inspection criteria and procedures are listed below.

- Field tests:
—Air lance.
—Probe.
—Vacuum box.
—Ultrasonic pulse echo.
—Ultrasonic impedance plane.
—Spark testing.
—Pressurized dual seam.
—Electrical resistivity.
—Hydrostatic.
—Seam strength, peel.
—Seam strength, shear.
- Laboratory tests:
—Bonded seam strength, shear.
—Bonded seam strength, peel.

FML Covers

The primary function of the inspector is to ensure that the FML is not damaged during cover placement operations. Covers over an FML will generally consist of earth (clay [natural and/or bentonite added], sand, silt, gravel, or a combination of soils) or some other material such as portland cement/gunite, geotextile or drainage net.

The majority of the above covers are placed over an FML as a protective layer against mechanical, weather or other potential damage Drainage nets and sand and gravel are used as a permeable layer to convey leakage and/or leachate that may accumulate on the upper and/or lower FML after put into use.

Specific sections and subsections in the manual discussing cover type and placement inspection criteria and procedures are as follows:

- Soil covers:
  - —Equipment.
  - —Personnel.
  - —Weather conditions.
  - —Earth cover placement.
- Portland cement concrete/gunite:
  - —Equipment.
  - —Personnel.
  - —Weather conditions.
- Drainage nets and geotextiles.

Conclusions

An improperly installed FML is little better than no liner at all, and may actually be worse, because it provides a false sense of security. Consequently, the role of the inspector in ensuring proper FML installation can be critical. The inspector needs to be aware of all procedures and criteria essential for proper installation, from unloading and storage at the site through actual placement and final cover.

Use of the manual described herein should lead to standardization of inspection procedures and insurance that FMLs at hazardous waste sites are properly installed.

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The complete report, entitled "Manual of Procedures and Criteria for Inspecting the Installation of Flexible Membrane Liners in Hazardous Waste Facilities," (Order No. PB 88-131 313/AS; Cost: $19.95) will be available only from:

National Technical Information Service
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