Minnesota Pollution Control Agency

High Density Polyethylene Liner Guidance

I. General

Scope

These guidelines describe the materials, installation, and testing of High Density Polyethylene (HDPE) liners. These guidelines have been developed by the Minnesota Pollution Control Agency (MPCA) and are intended to serve as recommended minimum requirements for the design, installation, and testing of HDPE liners. These guidelines are not, however, intended to replace competent engineering documents and practices produced and undertaken by qualified and experienced engineering designers and inspectors. Specifications issued by the engineer that deviate from these guidelines may be allowed; however, justification for these changes will require approval by the MPCA. The intended use of these guidelines is for applications involving municipal sewage and approved industrial wastes. These guidelines do not guarantee that the liner, when installed, will not fail during initial operation or at any time in the future. However, the information contained within should provide the engineer a firm basis for designing, specifying, and inspecting a HDPE liner.

In addition to this guidance, for stabilization ponds and aerated ponds, the MPCA has Recommended Additional Guidance

Pond Design Criteria that should be consulted for additional details about pond construction: http://www.pca.state.mn.us/index.php/view-document.html?gid=11503.

Prior to the placement of any synthetic liner, a pre liner inspection must be completed by the MPCA review engineer in accordance with the Prefill and Water Balance Criteria which can be found at http://www.pca.state.mn.us/index.php/view-document.html?gid=15336.

II. Materials/Handling

The MPCA requires a minimum thickness of 40 mil for HDPE liners. For exposed HDPE liners 100 mil is required (see section H of this document).

Test requirements can be found at the end of this document for both smooth and textured HDPE.

The Geosynthetic Institute (GSI) standard specification for "Test Methods, Test Properties and Testing Frequency for HDPE Smooth and Textured Membranes" describes material and testing requirements. This specification serves as material and testing requirements and are hereby, incorporated by reference. The tables included in the GSI guidance include all testing results that need to be submitted. The most current version can be found at: http://www.geosynthetic-institute.org/grispecs/gm13.pdf, the required results area also included as part of this fact sheet. Results of required tests must be submitted to the MPCA.

"The table in this MPCA guidance document is only a summary of the material properties contained in GSI standard specifications, GRI Test Method GM13, Revision 9, dated June 1, 2009. The values in this guidance document may not reflect the most resent version of the standard specifications. Any subsequent revisions to GRI Test Method RM13 shall be complied with and are hereby incorporated as part of this document."

Minnesota Pollution Control Agency • 520 Lafayette Rd. N., St. Paul, MN 55155-4194 • www.pca.state.mn.us
651-296-6300 • 800-657-3864 • TTY 651-282-5332 or 800-657-3864 • Available in alternative formats

Property	ASTM test method	40 mil (smooth)	100 mil (textured)
Thickness (mils)	D5199	40	100
Asperity Height	D7466	Na	10 mil
Density (g/cc)	D1505/D792	0.940	0.940
Tensile Properties	D6693 Type IV		
Yield Strength ((lb/in)		84	210
Break Strength (lb/in)		152	150
Yield elongation		12%	12%
Break elongation		700%	100%
Tear resistance (lb)	D1004	28	70
Puncture Resistance	D4833	72	150
Stress Crack Resistance (hours)	D5397	300	300
Carbon Black content	D1603	2.0-3.0%	2.0-3.0%
Carbon Dispersion	D5596	9 in Category 1 and 2 1 in Category 3	9 in Category 1 and 2 1 in Category 3
Oxidative induction time (OIT) (min.) – Standard	D3895	100	100
Oxidative induction time (OIT) (min.) – High Pressure	D5885	400	400
Oven Aging at 85C Standard OIT	D3895	55%	55%
Oven Aging at 8 High Pressure OIT	D5885	80%	80%
UV Resistance High Pressure OIT	D3895	50%	50%

Liner material, at a minimum, should meet the following requirements in addition to those found in the GSI standard specification:

1. Liner material should be supplied as panels to the site on labeled rolls. Labels on the rolls shall identify the thickness, length, width, date of manufacture, unrolling directions and identify any additional information deemed necessary by the engineer or manufacturer.

   This basic information will allow the inspector to quickly check and verify that the correct material is being delivered.

2. Rolls of liner material stored on site must be protected to keep polyethylene sheeting clean and dry. Dirt and wetness are two common causes for seam failures.

3. In addition to the manufacturer's certification at the time of shipment, a minimum of three random samples or one random sample for every ten acres of lined surface, whichever is greater need to be taken. These samples must be tested by an independent testing laboratory for thickness, density and tensile properties and reported to the engineer or contractor.

   Testing of random samples provides a check that shows if the material that was supposed to be supplied to the site is in facet being installed. Payment of these tests should be determined by the engineer and included in the contract documents as appropriate.

III. Installation

A. General

The intent of this section is to define the work and responsibilities related to the installation of HDPE for containment applications and groundwater protection. Liner installation includes, but is not to be limited to preparation of the subgrade, placement and seaming of liner panels, sealing around all appurtenances, patching and repairs to the liner, seam, and materials testing, covering of the liner and any other procedures necessary to attain proper installation of the liner.

1. With the bid, the contractor should name the proposed manufacturer and fabricator of the HDPE liner. At the time of shop drawing submittal, the contractor should provide a certification from the manufacturer stating that the subgrade preparation and cover material specifications will meet or exceed the requirements of the manufacturer and will adequately protect the manufacturer's product from damage.

   It is desirable that the manufacturer state that the subgrade specifications meet their requirements so that they will not reject the site when it is ready for liner

2. Upon acceptance of the project by the owner, the contractor is required to provide the owner with a liner warranty or a performance bond on the installation of the liner. The bond should cover all appropriate items that would cause the pond to leak beyond the 500 gallon/acre/day leakage requirement, i.e. rocks, abrasion, settlement, seaming, construction technique, ice, etc.

   This bond should be of sufficient dollar value to cover labor and materials to fully repair the liner and remedy the problem. This should include, but not limited to removal and replacement of the riprap, geotextile fabric, cover material, liner, subgrade, etc.

   Requirements of the warranty should cover liner materials. The engineer should consider including other items, such as seams/seaming, puncturing, etc. Bonding for the liner installation is at the discretion of the owner. The engineer should determine a specific dollar value for this bond sufficient to cover those items listed.

3. At the time of shop drawing submittal the liner manufacturer/contractor should furnish to the engineer a liner panel layout as required for liner installation. Liner layout should minimize the amount of seams located on the dikes running parallel to the dikes.

   Horizontal seams on dike slopes are always in a stressed condition that can lead to seam failure. If possible, they should not be allowed. Transverse seams on the pond bottom should be staggered so they do not line up.

4. Subgrade should be inspected by the liner installer prior to placement of the liner. Upon completion of the inspection, the installer shall either identify any workmanship and/or materials which are believed to not be in compliance with the project plans and specifications, or if subgrade is found to be adequate, issue a certification to that effect to the contractor. The contractor shall forward this certification to the owner/engineer.

5. Prior to placement of the liner, a preliner inspection must be performed by the MPCA. See Prefill and Water Balance Guidance for requirements (http://www.pca.state.mn.us/index.php/view-document.html?gid=11503).

6. Liner installation must be performed under the direction of a full time experienced installer. Installer needs to possess the technical expertise and authority to direct and certify all work related to the installation of the liner. The installer will identify in writing substandard workmanship and/or materials to the engineer.

   In the specifications the engineer must identify the amount of experience the installer is required to have. Directing the installation of at least three similar jobs or posting a bond for inexperienced installers is considered minimal.

7. Manufactures installation and seaming guidelines regarding ambient air and liner surface temperature (both extreme high and low) must be followed during installation. Failure to do so can void warranty and result in liner failure.

B. Subgrade

Any soil in contact with the liner must meet the following requirement:

The six inches of soil immediately beneath the liner shall be inorganic, free of all rocks, stones, sticks, and debris of any kind, with no particle larger than three-eighths inch diameter. Not more than 50 percent by weight of this material shall be between one-fourth and three-eighths inch diameter. Angular, sharp material is not allowed in the subgrade, regardless of diameter.

In addition, the underlying soils should be stable and relatively incompressible. Unsuitable underlying soil conditions should be corrected.

The determination of conformance to the subgrade requirement should be made by the engineer in consultation with a geotechnical firm during the preparation of plans and specifications. The engineer should select an appropriate type of subgrade to meet specific job requirements. The Minnesota Department of Transportation (MN/DOT) specification number 3149 for fine filter aggregate is an acceptable subgrade/cover requirement.

The following are three examples of subgrades for installation of a synthetic liner. If the engineer has determined that native soil will not meet subgrade requirements, then consideration should be given to bidding both items two and three below as alternatives. The haul distance and/or screening cost will influence where the breakeven point between the two alternatives is.

1. If native soil at the liner elevation meets subgrade requirements, no additional work is needed except for compaction.

    a. Surfaces to be lined should be excavated to the elevation of the liner and compacted to 95 percent of the standard proctor density.

    If there is any uncertainty about the acceptability or quantity of onsite native soils for direct contact with the liner, the engineer should consider a bid item for importing acceptable subgrade material. An estimate of the quantity of material needed and identification of borrow sites or other known sources of material should be included in the specifications. If subgrade material is needed and has to be hauled to the pond site, the inclusion of the bid item will help avoid an unexpected cost increase for hauling subgrade material. If a sufficient quantity of acceptable native soil is on site, the imported material can be deducted from the contract.

2. If native soil at liner elevation does not meet subgrade requirements, replace the top six inches of soil with acceptable material and compact.

    a. Surfaces to be lined must be excavated to a depth six inches below the elevation of the liner and compacted to 95 percent of the standard proctor density.

    b. Six inches of fill material meeting the subgrade requirements must be backfilled in areas to be lined. This layer will also be compacted to 95 percent of the standard proctor density.

    c. Where excavation greater than six inches is required as determined by the engineer or geotechnical firm, fill material must be placed according to the engineer or geotechnical firms recommendation and compacted to 95 percent of the standard proctor density. The top six inches of this fill shall meet the subgrade requirements.

3. If native soil at liner elevation does not meet subgrade requirements, place a geotextile fabric above and below the liner to protect it from punctures. No additional work is needed except for compaction and possibly some rock removal.

    a. Surfaces to be lined will be excavated to the liner elevation and compacted to 95 percent standard proctor density to provide a smooth flat surface. All rounded rocks protruding more than one inch and all sharp protruding rocks must be removed.

    b. A nonwoven geotexile fabric must be installed at all locations to receive liner. The fabric shall be a minimum of 7 oz/sq yd or 200 gm/sq m. The liner shall be placed directly upon the fabric.

    c. Following the liner placement, a second layer of nonwoven geotextile fabric (min 7 oz/sq yd) must be placed above the liner. Soil cover material will be placed on the fabric containing no rocks larger than four inches in diameter.

Subgrade General Requirements:

1. The subgrade must be graded or rolled to provide a smooth flat surface for placing the liner to within (+,-) 0.2 feet of design elevations. No abrupt changes in grade shall occur, such as vehicular ruts.

    Ruts force the liner to span the gap unless the liner perfectly conforms to the rut. When cover material is applied, the liner will stretch and may fail.

2. Liner must be sloped to avoid gas buildup below the liner. Consideration may also be given to providing a method of gas venting.

   The venting of air or other gases from under the liner is generally not necessary for a pond system with at least four feet of separation from the seasonal high water table and the liner. The bottom of a properly designed pond should have the subgrade and liner sloped in the range of 0.5 to 2.5 percent from the center of the pond to the dikes to ensure that air cannot be trapped under the liner. If the groundwater table is highly variable or large areas of organic material are present, venting may be considered.

   All vent outlets must be at least two feet above the high water elevation. Surface vents shall be placed with the vent opening facing down slope so that no surface water runoff can enter the vent opening.

   Vent pipes or draintile shall not be placed directly under the pond liner. If piping is used for vents, they shall be placed around the perimeter of the pond so that a pipe failure were to occur, it will not compromise the liner integrity.

3. During liner placing and seaming the subgrade must be kept free of standing water. If subgrade below the liner becomes wet and unstable, it must be dried and recompacted.

   A wet subgrade will lose its compaction, during the covering operation; equipment may cause subsidence of the subgrade resulting in failure of the liner.

C. Placement

1. Liner panels should be laid out according to plans supplies by the manufacturer and no deviation will be allowed except with approval of the engineer.
2. Liner panels must be secured in an anchor trench as determined by the engineer.

   Anchor trench size and location may be determined empirically or with design calculations. Anchor trench will vary depending on liner thickness, dike slope, etc. Design Calc. Ref. Designing With Geosynthetics, Robert M. Koerner, 1986.

3. Liner panels will be overlapping according to manufacturers' recommendation. Overlap distance must be sufficient so that all seam tests can be performed as stated in the various test procedures.

   Typical overlaps are three to six inches. There should be no loose flap on the top side of the liner, resulting from the overlap should be cut off to avoid catching during covering.

4. At no time during liner placement shall any vehicle be allowed directly on the exposed liner.

   Puncture of the liner will result regardless of the subgrade.

D. Seaming

1. All welds for seaming of HDPE panels will be made according to manufacturer's recommendations.
2. Welding equipment used for seaming should be capable of producing a continuous homogenous bond at every location, meeting seam strength requirements.

   Seam failure is the leading cause of liner failure.

3. Patches and repairs to the liner should be made within 48 hours of discovery of the defect using an extrusion welding technique or another welding technique approved by the engineer. Hand held hot air welding will not be allowed for general welds, patches, or repair welds.
4. Patches should be placed as soon as possible to avoid missing them. Hand held hot air welding should be used for tacking only since it does not produce an acceptable final weld for patches or seams.

   Patches should be made from the same material as the liner and have a continuous rounded edge with no distinct corners.

   Patches should be rounded to avoid corners that could catch during covering and rip off.

5. Fish mouths are not allowed. A fish mouth is defined as an area in the seam where one liner panel is first folded over on itself and a second liner panel is placed and welded over this fold. Where fish mouths occur, the liner must be cut, overlapped and covered with a patch.

   Fish mouths that are not properly repaired will leak.

6. All general welds, repair welds, and patches shall meet the following seam strength requirements:

    a. **Shear Strength**: The seam, when stressed perpendicular to the direction of the weld, should not under any condition fail before stretching and breaking of the liner panel adjacent to the weld.

    The actual numerical value of the shear strength of any sample at yield should not be less than 90 percent of the sheet tensile strength at yield as determined by independent laboratory tests performed on the actual liner material shipped to the site.

    The shear test will determine if excessive damage to the liner has occurred during the welding process. Test Method: ASTM D 3083.

    b. **Peel Strength**: The seam, when stressed in the 90 or 180 degree peel condition should not separate at the weld along the original contact area of the two liner panels or pieces. The liner adjacent to the weld should stretch and tear away from the welded seam before the weld breaks.

    The peel test will determine the actual seam strength and reflects the quality of the field welds. Test Method ASTM D 413.

E. Startup Testing

1. Daily, upon beginning of liner panel seaming with each crew, destructive and non-destructive seam testing should be performed to calibrate seeming equipment until the welds made by each seaming crew passes seam strength requirements. Startup testing shall be done under conditions representative of those on the pond liner to be seamed.
2. All test seams should be tested in accordance with seam testing procedures and must pass seam strength requirements before use or continued use of seaming equipment or personnel is allowed.

    This testing does not preclude startup on scrap material. It is intended so that when seaming does begin on the liner, passing welds are being immediately produced.

F. Seam Testing

1. Non-destructive testing

    a. Non-destructive tests should be performed by the contractor or engineer on all field seams, patches, and repair welds.

    b. This test should be performed by running a blunt instrument along the edge of the seam to find obvious unbonded areas.

    This is a quick and easy test that has a history of finding obvious bad seams that cannot be detected by eye. Test gives no indication of seam strength

    c. Vacuum box testing should be performed on every inch of every seam and patch.

2. Destructive Testing

    a. Destructive testing should be performed on all field seams. Destructive testing may be done on all patches and repair bonds as required by the engineer.

    Destructive testing is the only way to get an indication of seam strength. Destructive tests done on scrap samples will not be allowed to fulfill this requirement, since they cannot be made under the same conditions as seams.

    b. A tensiometer must be provided on the construction site during liner installation for the purpose of testing samples. Samples must be tested immediately by the inspector. The inspector should maintain a log of all sampling events. The log needs to include location, date, and time of the sampling events and include the outcome of all tests including numerical values. Upon completion of the liner installation, copy of this log should be forwarded to the owner.

    The tensiometer should be supplied by whichever party the engineer deems appropriate and included in the contract documents.

    c. Samples for destructive testing must be cut by the contractor at locations identified by the inspector. Test samples shall be of sufficient size to fulfill the requirements of the intended testing procedure(s).

    Independent testing laboratories may require different size samples to run seam tests. This should be checked beforehand.

d. Upon removal of sample, a patch made from the same material as the liner must be placed over the hole and bonded to the liner.

   Extrusion welding for patches and detail work is at the present time the only good method for this work.

e. Samples should be taken at the following frequency:

   1) One sample per 500 feet of seam or one sample per each seam length, whichever provides for the greatest number of samples. At least one of these samples per day should be divided in half with one half being tested with the on-site tensiometer and the other being sent to an independent testing laboratory for testing of shear and peel strength.

      Sampling frequency should be increased by the engineer if seaming problems are being encountered.

      Checking field and lab tests will allow for a comparison of the accuracy of the on-site tensiometer against the laboratory tests, lab tests are assumed to be more accurate.

   2) Two samples per dike face must be tested by both the on-site tensionmeter and independent testing laboratory.

      Any remaining field sample should be labeled and saved until lab test results are received.

   3) Additional samples should be taken at any location as directed by the engineer.

      Dikes are the most difficult areas to weld. Sampling and testing should be done at the frequency, which will ensure that good seams are being produced.

f. Field samples should be tested for both shear and peel strength. Failure of either test will cause the weld to be rejected at this location.

g. Upon rejection of the original sample, two new test samples should be removed and tested. These samples must be taken at a maximum of ten feet on each side of the original sample. Subsequent failure of these samples will cause the testing to move further down the seam until the extent of the faulty seam has been determined. All faulty seam areas should be bounded by two passing test samples.

h. Faulty seams should be repaired by placing a patch over the entire faulty seam area and welded.

i. All seams and haul roads should be accurately depicted on the as-built drawings.

G. Cover

1. As a minimum, a uniform 12-inch layer of cover material should be placed on the liner. For exposed HDPE Liner, see the “Exposed HDPE Liner guidance” found in part H of this document.

   Cover material depth will be greater in the center of the pond due to the slope on the subgrade. This is a good location for haul roads if used.

   The six inches of soil immediately on top of the liner shall be inorganic, free of all rocks, stones, sticks, and debris of any kind, with no particle larger than three-eighths inch diameter. Not more than 50 percent by weight of this material shall be between one-fourth and three-eighths inch diameter. Angular, sharp material is not allowed in the subgrade, regardless of diameter.

   Minnesota Department of Transportation specification number 3149 is acceptable for cover.

2. Placement of cover material should be done in such a manner as to preclude any damage to the liner.

   Sharp turning or abrupt stops and starts by equipment on the liner cover soil can cause damage to the liner.

3. Upon completion of the covering operation, the cover material should be smoothed to the required elevation (+,-) 0.2 feet.

H. Exposed HDPE liner

The MPCA requires a minimum thickness of 100 mil for exposed liners.

1. In addition to the above requirements for HDPE Material, Testing and Installation, the following needs to be addressed if an exposed HDPE liner is being installed:

   a. For safety reasons, textured HDPE must be used on dike faces.

b. To further eliminate seaming, textured HDPE is encouraged to be used for the entire liner rather than seaming with a smooth HDPE for the bottom.

c. For exposed HDPE lined ponds, ropes must be anchored, at a minimum, in each corner of the pond to provide an escape route.

d. If chemical addition will be used in the pond, consideration must be given to vehicle/boat access to the pond.

e. Ballast are required at the toe of the interior dike to counteract buoyancy of the liner.

f. Prior to placement of the liner, a preliner inspection must be performed by the MPCA. See Prefill and Water Balance Guidance for requirements (http://www.pca.state.mn.us/index.php/view-document.html?gid=11503

g. Anchor trench recommendations from the manufacturer must be followed.

I. Boots

Effective seams and seals around pipes penetrating through the liner or around other structures are critical to preventing leaks. Pipe boots are frequently found to be the cause of leakage at ponds that do not pass the water balance test.

Boots around pipe penetrations should be of the same material and thickness as the specified liner. Manufacturer's recommendations for attaching the boot to the pipe and seaming the boot to the liner shall be followed. All pipe boots shall be appropriately sized to the dimensions of the pipe and fit snugly with no wrinkles or fishmouths. The liner under the boot must remain in contact with the subgrade surface.

When stainless steel pipe bands are used to clamp the boot to the pipe, the straps shall not be placed in direct contact with the pipe boot material. A neoprene gasket, or other material specified by the manufacturer shall be placed between the liner and pipe band.

IV. Certification

Upon completion of the covering operation, the contractor should certify in writing to the owner that all materials, equipment, and construction have been completed in conformance with the plans and specifications.

V. Water Balance Test

After completion of the liner installation, and before any water may be added to the pond, a prefill inspection must be completed by the MPCA. If the completed construction passes inspection, authorization will be granted to begin filling the pond with enough water to perform a water balance test. Prefill inspections and water balance testing shall be in accordance with the MPCA's Prefill and Water Balance Criteria, which can be found at:

http://www.pca.state.mn.us/index.php/view-document.html?gid=15336.

VI. Warranty

Upon acceptance of the project, the owner should be provided with a liner system warranty and/or performance bond which cover all appropriate items that would cause the pond to leak beyond the 500 gal/acre/day leakage requirement, i.e. Rocks, abrasion, settlement, seaming, construction technique, ice, etc. This warranty or bond should be of sufficient dollar value to cover labor and materials to fully repair the liner and remedy the problem. This should include, but not limited to detection of the leak, removal and replacement of the riprap, geotextile fabric, cover material, liner, subgrade, etc. The terms of the warranty and length of coverage should be specified in the contract documents to assure comparable bids. Manufacturers typically provide prorated material warranties ranging from 1 to 30 years depending on the specific application. Installation warranties are generally specified as one to five years in length.

Bonding for the liner installation is at the discretion of the owner. The engineer should determine a specific dollar value for this bond sufficient to cover those items listed.