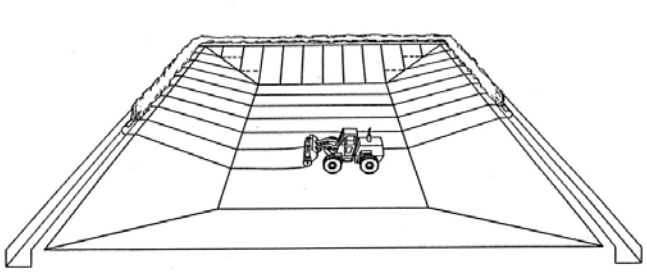
Technical Reference Document for Liquid Manure Storage Structures

SYNTHETIC LINERS

TABLE OF CONTENTS



Installation of a plastic liner into an earthen manure storage structure

SECTION 1 - PURPOSE AND SCOPE

1.1. Purpose of the Standard – The Technical Reference Document *Synthetic Liners* provides specifications and construction procedures to Engineers for the design of synthetic liners for the conditions of Manitoba.

1.1.1. . This standard is intended as a supplement to the Technical Reference Document Earthen Manure Storage Structures.

1.1.2. In Manitoba, the regulatory agency is Manitoba Conservation.

1.1.3. The general information that is required by the regulatory agency for obtaining a construction permit for an earthen manure storage structure comprising of a synthetic liner is specified or referenced herein.

1.2. Requirement for a Synthetic Liner – Depending on the site's geological and hydrogeological features, earthen manure storage structures may be required to contain a liner. If good clay or clay-till is not available at a reasonable distance from the site, a clay-based liner may not be possible. In such cases acceptable containment and seepage control is still possible with the use of a synthetic liner.

1.3. Definitions – Synthetic liners are very low permeability manmade membranes or barriers used to control fluid migration in an earthen manure storage structure. They are also referred to as geomembranes and can be polyvinyl chloride (PVC) or high density polyethylene (HDPE).

SECTION 2 - RESPONSIBILITIES OF THE ENGINEER

2.1. Qualifications – The Engineer responsible for the design, inspection and certification of an earthen manure storage structure comprising of a synthetic liner shall be licensed to practice engineering by the Association of Professional Engineers and Geoscientists of the Province of Manitoba.

2.2. Responsibilities – The above Engineer shall comply with the Technical Reference Document *Role and Responsibilities of the Engineer (RRoE)*.

2.2.1. Notwithstanding the requirements outlined in this Technical Reference Document, the Engineer must ensure that the design meets any other standards or document of the Technical Reference Manual for Liquid Manure Storage Structures that apply.

2.2.2. It is the responsibility of the client and the developer, where applicable, to ensure that the contract between the developer and the Engineer is adequately covering the design, supervision and construction requirements set out herein and any other standards or document in the Technical Reference Manual for Liquid Manure Storage Structures that apply.

2.3. Completeness of Design – The Engineer whose professional seal appears on the design drawings is responsible for both the completeness of data acquired and the design of the synthetic liner.

Plastic liner used to line an earthen manure storage structure

2.4. Other Acts and Regulations – The Engineer is responsible for complying with all of the relevant Acts and regulations in force in Manitoba.

2.5. Other Standards – Provincial, national and international standards and their respective abbreviations are listed in Section 13. In all cases, the most current edition of the referenced standard is implied. Additional relevant documents are also referenced in section 12.

SECTION 3 - INFORMATION REQUIREMENTS

3.1. Submissions – The information required for the evaluation of an application for a new, expanded or modified earthen manure storage structure is outlined in the Technical Reference Document *Earthen Manure Storage Structures*. For the purpose of evaluating an application for an earthen storage structure that is comprised of a synthetic liner, the Engineer shall submit to the regulatory agency additional information including, but not limited to the following details of the synthetic liner design and site characteristics:

3.1.1. A design summary including:

- storage wall section design;
- degradation control provisions for the exposed surfaces of the liner;
- details of erosion control and sealing procedures around pipe inlets, pumping or agitation pads and overflow or transfer devices;
- transportation patterns, vehicular loading and any limitations to vehicular traffic;
- requirements for installation;
- any specific liner material installation procedures required by the manufacturer;
- documentation from the manufacturer certifying the liner design and construction;
- construction notes;
- site specific operational notes (if the design is dependent on specific operation and management factors);
- proposed system for detecting pollution or leaks; and
- details of monitoring well design.

3.1.2. Geotechnical information including:

- material specifications;
- description of soil testing and analyses;
- all applicable soil testing results; and
- depth to seasonal high ground water.

3.1.3. Recommendations for regular inspection, maintenance and repair of the liner, including:

- the frequency of inspection, critical features to inspect and method of inspection (visual, monitoring data etc.);
- procedures for regular maintenance and preventative repairs; and
- contingency plans that include procedures for the repair of damaged features.

Inspection, maintenance and preventative repair recommendations shall include but are not limited to:

3.1.3.1. Annual inspections – Annual inspections by a qualified professional are necessary to ensure the integrity of the synthetic liner is maintained. The liner should be inspected for the following:

- evidence of erosion;
- exposure of the liner;
- wheel damage;
- any penetration/puncture damage;
- evidence of seepage under the liner;
- accumulation of leachate in subsurface drains or any secondary containment systems; and
- signage for adequacy and visibility.

SECTION 4 - GEOMEMBRANE LINERS

4.1. Design Criteria – The design of the geomembrane liner shall take into account the following:

4.1.1. Liner Thickness – A minimum liner thickness of 30 Mil PVC (non-reinforced) or 60 Mil HDPE shall be used where subgrade can be smoothed as outlined in Section 6.

4.1.1.1. Wherever the subgrade cannot be prepared as outlined in Section 5 and a PVC liner is used, a thickness greater than 30 Mil and/or reinforced geomembrane or bedding material such as sand or geotextile cloth, shall be used upon approval by the regulatory authority.

4.1.2. The Inside Wall Slope – The slopes of the inside walls shall be no steeper than 3:1 (horizontal:vertical) for HDPE liners and no steeper than 4:1 for PVC liners.

4.1.3. The coefficient of thermal expansion for geomembranes is high and shall be factored into the design when allowing for overlap and anchoring.

4.1.3.1. The manufacturer's design specifications for "slack allowance" shall be followed.

4.2. Shipping, Handling and Storage – Geomembrane Liners shall be shipped, handled and stored so that damage to the liner is prevented.

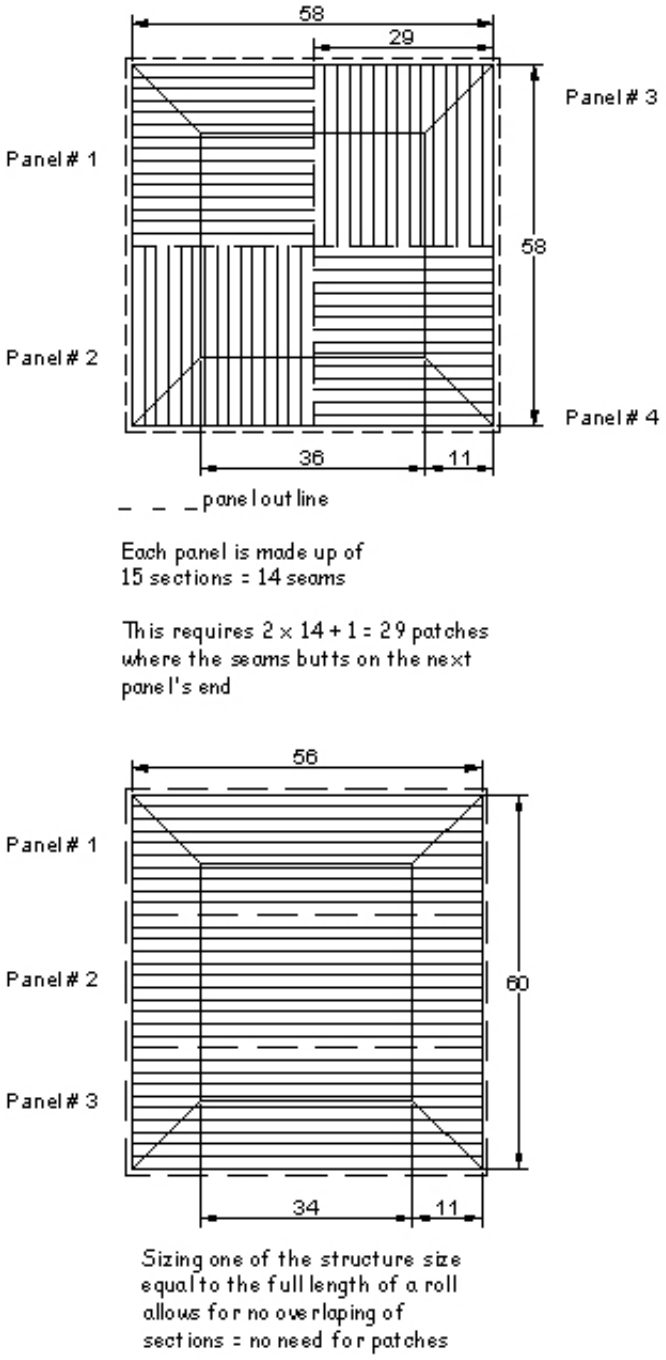
4.2.1. Liner panels shall be properly rolled onto a core or folded onto a pallet.

4.2.2. Proper covering shall be used to prevent damage due to puncture, moisture or mechanical abrasion.

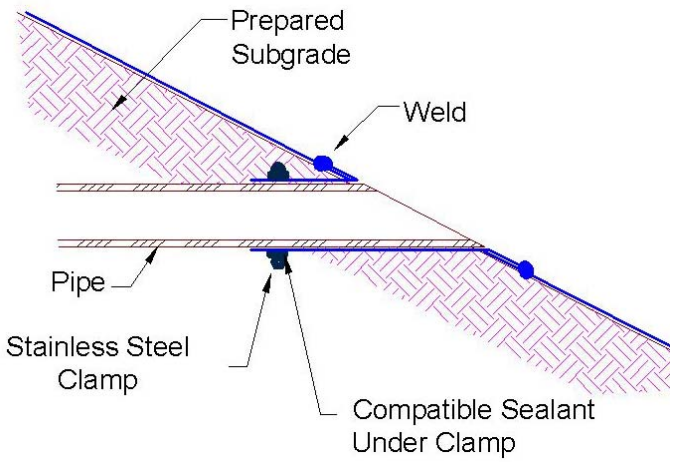
4.2.2.1. Protective covers shall not be removed until immediately prior to installation.

4.2.2.2. Individual rolls of HDPE that are 100 % field seamed shall be palletized or core wrapped.

4.2.3. The total mass of factory seamed PVC panels shall be no greater than 1800 kg if machine placement is used or 1400 kg if manual placement is used.



Design consideration when sizing structure's dimension relative to factory dimensions of liners



Alternative waterproofing approach where pipe and liner materials are different.

4.3. Optimum Panel Sizing – The number of seams and, in particular, the end of roll seams can be minimized or even avoided by matching the width or length of the earthen manure storage structure to the length of the liner panels.

4.3.1. The liner manufacturer and/or project Engineer should specify the optimum storage width related to the liner panel dimensions.

4.3.1.1. To prevent the need for cross seaming over factory seams, wherever possible panels shall reach in one piece from anchor to anchor.

4.3.1.2. Where cross seams overlap factory seams, a patch shall be applied over the seam junction to prevent leakage.

4.4. Installation Procedures – The geomembrane liner shall be installed in the earthen manure storage structure according to the following:

4.4.1. The liner shall be placed in a relaxed condition, free of tension and minimum wrinkling with no overlap wrinkling.

4.4.2. The liner shall be installed at temperatures above 0°C.

4.4.3. Traffic during installation shall be limited to small rubber tire units only.

4.4.3.1. The maximum wheel pressure shall be no greater than 35 kPa.

4.4.3.2. The total load shall be no greater than 350 kg.

4.4.4. To prevent physical damage, no object shall be dragged across the liner.

4.5. Pipe Inlets and Outlets – Where used, pipe collars shall be selected and installed in accordance to the specifications under this section.

4.5.1. Factory or fabricated pipe collars shall be used to seal all pipe penetrations. Flush mount installation procedures are recommended.

4.5.1.1. Any pipe penetrating the liner shall not extend more than 0.15-m past the edge of the collar.

4.5.1.2. Where pipes will be used for agitation or pump out, the pipe must be securely embedded in a concrete collar of sufficient dimension to minimize risks of mechanical damage to the liner.

4.5.1.2.1. The edges of the concrete collar shall be rounded to a radius of not less than 12 mm.

4.5.1.2.2. A 12 oz non-woven geotextile fabric shall be installed to separate the synthetic liner and the concrete surfaces of concrete collars.

4.5.1.2.3. Anchor bolts and batten bars shall be made of stainless steel material.

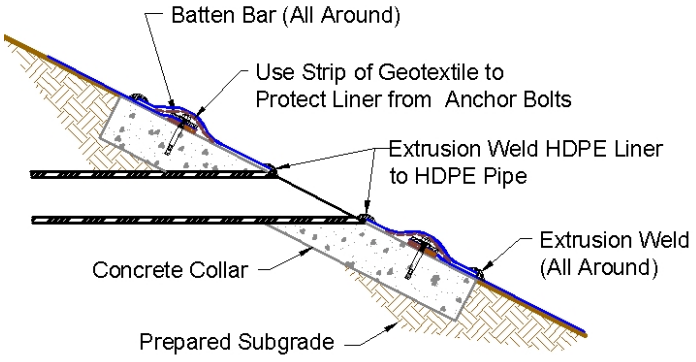
4.5.2. Where flush cut pipes are installed and welded to the liner, a qualified installation supervisor designated by the Manufacturer shall supervise the installation.

4.6. Field Seams

4.6.1. PVC and HDPE seams shall be made by double heat fusion wedge welding.

4.6.1.1. Where double heat fusion wedge welding is not possible, and only upon approval by the regulatory agency,

- solvent welding can be used for PVC liners;
- extrusion welding can be used for HDPE liners.



Recommended waterproofing approach for HDPE pipes. Not shown is a geotextile fabric separating the concrete and the HDPE liner.

4.6.2. Overlap width shall be strictly in accordance with the manufacturer's requirements.

4.6.3. All panels opened and deployed shall be seamed on the same day.

SECTION 5 - SUBGRADE PREPARATION FOR SYNTHETIC LINERS

5.1. Subgrade Preparation – An earthen subgrade is preferable to a granular subgrade since granular material may contain unacceptable void space and may be unstable.

5.1.1. The subgrade surface shall be firm, unyielding and free of voids and cracks.

5.1.2. The subgrade surface shall be machine smoothed to ensure no protrusions greater than 12 mm, ruts, abrupt grade change or voids.

5.1.2.1. Where smooth rounded stones larger than 50 mm diameter are visible in the subgrade, where smooth rounded stones less than 50 mm diameter cannot be driven into the subgrade with rolling equipment, or where the subgrade features angular stones or gravel of any size, a subgrade cover shall be used to protect the synthetic liner.

5.1.2.2. A suitably thick layer of soil material can be used as subgrade cover. This soil material shall be devoid of any gravel or angular stones, and shall not include rounded stones greater than 12 mm. The soil material shall be compacted to 95% of its maximum Proctor dry density with smooth rolling equipment.

5.1.2.3. An alternative subgrade cover material can be a non-woven geotextile of a minimum weight of 8 oz.

5.1.3. The floor of earthen manure storage structures shall be landscaped to provide a 2 % slope as required for facilitating drainage of liquids towards a leachate collection line.

5.1.3.1. Where facilities are comprised of a floor of large dimension, a transverse slope may be constructed to minimize earthwork while allowing for drainage to a collection point. Such transverse drainage shall be installed on a minimum slope of 0.5%.

5.1.4. The slopes and base of the earthen manure storage structure shall be disked to a minimum depth of 20 cm and compacted to within 95 % of maximum Proctor density (ASTM D698) at a moisture content between 0.9 and 1.2 optimum.

5.1.5. Subgrade densities shall be confirmed by in-field density checks carried out with a nuclear densometer operated in accordance with ASTM D2922.

5.1.6. The subgrade shall be free of standing water, mud, snow or excessive moisture during installation of the liner.

5.1.7. The synthetic liner shall not be constructed below the seasonal high water table or in into saturated conditions unless the Engineer can show that a drainage system or the liner ballast will counteract any deterioration of the liner due to hydraulic pressure.

SECTION 6 - LINER VENTING AND DRAINAGE

6.1. Preventing Uplift of Liners - Gas formation under the liner is unusual but it occurs when a liner is placed over a surface previously covered with manure, sewage or other decomposable material. Biogas formation will also readily form after minor amounts of liquid manure flow through small pin holes or imperfect seams occurring during construction or during operation. Biogas pockets will lead to the creation of large gas bubbles under the liner, which results in "whale backs" extending beyond the surface of liquid in synthetic lined earthen manure storage facilities.

6.2. Venting - To prevent the formation of biogas formation under the liner, a proper venting system shall be designed and installed in all synthetic lined manure storage structures.

6.2.1. All perforated conduits, wicks or plastic drains used for venting or dewatering shall be surrounded by a suitable filter cloth.

6.2.2. A venting and network of perforated conduits, wicks or plastic drains shall be installed in a fashion so as to intercept large biogas pockets and allow for venting on the outside of the lined area.

6.2.3. The venting network shall be connected to a low vacuum generation device, such as a wind turbine ventilator, to facilitate gas flow to the outside of the lined area. The design shall include protection for the vacuum generation device from mechanical damage by equipment used to maintain the berms or to empty from the manure storage structure.

6.3. Leachate Detection and Drainage - As a means for early detection of major perforations or imperfections in the liner installation, a leachate detection system shall be installed immediately under synthetic liners.

6.3.1. The floor of the liquid manure storage structures shall be sloped so as to allow effective drainage liquid manure passing through holes in the synthetic liner towards a drainage network.

6.3.2. The leachate detection system shall be comprised of a drainage network of suitable perforated conduits installed on a minimum slope of 0.5%. The drainage network shall route leachate to a sump located on the outside of the liquid manure storage facility.

SECTION 7 - ANCHORING SYNTHETIC LINERS

7.1. Anchoring Requirements – The liner shall be properly anchored at the top of the berm slope. There are two acceptable methods for anchoring the liner. They include the use of a trench or a swale as follows:

7.1.1. The Trench – Whenever possible the liner (PVC or HDPE) shall be properly anchored in a trench at the top of the slope.

7.1.1.1. The trench shall be located no closer than 1 m from the top inside edge of the berm of the earthen manure storage structure.

7.1.1.2. The trench shall be no less than 450 mm wide by 450 mm deep.

7.1.1.3. The front edge of the trench shall be rounded to prevent a sharp liner bend.

7.1.1.4. The liner material shall be placed in the trench so that at least one side and the bottom of the trench are covered.

7.1.1.5. The trench shall be filled with soil material devoid of any gravel or angular stones, and shall not include rounded stones greater than 12 mm. The soil material shall be compacted to 95% of its maximum Proctor dry density with smooth rolling equipment, can be used as subgrade cover.

7.1.1.6. .

7.1.2. The Swale – The liner can be anchored by extending the liner back from the slope crest in a "swale" of sufficient width to create the necessary anchorage after covering with cover materials.

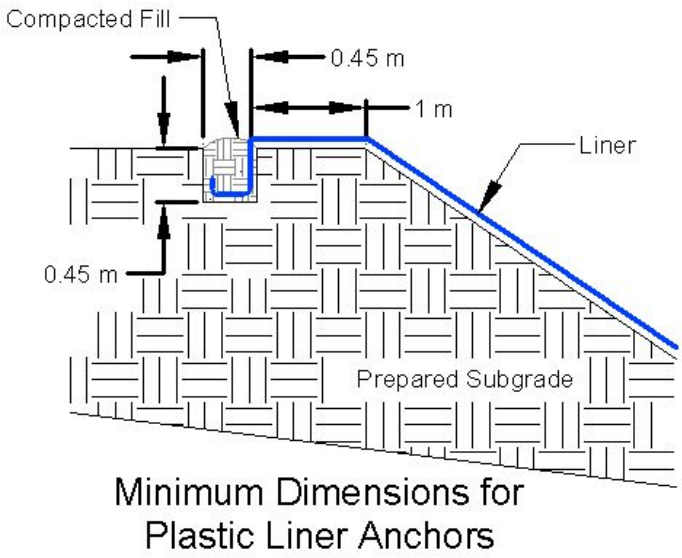
7.1.2.1. The swale shall be no closer than 1 m from the top inside edge of the berm.

7.1.2.2. The swale shall be no less than 2 m wide and shall provide a minimum depth of 300 mm

7.1.2.3. The use of a swale is site-specific and shall be approved by the project Engineer.

7.1.3. Cover materials shall be placed carefully over the liner to create sufficient anchor resistance.

SECTION 8 - PROTECTIVE COVER FOR SYNTHETIC LINERS



Typical trench for anchoring geomembrane liners

8.1. Placement of the Liner Cover – The liner (PVC or HDPE) must be protected from environmental or mechanical damage including livestock or wildlife trampling.

8.1.1. Prior to placing any other material over a PVC liner, a geotextile fabric shall be laid immediately over the PVC geomembrane.

8.1.2. A minimum cover of 300 mm shall be placed on all areas of PVC liners. In areas where wheel traffic may occur and around pumping pads and pipe inlets, a minimum cover of 600 mm is required.

8.1.3. Soil for the cover shall be placed ahead of machines and pushed upslope rather than downslope.

8.1.4. Machine pad pressure on the cover material shall not be greater than 35 kPa.

8.1.5. Cover materials shall not be dumped onto a lined area where the liner may be punctured or stretched.

8.1.6. Only traffic required for the operation and maintenance of the storage structure shall be permitted in or on the storage structure.

8.1.7. If the HDPE liner is UV protected, it may be installed without a cover at the discretion of the designer.

SECTION 9 - INSTALLATION OF OTHER STRUCTURES

9.1. Installation of Other Structures – Erosion pads, agitator pads, access ramps, concrete, or geogrid shall be installed without intrusion into the soil cover material.

A nonslip walkway and suitable handrail is required as a safety measure to prevent accidental falls where common berms are wrapped under plastic liners

9.1.1. Any concrete form work shall be surface mounted with no rods or pegs penetrating the cover material.

9.1.2. A geotextile fabric of minimum weight of 12 oz shall be placed between any concrete structure and the liner.

9.1.3. The concrete form design and concrete placement method shall be such that the final concrete structure will not present any sharp edges.

9.1.4. All concrete ramps or pads shall be designed with sufficient anchorage at the top of the berm to prevent any sliding down the lined slope.

SECTION 10 - SAFETY

10.1. Safety Around HDPE Liners - Where HDPE or any other plastic liners are left exposed on top of berms, adequate signage and safety devices shall be included as part of the manure storage structure's design.

10.1.1. Adequate signage around the berms of manure storage structures shall inform workers and by-standers of slippery conditions prevailing on the liner surface and the danger of falling in the storage structure. Warning sign shall clearly state that a minimum of two (2) persons shall attend any inspection or work, and that appropriate life-line retrieval equipment be available to these persons.

10.1.2. In all instances of multi-cell earthen manure storage structure designs including a common berm, warning signage as per section 10.1.1 shall be provided at each end of the common berm(s).

10.1.3. Where multi-cell earthen manure storage structure designs include a manually operated transfer valve located into the common berm between two cells, and where this common berm is completely covered with HDPE liner material, a non-slip walkway shall be included in the design.

10.1.3.1. The walkway shall run from the outermost edge of the liner on the perimeter berm of the earthen manure storage structure up to the location of the valve.

10.1.3.2. The walkway shall include a suitable handrail.

10.1.3.3. Where the manual valve is located into a manhole, the non-slip walkway shall provide enough non-slip footing and handrail protection to allow operation of the valve without stepping on the exposed liner surface.

SECTION 11 - MAINTENANCE AND REPAIR

11.1. Damaged Areas – Damaged areas identified during routine inspections shall be carefully exposed by removing the soil cover and patched according to the manufacturer's specifications.

11.1.1. The minimum overlap of the patch shall be 300 mm.

11.1.2. The repaired area of PVC liners shall be recovered with soil.

11.1.3. The project Engineer shall inspect all repairs and either approve the repairs or require additional protection such as erosion protection at inlet pipes, transfer lines, or agitator pads and protection from wheel damage.

SECTION 12 - QUALITY ASSURANCE

12.1. Quality Control – Quality control of the manufactured products is regulated by either the National Sanitation Foundation (NSF) or the American Society for Testing and Material Standards (ASTM).

12.2. Supervision of Installation – The installation of geomembrane liners shall be performed under the continuous and direct supervision of the Engineer or a qualified installation supervisor designated by the Manufacturer.

12.2.1. The qualified installation supervisor shall be able to produce to the regulatory authority proofs of training or certification from the Manufacturer stating his or her qualifications as a geomembrane installation supervisor.

12.3. Testing – Destructive testing of random liner material samples (not used in the earthen manure storage structure) shall follow ASTM D4437.

12.4. Field Testing of Seams - All liner seams shall be subject to non-destructive field testing following ASTM D4437.

12.4.1. PVC seams shall be tested using the air lance method, where a single solvent welded seam has been used, or the air channel test where a double wedge welded seam had been used.

12.4.2. HDPE seams shall be tested using the vacuum test method or air channel test method.

SECTION 13 - ISSUANCE OF CERTIFICATES

13.1. Manufacturer's Certificates – The Engineer shall provide the regulatory agency with documentation from the Manufacturer certifying the liner design and construction.

13.2. Certification – The Engineer shall provide the appropriate regulatory agency with a final letter of certification indicating that the manure storage structure has been completed in conformance with submitted **engineering plans** and **meets required codes, regulations and Technical Reference Documents mentioned herein.**

13.2.1. The letter of certification shall be affixed with the Engineer's seal in a manner acceptable to the guidelines of the Association of Professional Engineers and Geoscientists of the Province of Manitoba.

13.3. Construction Report - The letter of certification must be accompanied with a prepared construction report.

13.3.1. In the case of a synthetic liner, the construction report must provide accurate information on the following aspects of the construction work:

- inspection and installation supervision report.
- construction details not consistent with submitted plans
- "As Built" drawings
- nuclear densometer results
- results from destructive testing of the liner
- method, dates and results from all seam tests
- quality Assurance/Quality Control report
- monitoring well logs
- monitoring well water elevations
- background water quality results
- top of dike and storage bottom elevations

13.3.2. Certification can be provided if construction details do not conform to engineering plans submitted provided these details were approved by the regulatory agency and referenced in a construction report.

SECTION 14 - REFERENCES

Document	Abbreviation
ASTM D5084 Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter	ASTM D5084
ASTM D4437 Standard Practice for Determining the Integrity of Field Seams used in Joining Polymeric Membranes	ASTM D4437
ASTM D698-00a *Standard Test Method for Laboratory Compaction Characteristics of Soil using Standard Effort*	ASTM D698
ASTM D1587-94 *Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils*	ASTM D1587
ASTM D2922-96e1 *Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)*	ASTM D2922
ASTM D2937-94 *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*	ASTM D2937
ASTM D3017-96 *Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)*	ASTM D3017