Appendix B - Typical Quality Control/Assurance Program (for landfills)

(Directly from: Nova Scotia Department of the Environment Municipal Solid Waste Landfill Guidelines, Government of Nova Scotia, Department of the Environment, October 1997)

1.0 PURPOSE

1.1 Quality Control

1.1.1 For the purpose of this specification, quality control shall be defined as a planned system of inspection and tests to directly monitor and control the quality of the work.

1.1.2 The Applicant shall submit a quality control, inspection and test program for all landfill components.

1.1.3 The Applicant shall employ a quality control inspector (Inspector) who may be the same person as the installation supervisor.

1.2 Quality Assurance

1.2.1 For the purpose of this specification, quality assurance is defined as a planned system of activities carried out by the Applicant or his Representative that provides assurance that the landfill components were manufactured and installed as specified.

1.2.2 The quality assurance program shall include tests similar to those carried out for quality control.

2.0 GEOMEMBRANE

2.1 General

Geomembranes shall be tested for both manufacture and installation. Both destructive and non-destructive tests shall be used.

2.2 Geomembrane Testing

2.2.1 A minimum of one complete set of quality control tests on geomembrane rolls shall be performed at the frequencies given in Table 1 to verify that all other specified parameters are in compliance with the material specifications.

2.2.2 Test samples which fail to meet strength and environmental specifications shall result in rejection of applicable rolls. Further testing on geomembrane manufactured from the same resin batch shall be conducted

to determine acceptability.

2.2.3 A quality assurance consultant shall confirm that required quality control has been done and shall certify the quality of the geomembrane, prior to delivering. A quality control certificate is required for each batch of resin and each production shift. The certificate shall include:

- Product Identification
- Roll Numbers
- Sampling Procedures
- Test Methods
- Test Results (including Environmental Stress Cracking or single-point Notched and Constant Tensile Load Time to Failure test data)
- Signature of Responsible Party

The consultant may also request that all production line records be submitted for review.

2.2.4 The consultant shall have authority to visit the manufacturing facility at any time to witness production and quality control testing, examine production records and take independent samples.

2.3 Non-Destructive Testing

2.3.1 Test Seams (Start-up) - Test seams shall be made to verify that adequate conditions exist for field seaming to proceed. Each seaming apparatus shall produce a test seam at the beginning of each shift. In addition, if a seaming operation has been suspended for more than four hours, or after every 5 hours or if a breakdown of the seaming equipment occurs, a test seam shall be produced prior to resumption of seaming operations.

Test seams shall be made in the field on pieces of the approved geomembrane. Each test seam shall be at least 1.5 m long by 300 millimetres wide for extrusion and 3 m long by 300 millimetres wide for fusion, with sufficient overlap for peel testing in the field tensiometer.

Two samples 25 millimetres wide shall be taken from each end of the test seam using an approved template. The samples shall be tested in the field tensiometer, one from each and in peel and shear respectively. Samples tested in peel shall not fail in the seam. All test samples shall exhibit film tear bond and strength as defined under seam properties, Table 1.

Table 1: Geomembrane

Material Property	**Minimum Average Roll Values (Metric)**	
Nominal Thickness		**1.5 mm (60mils)**
	Units	**Value**
Thickness, ASTM[4] D751, NSF[5] Mod., Nominal	mm	1.50
Indent Lowest Individual Reading	mm	1.37
Density, ASTM D1505	g/cm^3	0.940
Melt Flow Index, ASTM D1238 Cond. E. Max	g/10 min.	1.0
Carbon Black Content, ASTM D1603	percent	2.0 - 3.0
Carbon Black Dispersion, ASTM D3015	rating	A2
Minimum Tensile Properties, ASTM D638 Stress at Yield	N/cm	231
Stress at Break	N/cm	399
Stress at Yield nominal gage of 1.30" per NSF Mod.	percent	13
Stress at Break nominal gage of 2.5" per NSF Mod.	percent	560
Tear Resistance, ASTM D1004	N/cm N	1230 200
Puncture Resistance, FTMS[2] 101, 2065	N/cm N	2280 347
ESCR[3], ASTM D1693, NSF Mod., Pass	hours	1500
Dimensial Stability, ASTM D1204, NSF Mod., Max.	percent	2.0
Low Temperature Brittleness	°C	-60
Single-Point Notched Constant Tensile Load time to Failure	(hr)	200
Field Seam Properties 1. Shear Strength 2. Peel Strength	 N/cm N/cm	 212 FTB and 139

1. Film Tear Bond (FTB) is defined as failure of one of the sheets by tearing, instead of separating from the welded seam - that test specimen shall no fail by more than 10% into the seam. For double hot wedge fusion welded seam, both inside and outside tracks shall be tested.
2. FTMS: Federal Test Method Standard
3. ESCR: Environmental Stress Crack
4. ASTM: American Society for Testing and Materials Standards
5. NSF: National Sanitation Foundation

If the seam fails to pass, the seaming apparatus shall not be used for field seaming until any deficiencies have been corrected. This shall be verified by the production and successful testing of two consecutive test seams.

2.3.2 Vacuum Testing - All extrusion welded seams and "T" seams shall be evaluated using vacuum box testing.

A sudsy soap solution shall be applied to the test section and the vacuum box placed over the section. The vacuum box shall maintain at least .2 bar vacuum during the test. Once a tight seal has been established, the test section shall be viably examined for a period of not less than 10 seconds to determine whether bubbling of the soapy solution at the seam is occurring. The vacuum box is then moved and the process is repeated on the next adjacent section. A minimum of 100 millimetres overlap shall be provided between all test sections.

All locations where bubbling of the sudsy solution is observed shall be clearly marked for repairs with a high visibility marker and recorded by number on field test reports. Any failed portion of seam shall be repaired and retested.

2.3.3 Air Pressure Testing - Double wedge welded seams shall be sealed off at both ends. If the end of a seam will be an integral part of the geomembrane, the sealing shall be done in such a way that it does not harm the function of the geomembrane. The pressure feed device shall be inserted into the air channel at one end of the seam and pressurized to 1.5 - 2.0 bars. The feed valve shall be closed and the pressure sustained for a period of not less than 3 minutes. The pressure shall then be released by slitting the air channel at the opposite end of the seam. The Inspector shall observe the drop in pressure on the manometer to verify the continuity of the air channel.

If a pressure loss of greater than .2 bar is observed or if the required pressure cannot be reached, then the seam shall be rejected, and shall be either reconstructed in its entirety or the leak located and patched. The entire seam shall then be retested according to the procedure outlined above.

2.3.4 All seams shall be non-destructively tested by the Installer over their full length to verify the integrity of the seam. Non-destructive testing shall be performed concurrently with field seaming. All non-destructive testing shall be observed and documented by the Inspector.

2.3.5 Seams failing a test shall be repaired and retested.

2.3.6 Cap seams which cannot be subjected to a non-destructive test using geomembrane of the same batch under the supervision of the inspector. Test the cap seams. Alternatively, remove the seam and

adjacent geomembrane panel, replace and test.

2.4 Destructive Testing

2.4.1 Destructive testing of field seams shall be performed at selected locations in order to verify seaming properties. All sampling and testing shall be done concurrently with field seaming so that verification of field seam properties is made as the work progresses and corrective action implemented, if necessary.

2.4.2 Test samples shall be taken at an average frequency of one test location per 150 meters of seam. Sample locations shall be determined by the Inspector taking into consideration the difficulty of subsequent repair and testing.

2.4.3 Samples shall be cut under the direction of the Inspector. Each sample shall be indelibly numbered and identified. Each sample shall be identified with the sample number, seam number, panel number, date, name of welding technician, and welding equipment number.

2.4.4 The Inspector may increase the amount of destructive testing based on the results of previous testing. Additional samples may also be required when the Inspector has reason to suspect the presence of excess crystallinity, contamination, faulty seaming equipment or any other reason affecting seam quality.

2.4.5 The test sample shall measure approximately 300 millimetres wide by 1.0 metre long with seam centred lengthwise along the sample.

2.4.6 25 mm wide sample strips shall be cut from the sample using an approved die, and tested by an on-site tensiometer. Two 25 mm wide samples shall be taken from each end for shear and peel testing. The seam shall not fail either test as specified in Section 2.3.

2.4.7 The remaining sample shall be tested in an independent tensiometer to qualify seam strength properties and FTB according to the procedures outlined in this section.

The Inspector shall cut ten (10) 25 mm wide replicate specimens from his sample and shall test 5 specimens for seam shear strength and 5 for peel strength. To be acceptable, 5 out of the 5 replicate specimens must pass for each mode of testing. All specimens must fail in Film Tear Bond (FTB); any specimen that fails through the weld, or by adhesion at the weld-sheet interface, is a non-film Tear Bond break and shall be

considered a failure.

2.4.8 The test method and procedures to be used by the Inspector shall employ a grip separation rate of 50 mm/min for peel and shear.

2.4.9 The area from which the destructive test sample was take shall be repaired without delay and shall be non-destructively tested by vacuum box as described in Section 2.3.2.

2.5 Inspection and Acceptance

2.5.1 As the work progresses, the Inspector shall document all locations requiring repair work and shall verify and document that all repairs have been successfully made. No work on the liner shall be allowed if the Inspector is not present. This is to include start-up tests, general seaming and patching, and any work at penetrations or structures.

2.5.2 Seams are only considered to be accepted after they have passed the specified non-destructive and destructive tests, and the equipment used to produce the seams have passed the required start-up tests. If a seam fails the above criteria, the seam must be reconstructed.

2.5.3 A double hot wedge fusion seam shall be considered acceptable only when both outside and inside track welds are destructively tested and meet the specification criteria.

2.5.4 If a seam fails the destructive test, the seam may be reconstructed between the point of failure and any previously accepted test.

2.5.5 In lieu of .4 above, the Installer may trace the extent of unacceptable seam. Take 25 mm samples at minimum 3 metre distance on each side of failed section. Test in both shear and peel. If one or both tests fail, continue along seam at minimum 3 metre increments. Continue until tests indicate pass results. Then take large samples for field laboratory tensimeter testing. If field laboratory tests pass, make repairs - if fail, continue.

2.5.6 Reconstruction or repair of failed seam lengths shall be either by capping of the failed seam (extrusion or fusion weld) or, in the case of a double fusion weld, by extrusion fillet welding the overlap to the bottom sheet. Cutting off the overlap and topping the failed fusion weld with extrudate will not be permitted.

2.5.7 If the overlap of the outside (i.e. visible) weld is less than 30 mm extrusion welding of the overlap to the bottom sheet in the failed section will not be permitted.

2.5.8 Continuity of all reconstructed seams to be subject to non-destructive testing. If reconstructed length exceeds 50 metres, sample shall be taken for laboratory destructive testing.

2.5.9 The entire geomembrane surface shall be examined by the Inspector to confirm that it is free of any defects, blisters, undispersed raw materials, or contamination by foreign matter. The geomembrane surface shall be cleaned, if required, so that it is free of dust, mud, debris or any other material which may inhibit a thorough examination of the surface. Any suspect areas shall be clearly marked by the Inspector and non-destructively tested according to the appropriate specified testing procedure.

2.5.10 Overburden shall not be applied to any portion of the liner system until that portion system is inspected and has been approved.

2.5.11 Gouges or scratches associated with grinding or from other sources whose depth is in excess of 10% of the geomembrane thickness shall be classified as defects and will require appropriate repairs in accordance with these specifications.

2.5.12 Small tears, wrinkles or pinholes to be repaired by seaming or patching. Other areas to be patched or capped.

2.5.13 Patches shall be round or oval, of the same material and thickness, and shall extend a minimum of 150 mm beyond the damaged or faulty area in all directions.

2.5.14 Geomembrane surfaces to be patched shall be abraded, in accordance with these Specifications. Surfaces must be clean and dry.

2.5.15 Use approved extrusion welding equipment.

2.5.16 All repairs to be non-destructively tested.

2.5.17 Cut and repair any large wrinkles or "fishmouths" identified by the Inspector.

3.0 SOIL LINER

3.1 Soil Liner Quality Control

Quality control of low permeability fill material and placement shall be based on the following minimum procedures and criteria:

3.1.1 Prior to constructing the soil liner, a test section shall be constructed in two lifts to the specified thickness, consisting of not less than three panels 3 m wide and 10 m long.

3.1.2 Mixing methods shall be modified as necessary to achieve specified coefficient of permeability.

3.1.3 Placement and compaction methods shall be modified as necessary to achieve specified coefficient of permeability.

3.1.4 Samples and measurements of test section shall be taken. Physical parameters to be tested in the laboratory include grain size, moisture content, Atterberg Limits, moisture density relationship and hydraulic conductivity. Compacted in-situ density (by Nuclear Method ASTM D2922) and permeability by air entry infiltrometer shall be measured.

3.1.5 The method of construction, verified by the Applicant shall then be submitted to the Department. Once submitted, no deviation from the method of construction will be allowed by the contractor unless written approval is obtained from the Department.

3.1.6 The Installer shall employ a certified geotechnical company with laboratory testing capabilities that can supply the qualified personnel and equipment necessary to perform the required tests.

3.1.7 The geotechnical company shall perform all required tests on the soil liner material at the mixing/stockpile area. The results of these tests shall be approved prior to the material being used for liner construction.

3.1.8 The geotechnical company shall perform all tests on the liner subgrade. The results of these tests shall be available for inspection as required.

3.1.9 The geotechnical company shall perform all required tests on the liner material while it is being placed, and after it is complete, as defined in this specification. The results of these test shall be submitted for approval immediately upon completion of the Test.

3.1.10 The geotechnical company shall certify that all specified requirements are met.

3.2 Soil Liner Quality Assurance

3.2.1 Quality Assurance of soil liner material and placement shall be

based on the following minimum procedures and criteria:

3.2.1.1 An independent Inspector shall perform all required tests on the soil liner material at the stockpile area. The results of these tests shall be submitted for approval prior to the material being used for liner construction.

3.2.1.2 The Inspector shall perform all required tests on the soil liner material while it is being placed, and after it is complete. The results of these tests shall be submitted for approval immediately upon completion of the tests.

3.2.1.3 The average results of any ten consecutive density tests shall be equal to or greater than the specified density.

3.2.1.4 Results of not more than two in any ten consecutive density tests may be less than the specified density.

3.2.1.5 Results of any ten consecutive moisture content tests shall be within the specified moisture content limits.

3.2.1.6 Results of not more than two in any ten consecutive moisture content tests may lie outside the specified content limits.

3.2.1.7 Permeability evaluated from results of tests shall be equal to or less than the specified permeability.

3.2.1.8 Average of results of any ten consecutive grain size tests shall be within the specified limits for grain size.

3.2.1.9 The testing shall include the items identified in Table 2 as a minimum:

3.2.1.10 Any portions of the completed liner which do not achieve compacted dry density and moisture contents in the range specified shall be replaced.

Table 2: Soil Liner Testing

Item	Testing	Minimum Frequency
Soil Prior to Placement	Moisture Content	750 m^3
	Moisture-density curve	1 test/4000 m^3
	Grain Size	1 test/750 m^3
	Atterberg Limits (liquid limit and plasticity index)	1 test/4000 m^3
	Lab permeability (remolded samples)	1 test/7500 m^3
In Place Liner	Density	Every 200 m^2 of exposed lift surfaces
	Moisture Content	100 m^3
	Atterberg Limits (liquid limit and plasticity index)	2 tests/hectare/lift
	Grain size (to the 2-micron particle size)	2 tests/hectare/lift
	Moisture-density curve	1,500 m^3 or a minimum of 1 every 3 days of placement
	Laboratory permeability of undisturbed soil sample	2 test/hectare/lift – air apparatus
	In-situ permeability	5 tests/hectare/lift – undisturbed Shelby sample

3.2.2 Method of testing of the soil liner shall be as follows:

3.2.2.1 The maximum density of low permeability fill and the optimum water content for compaction will be determined in accordance with ASTM D698, Method D.

3.2.2.2 Bulk density will be determined in the field in accordance with ASTM D2922 or with ASTM D1556, whichever is most suitable, to obtain a representative density of the fill tested.

3.2.2.3 Particle size analysis of the soil will be performed in accordance with ASTM D422.

3.2.2.4 Samples for hydraulic conductivity testing of the compacted fill shall be collected in thin walled Shelby tubes from the compacted liner and tested in the laboratory. Confining pressure during the permeability testing will be equal to the applicable surcharge load.