

Technical Reference Document for Liquid Manure Storage Structures

EARTHEN MANURE STORAGE STRUCTURES

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SECTION 1 - Purpose and scope

1.1. Purpose of the Technical Reference Document – The Technical Reference Document *Earthen Manure Storage Structures* defines the engineering requirements for designing earthen manure storage structures and provides additional references to assist with the analysis and design for the conditions of Manitoba.

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

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

1.2. Definition – An earthen manure storage structure is defined as a containment structure built primarily of soil.

It typically consists of an excavation below grade with low containment dikes above grade. It may include a compacted clay liner or a synthetic liner.

1.3. Site Suitability – Earthen manure storage structures may be used for the storage of liquid manure at sites where the geology, soil and groundwater conditions are suitable. In Manitoba, *The Livestock Manure and Mortalities Management Regulation MR 42/98* states the conditions and requirements for design and construction of earthen manure storage structures. The assessment and selection processes evaluate the overall site suitability and outline when an earthen manure storage structure is appropriate for a specific site. This Technical Reference Document only deals with site specific issues related to earthen manure storage structure siting and design.

1.3.1. The suitability of each site for an earthen manure storage structure must be established. The site may be considered suitable for an earthen manure storage structure without a liner, suitable for an earthen manure storage structure with a compacted clay liner, suitable for an earthen manure storage structure with a synthetic liner, or unsuitable for an earthen manure storage structure.

1.3.1.1. Where a compacted clay liner is required, the Engineer shall follow the design and construction specifications laid out in the Technical Reference Document *Compacted Clay Liner*.

1.3.1.2. Where a synthetic liner is required, the Engineer shall follow the design and construction specifications laid out in the Technical Reference Document *Synthetic Liner*.

SECTION 2 - RESPONSIBILITIES OF THE ENGINEER

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

2.2. Role and 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 documents 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 documents 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 the data acquired and the design of the earthen manure storage structure base, walls, dikes and liner. Where applicable, the Engineer is also responsible for the design of the transfer piping from the source of the liquid manure to the earthen manure storage structure, solid/liquid separators, access ramps for portable pumps and agitators, the soil drainage system, safety fencing, and any proposed system for detecting pollution or leaks.

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

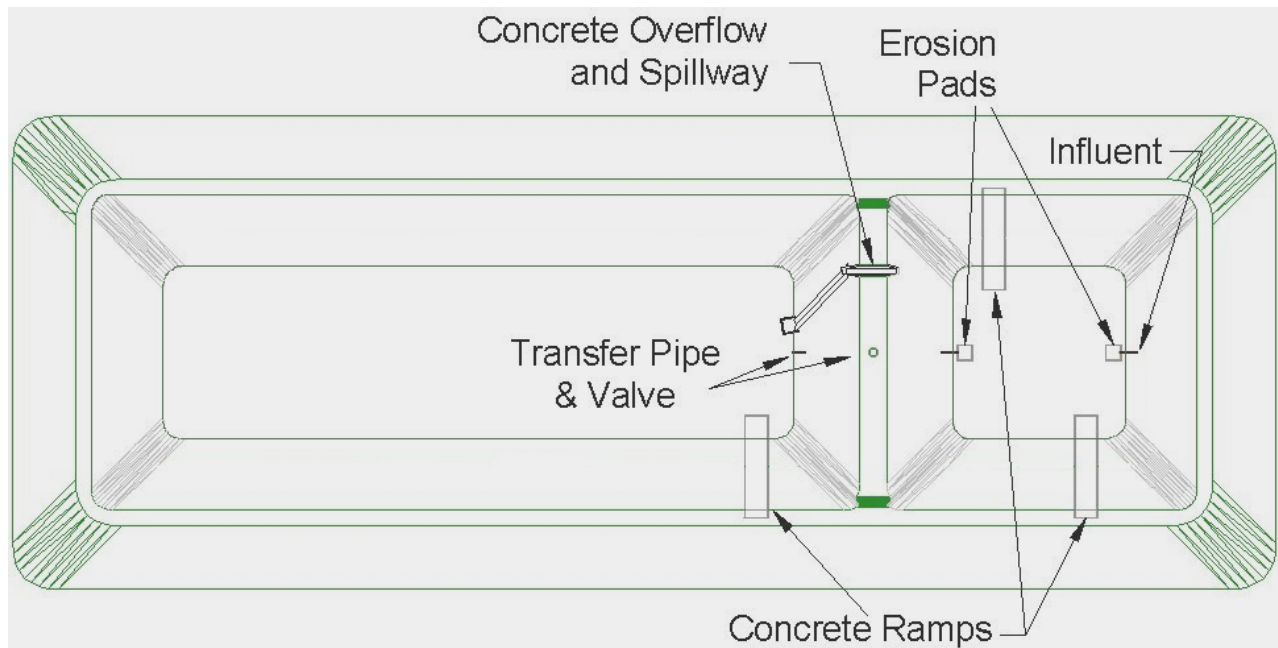
2.5. Other Standards – Provincial, national and international standards and their respective abbreviations are listed in Section 11. In all cases, the most current edition of the referenced standard is implied. Additional relevant documents are also referenced in Section 11

SECTION 3 - INFORMATION REQUIREMENTS

3.1. Submissions – For the purpose of evaluating an application for a new, expanded or modified livestock manure storage structure, the Engineer shall submit to the regulatory agency information including, but not limited to, the following details of the storage structure design and site characteristics:

3.1.1. Site plan showing the location of the manure storage structure and distances to:

- property lines;
- closest residence not associated with the operation;
- closest community;
- public roads;
- manure source (barn);
- known water wells, sinkholes and surface water features;
- location of any abandoned water wells;
- bore hole locations for soil and site evaluation;
- proposed system for detecting pollution or leaks (if applicable);
- layout of any underground pipelines from the storage structure to remote field locations, inclusive of cleanout locations, and
- underground utilities.



Complete drawings must be prepared.

3.1.2. Detailed construction drawings drawn to scale, signed and sealed by the Engineer including, but not limited to:

- the manure storage facility;
- piping for manure transfer and handling;
- any associated structures;
- location and details of pumping pads and access ramps;
- location and details of inlets, outlets and agitation facilities;
- a cross section of the storage structure berms showing clearly the presence of a liner and its type, where applicable;
- details of erosion control around pipe inlets, pumping or agitation pads and overflow or transfer devices;
- location and details of any underground pipelines;
- location and details of monitoring wells (if applicable);
- construction notes; and
- site specific operational notes (if the design is dependent on specific operation and management factors).

3.1.3. A design summary including, but not limited to:

- material specifications;
- transportation patterns, vehicular loading and any limitations to vehicular traffic;
- erosion control provisions for the exposed surfaces of the berms; and
- statement of full compliance with the codes and standards and Technical Reference

Document for Liquid Manure Storage Structure cited in this document.

3.1.4. Geotechnical information including, but not limited to:

- bore hole logs for the proposed location of the earthen manure storage structure;
- depth to seasonal high ground water;
- depth to bedrock;
- type of bedrock;
- description of soil testing and analyses;
- all applicable soil test results; and
- requirements for construction.

3.1.5. Design assumptions regarding the storage structure capacity estimate including, but not limited to:

- storage period;
- livestock manure production over the storage period;
- allowance for accumulation of solids;
- additional waste water;
- precipitation over the storage period (less evaporation); and
- freeboard.

3.1.6. Recommendations for regular inspection, maintenance, and repair including, but not limited to:

- the frequency of inspection, critical features to inspect, and method of the inspection (visual, monitoring data etc);
- procedures for regular maintenance and preventative repairs; and

- contingency plans that include procedures for the repair of damaged features.

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

3.1.6.1.1. Liquid manure levels – To protect against overflow, liquid manure levels should be verified on a weekly basis beginning when the stored liquid manure is estimated to reach 80 % of the design volume.

3.1.6.1.2. Annual inspections – Annual inspections by a qualified professional are necessary to ensure the integrity of the earthen manure storage structure is maintained. The inspections should include:

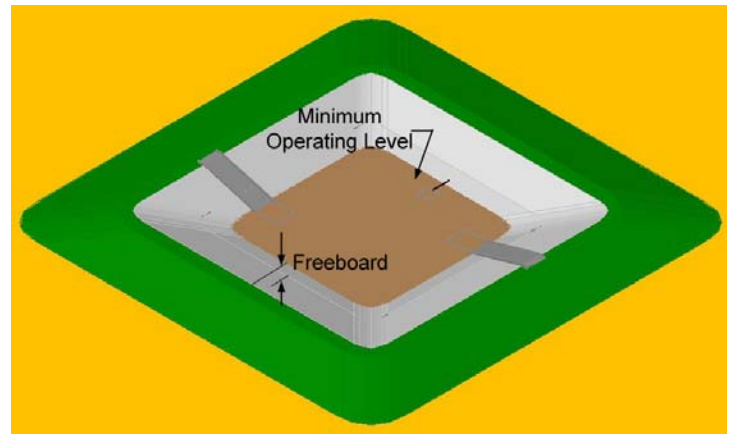
- walls for erosion or cracking;
- subsurface drains or secondary containment systems for accumulation of leachate; and
- signage for adequacy and visibility.

SECTION 4 - DESIGN CRITERIA

4.1. Design and Construction Requirements – The design and construction of all earthen manure storage structures shall take into account the following:

4.1.1. Design Criteria – Earthen manure storage structures may be any shape that is practical for operation and maintenance, although the rectangular earthen manure storage structure is the most common.

4.2. Volumes and Freeboard – Manure storage structures shall be designed to contain the total amount of manure estimated to be produced over the required storage period plus precipitation over the storage period (less evaporation), accumulation of solids, any additional liquids to be stored (such as milkhouse wash water), and an allowance for freeboard. Estimated manure production and the required storage period shall be based on published provincial data or statistics from operations using similar livestock production systems. It is the responsibility of the Engineer to ensure that the earthen manure storage



The sizing of an earthen manure storage must allow for a freeboard and a minimum operating level

structure is designed for adequate capacity.

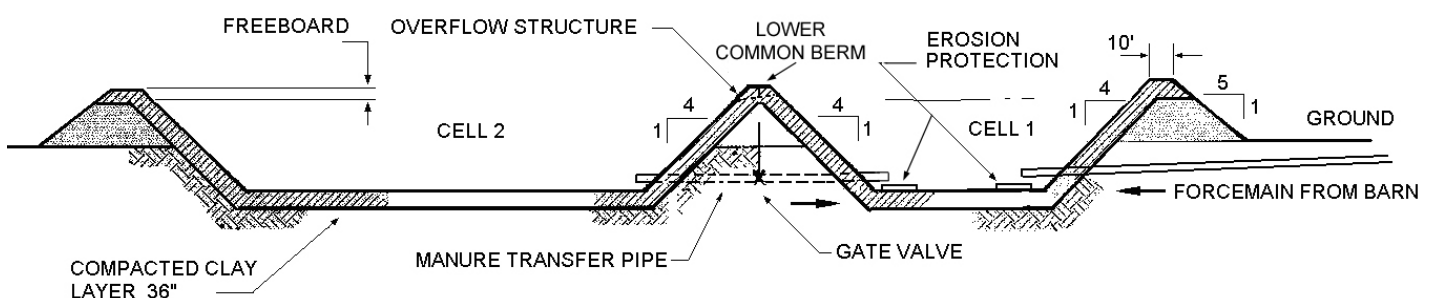
- Guidance on calculating manure storage volumes is available from Manitoba Agriculture, Food and Rural Initiatives – Regional Offices and Livestock Industry Branch.

4.2.1. Freeboard – The storage structure shall have a reserve capacity to contain a major rainstorm without overflowing. A major rainstorm is considered to be all of the precipitation received over a 24-hour period at a time recurrence of once in 25 years. The freeboard is the unfilled capacity below the top of the dikes and above the maximum operating level. The level of liquid in the earthen manure storage structure should not rise above the maximum operating level except in the event of a major storm.

4.2.1.1. The minimum acceptable vertical distance between the maximum operating level and the top of the dikes shall be no less than 0.5 metre.

4.2.1.2. The maximum operating level shall be clearly marked to assist the operator in maintaining the freeboard.

4.3. Geometric Design – The characteristics of the material for construction, safety considerations, and



Two cell systems are commonly used in larger earthen manure storage structures
Winter 2007

maintenance requirements shall be incorporated into the design of the berms and slopes of the walls.

4.3.1. Inside Wall Slope – The slopes of the inside walls shall be no steeper than 3:1 (horizontal:vertical) and shall be consistent with the requirements of the liner design and pump out equipment.

4.3.2. Exterior Wall Slope – All exterior wall slopes shall be no steeper than 4:1 (horizontal:vertical) and shall be designed to accommodate seeding and maintenance equipment.

4.3.3. The minimum top width of embankments shall be no less than 3 metres. Greater widths may be required to accommodate tractors, pumps and other equipment. The top of the berm shall be sloped away from the storage structure to facilitate drainage.

4.4. Earthwork Protection – The earthen manure storage structure design shall contain provisions for leakage protection and protecting the in-place earthworks from erosion over the design life.

4.4.1. Leakage Protection – Installation of a bentonite collar or other suitable leakage prevention shall be provided around piping and other objects extending through and below the liner. Trenches excavated for the installation of pipes shall be backfilled with compacted soil. A leak proof bond between the fill and native material shall be provided. A bentonite collar or other suitable leakage protection shall be provided around the pipe section beneath the berm.

4.4.2. Protection of Slopes – All exterior slopes and the upper portion of the inside slopes that correspond to the design freeboard depth shall be covered with topsoil and seeded to grass to prevent erosion. Deep-rooted plants, shrubs and trees are not permitted on or near the banks of the earthen manure storage structure since roots may penetrate and damage the liner.

4.4.3. Erosion Control around Inlet Pipes and Transfer Pipes – Flow into the earthen manure storage structure from pipe inlets or transfer pipes can cause significant erosion if the soil is not protected.

4.4.3.1. Where the manure is discharged near the top of the earthen manure storage structure (top loading), the liquid manure must be routed onto an influent spillway designed to contain the flow of liquid manure.

4.4.3.1.1. The discharge pipe inlet shall protrude into the spillway over a distance of at least 4 times the diameter of the inlet pipe. This minimum length of pipe shall be in line with the axis of the spillway.



Depending on the site hydrogeology, an earthen manure storage may require a compacted clay liner.

4.4.3.1.2. The manure inlet pipe shall be anchored to the spillway at sufficient locations to prevent movement.

4.4.3.1.3. The discharge point of the manure inlet pipe shall be below the elevation of the spillway sides at a location corresponding to the discharge point of the pipe.

4.4.3.1.4. The top edges or curbs of the spillway shall have a height no less than 2 times the largest diameter of the manure inlet pipe.

4.4.3.2. Protection against scouring and erosion at all discharge locations, inclusive of manure return pipes used in multi-cells design and where manure is discharged near the bottom of the structure (bottom loading), shall be provided. Erosion control pads shall consist of a curbed concrete pad.

4.4.3.2.1. Erosion pads under manure inlet pipes shall have for minimum dimension 3 m long by 3 m wide.

4.4.3.2.2. Curbs with a minimum height of 0.2 m shall be provided on all sides of erosion protection pads.

4.4.3.2.3. Unless otherwise approved by the regulatory authority, erosion protection pads shall be made out of suitably reinforced concrete.

4.4.3.2.4. Manure pipe inlets discharging effluent over an erosion protection pad shall be anchored onto the pad.

4.5. Pumping and Agitation Pads – Depending on the size of the earthen manure storage structure, multiple pumping stations may be required to empty it. Pumping and agitation equipment can damage unprotected soil from wheel damage and pumping and agitation activities.

Provision shall be made for the protection of applied or constructed liners from pumping and agitation equipment. Pads and access ramps shall be designed to ensure the adequate protection of the floor and side slopes of the earthen manure storage structure.

4.5.1. Erosion proof access ramps and pads shall be provided at each pumping or agitation station. Access ramps and pads shall be constructed as a curbed concrete ramp or pad..

4.5.2. In the cell where annual pump out occurs, at least two access ramps and pumping pads shall be provided. Additional access ramps and pumping pads may be required to ensure adequate agitation and emptying of large earthen manure storage structures.

4.5.3. In secondary or subsequent cells of multi-cell earthen manure storage structures, at least one access ramp and pumping pads shall be provided.

4.5.4. The location of the pumping pads shall be well marked so that it is easy to locate agitation equipment over the centre of the pad.

4.5.5. All access ramps and pumping pads feature a 0.3-m high curb on all sides, with the exception of the side from which pumping or agitation equipment must use to enter the storage structure.

4.5.5.1. Where the design of the pumping pad includes “drain back” openings in the curbs allowing manure to free flow to the floor of the pad, these openings shall have a diameter no greater than 0.15 m or an area no larger than 0.025m² where the opening is not circular.

4.5.6. Agitation ramps shall be anchored into the top of the berms into a trench at least 0.5 m deep made at a distance of at least 1 m from the inside edge of the earthen manure storage structure.

4.6. Overflows and Spillways - Multi-cell earthen manure storage structures commonly have an overflow channel or overflow pipes for transferring liquids from a primary cell to a secondary cell, or from a secondary cell to a tertiary cell.

4.6.1. The bottom of the overflow channel or pipe shall be located no less than 0.8 m below the lowest point on the perimeter berm of a manure storage structure.

4.6.2. Where the overflow transfer structure is a channel, the channel floor and sides shall be completely lined with a suitably reinforced concrete layer at least 100 mm thick.

4.6.2.1. Where the earthen manure storage structure is not completely lined with an HDPE liner, overflow channels shall transfer manure a

suitably reinforced 100-mm thick concrete spillway that shall extend to the floor of the structure. The spillway shall be shaped so as to provide flow guidance onto an erosion pad designed as per 4.4.3.2.

4.6.2.2. Where the earthen manure storage is completely lined with an HDPE liner, the concrete spillway and erosion pad described in 4.6.2.1 may be substituted for a double layer HDPE liner.

4.6.3. Where the overflow transfer consists of a pipe, the pipe shall either discharge manure directly onto an erosion pad as described in 4.4.3.2 or on a spillway as per 4.6.2.

4.7. Lift Stations and Wet Wells Located on Berms - Where a manure influent lift station or wet well is installed onto the berm of an earthen manure storage structure, it shall be installed on the inside berm of the structure so as to guide any overflow from the appurtenance into the earthen manure storage structure.

4.8. Surface Water Protection – Where necessary, the earthen manure storage structure design shall include measures to protect surface water quality by managing runoff on the site. The storage structure shall be located in an area free from collecting surface runoff. The earthen manure storage structure location and design shall include provisions for accidental overtopping or spills such that all liquids are contained on the livestock operation site and no manure enters a drainage channel or depression that may carry surface water.

SECTION 5 - MATERIAL SUITABILITY

5.1. Specifications for Construction Material - The Engineer shall collect samples of the material to be used for the construction of the earthen manure storage structure to establish its suitability.

5.1.1. Where a borrow area is used as a source of alternate material for constructing the berms of an earthen manure storage structure, the borrow area shall be sampled for material suitability. The regulatory agency may require a specific number of samples depending on the variability of the soil and geologic conditions at the site.

5.1.2. The Engineer shall be responsible for ensuring that adequate testing is carried out to accurately characterize the material to be used for construction.

5.2. Laboratories – Only laboratories approved by the regulatory authority shall be used to analyze materials to be used in the construction of earthen manure storage structures for particle size distribution, Atterberg limits, and hydraulic conductivity.

5.3. Testing Requirements for Material Characterization – In order for the material to be approved for use in the construction of an earthen manure storage structure without the need for additional testing, it must meet the criteria described in Subsections 5.3.1 and 5.3.2.

5.3.1. All materials collected in the site investigation for the construction of an earthen manure storage structure shall be analyzed for particle size distribution following ASTM D2487 and ASTM 422, and Atterberg Limits following ASTM D4318 or any other method pre-approved by the regulatory agency.

5.3.2. If the distribution of the particle size classes and the Atterberg limits fall within the ranges given in Subsection 5.3.2.1. and 5.3.2.2, the material is considered acceptable for earthen manure storage structure construction without the need for additional laboratory testing providing it is installed using the recommended equipment as described in Section 6.1. The use of materials (as defined above) with the appropriate construction methodologies and equipment are expected to produce an earthen manure storage structure with hydraulic conductivities of 1×10^{-9} metres/second or less.

5.3.2.1. Acceptable Particle Size Ranges (by weight):

- Percent Fines ≥ 50 %;
- Clay Content ≥ 20 %;
- Sand Content ≤ 45 %; and

where the fines are defined as the soil fraction which passes through a No. 200 (75- μ m) US standard sieve, and clay and sand are defined in the ASTM D2487-00 standard.

5.3.2.2. Acceptable Atterberg Limits:

- Plasticity Index (PI): $PI \geq 20$ %
- Liquid Limit (LL): $LL \geq 30$ %

5.3.2.3. Poorly graded materials with high silt

content may not be considered acceptable. Such materials do not compact well and are highly erodible.

5.3.3. If the distribution of the particle size classes and the Atterberg limits **do not** fall within the acceptable ranges given in Subsection 5.3.2.1. and 5.3.2.2, a compacted clay or synthetic liner will be required.

5.3.3.1. The Technical Reference Documents *Compacted Clay Liners* and *Synthetic Liners* show the design and construction requirements for acceptable liner alternatives for earthen manure storage structures.

SECTION 6 - CONSTRUCTION PROCEDURES

6.1. Construction Requirements – The construction of an earthen manure storage structure shall be according to the earthen manure storage structure design and follow the specifications of this section.

6.2. Topsoil Removal – Topsoil shall be stripped to the subsoil layer from the area where any dike is to be constructed and stockpiled for use in the outside slopes of the structure.

6.3. Lift Height – All material shall be placed in lifts no greater than 0.15 m and then compacted.

6.4. Recommended Equipment – The recommended compaction equipment for the construction of an earthen manure storage structure is the Sheepsfoot Roller Compactor. Many different models of Sheepsfoot Roller Compactors are available. Only those meeting the following criteria shall be considered acceptable:

6.4.1. Soil Contact Pressures – The compaction equipment or rollers shall be ballasted to attain soil contact pressures of at least 2400 kPa.

6.4.2. Soil Contact Pressure Measurement – Contact pressures shall be measured by dividing the total mass of the roller by either the total area of the maximum number of tamping feet in one row parallel to the axis of the roller; or by calculating 5 % of the total foot area, whichever is the greater.

6.4.3. Tamping Feet Requirement – The tamping feet shall be 200 mm to 250 mm in length from the cylindrical surface of the roller. The tamping feet shall have a face area between 4500 and 6000 mm². The compactor feet shall be spaced to provide at least 4 tamping feet for each 0.25 m² of cylindrical surface.

6.4.4. Equipment Cleaning – All equipment shall be equipped with cleaning fingers to prevent the accumulation of material between the tamping feet and to allow full penetration of the feet through the lift being compacted.



Tow behind Sheepsfoot Roller

6.5. Other types of Compaction Equipment – Other compaction equipment can only be used after obtaining a written approval from the regulating authority. Smooth drum steel rollers are not acceptable as compaction equipment.

6.5.1. Other types of Compaction Equipment – When a sheepsfoot roller compactor is not available, other compaction equipment, may used, subject to approval by the regulating authority.

6.6. Compaction Monitoring - Compaction should be monitored at frequent intervals during construction to ensure that target material dry bulk density values are achieved. Frequency of monitoring shall be greater where fill material properties change as excavation proceeds.

6.6.1. Where the depth of fill will be less than 1 m but greater than 0.5 m, dry bulk density measurements shall be collected a minimum of two (2) times during the fill and compaction process. Additional dry density measurements shall be taken at a frequency such as to provide dry density measurements for no less than one (1) time for each additional meter of fill beyond the first 1 m of compacted earthwork.

6.6.2. Where soil properties are variable, representative soil samples shall be collected at the location where dry bulk density measurements are made, and analyzed for soil particle size distribution.

6.6.3. Where the depth of cut exceeds 2 m in “cut & fill” earthen manure storage structures, dry density measurement of the undisturbed native material shall be measured.

6.6.3.1. Where the dry bulk density of the native material in the excavated portion of an earthen manure storage structure is found to be less than 95% of the maximum Proctor dry density, the soil in the entire cut surface shall be over-excavated to 0.3 m and replaced in 0.15 m lifts and compacted to 95% of its maximum Proctor dry density.

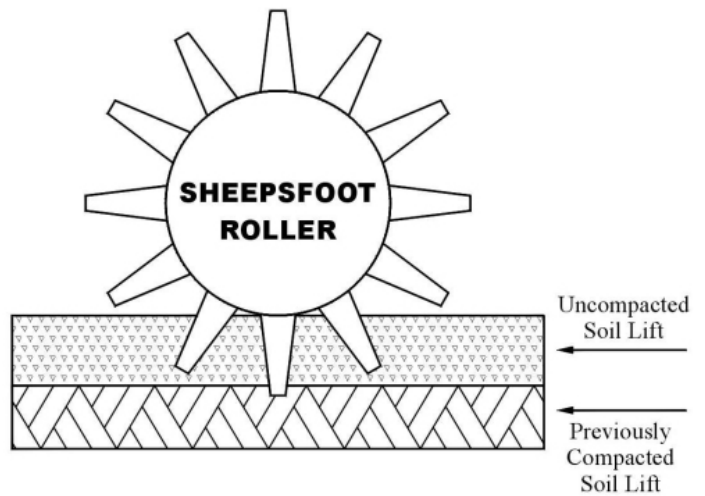
6.7. Final Surface Treatment – Where a compacted clay or synthetic liner will not be installed, the sides and bottom of the earthen manure storage structure shall be disced to a minimum depth of 20 cm and compacted to within 95 % of maximum Proctor density (ASTM D698) at a moisture content between 0.9 and 1.2 optimum.

6.8. Construction Below Freezing – Excavation and compaction shall be completed only when soil temperatures are above freezing.

SECTION 7 - LINER DESIGN AND CONSTRUCTION

7.1. Compacted Clay Liners – Site characteristics may be such that a compacted clay liner is required. Details on the design and construction of compacted clay liners can be

Sheepsfoot Roller with Feet Fully Penetrating Uncompacted Soil Lift into Previously Compacted Soil Lift



Contact pressure and sheepsfoot length are two key parameters for proper compaction with sheepsfoot rollers

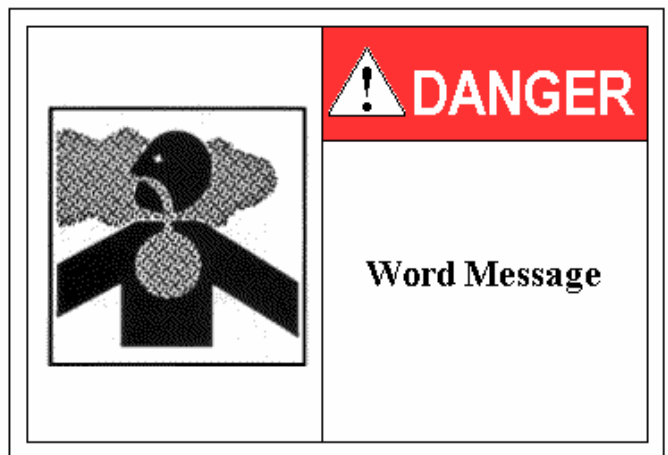
obtained in the Technical Reference Document - *Compacted Clay Liners*.

7.2. Synthetic Liners – Site characteristics may be such that a synthetic liner is required. Details on the design and construction of synthetic lines can be obtained in the Technical Reference Document - *Synthetic Liners*.

SECTION 8 - SAFETY

8.1. Worker Safety – Whenever work involves repairs to an existing manure storage structure or its expansion or modification, regardless whether or not manure gases are expected, the provisions of The Workplace Safety and Health Act W210 shall be met in regard to safety considerations for manure gases.

8.2. Manure Gases – The gases generated by the storage of liquid manure can be fatal and explosive in confined areas.



The Engineer is responsible for ensuring that proper signage will be installed

Inhalation of these gases can be a serious health risk. The concentration of manure gases is higher and more dangerous in confined areas where the liquid manure is stored. Liquid manure storage structures with covered tops are particularly dangerous. NEVER ENTER A LIQUID MANURE STORAGE STRUCTURE without the proper breathing apparatus.

8.3. Safety Responsibilities - The Engineer shall provide recommendations regarding:

8.3.1. Signage: signs that clearly describe the risk of manure gas and any other potential hazard and which prohibit entry into the earthen manure storage structure and any of its appurtenances listed in 8.4.2, shall be posted in accordance with ASAE S441 and include phone numbers of people to contact in case of an emergency.

8.3.2. Breathing Apparatus: availability of a breathing apparatus to workers in areas with concentrated manure gases. Manure gases are released in higher concentrations during agitation.

8.4. Access - Access limiting devices shall be included in the design for all manure storage structures and any appurtenances associated with the design.

8.4.1. A suitable fence 1.2 m high shall be installed to prevent accidental access to the manure storage structure.

8.4.2. Lift stations, valve access holes, pump out access ports and other similar appurtenances large enough to allow for workers, operators or by-stander's access must be securely capped with a locked or sealed cover, grate or latch door fabricated from weather and manure resistant material.

SECTION 9 - QUALITY ASSURANCE

9.1. Inspection – During construction, the earthen manure storage structure shall be inspected by the Engineer to ensure that it was built as designed and is in compliance with all applicable technical reference documents, standards, codes and regulations.

9.2. Quality Control - During construction of the earthen manure storage structure, the Engineer shall measure the soil moisture content and dry density at sufficient representative locations in the floor and sides of the liner.

9.2.1. Nuclear methods for soil dry density and soil moisture content can be used provided the procedures and equipment used are in accordance with ASTM D2922 for soil dry density measurements and D3017 for soil moisture measurements.

9.2.2. Dry density and soil moisture content can be determined from laboratory analyses of undisturbed

soil cores taken following either ASTM D1587 or ASTM D2937. Other ASTM soil sampling procedures can be used subject to pre-approval by the regulatory authority.

9.2.3. All core and probe entry holes shall be sealed by backfilling with bentonite.

9.3. Final Inspection – The Engineer shall make arrangements with the regulatory agency for a joint final inspection after completion of the construction and before commissioning of the manure storage structure.

SECTION 10 - ISSUANCE OF CERTIFICATES

10.1. Certificate – 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 Document mentioned herein.**

10.1.1. 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.

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

10.2.1. In the case of earthen liquid manure storage structures, the construction report must provide accurate information on the following aspects of the construction work:

- all laboratory reports on soil sample testing;
- "As Built" drawings;
- nuclear densometer results; and,
- top of dike and storage structure bottom elevations

10.2.2. 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 11 - RESOURCE INFORMATION

Resource Information	Abbreviation used
Standards	
Technical Reference Document <i>Role and Responsibilities of the Engineer</i>	RRoE
Technical Reference Document <i>Compacted Clay Liners</i>	
Technical Reference Document <i>Synthetic Liners</i>	
ASAE EP470 <i>Manure Storage Safety</i>	
ASAE S441 <i>Safety Signs</i>	ASAE S441
ASTM D698 <i>Standard Test Method for Laboratory Compaction Characteristics of Soil using Standard Effort</i>	ASTM D698
ASTM D1587 <i>Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils</i>	ASTM D1587
ASTM D2487 <i>Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)</i>	ASTM D2487
ASTM D2922 <i>Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)</i>	ASTM D2922
ASTM D2937 <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>	ASTM D2937
ASTM D3017 <i>Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)</i>	ASTM D3017
ASTM D422 <i>Standard Test Method for Particle-Size Analysis of Soils</i>	ASTM D422
Societies	
American Society of Agricultural Engineering	ASAE
American Society for Testing and Material	ASTM