STANDARD NUMBER 54

Flexible Membrane Liners

NATIONAL SANITATION FOUNDATION
LISTING SERVICES

NATIONAL SANITATION FOUNDATION
STANDARD 54
FOR
FLEXIBLE MEMBRANE LINERS

As Prepared by
The Joint Committee
on
Flexible Membrane Liners
and
Recommended for Adoption
by
The NSF Council of Public Health Consultants
Adopted
by
The NSF Board of Trustees

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National Sanitation Foundation
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The following is a list of nationally uniform sanitation standards and criteria established by the National Sanitation Foundation.

Current standards and criteria include:

1 Soda Fountain and Luncheonette Equipment
2 Food Service Equipment
3 Spray-Type Dishwashing Machines
4 Commercial Cooking and Hot Food Storage Equipment
5 Commercial Hot Water Generating and Heat Recovery Equipment
6 Dispensing Freezers
7 Food Service Refrigerators and Storage Freezers
8 Commercial Powered Food Preparation Equipment
12 Automatic Ice Making Equipment
13 Refuse Compactors and Compactor Systems
14 Plastic Piping System Components and Related Materials
18 Manual Food and Beverage Dispensing Equipment
20 Commercial Bulk Milk Dispensing Equipment and Appurtenances
21 Thermoplastic Refuse Containers
23 Marine Sanitation Devices
24 Plumbing System Components for Mobile Homes and Recreational Vehicles
25 Vending Machines for Food and Beverages
26 Pot, Pan and Utensil Commercial Spray Type Washing Machines
29 Detergent and Chemical Feeders for Commercial Spray Type Dishwashing Machines
30 Cabinetry and Laboratory Furniture for Hospitals
31 Polyethylene Refuse Bags
35 Laminated Plastics for Surfacing Food Service Equipment
36 Dinnerware
37 Air Curtains for Entranceways in Food Establishments
38 Test Kits for Swimming Pool Water
39 Resilient Artificial Recreational Surfaces
40 Individual Aerobic Wastewater Treatment Plants
41 Wastewater Recycle/Reuse and Water Conservation Systems
42 Drinking Water Treatment Units — Aesthetic Effects
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C-8 Pitless Well Adapters
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C-10 Ductless Air Circulating and Treatment Devices

THE NATIONAL SANITATION FOUNDATION

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The appendices referenced in NSF standards are not considered an integral part thereof. The appendices are provided as general guidelines to the manufacturer, regulatory agency, user or certifying organization.

PREFACE

The development of the NSF Standard for Flexible Membrane Liners (FML) began as a response to a growing national interest in responsible containment of certain hazardous waste materials. In January of 1978, a meeting of lining industry, regulatory and user representatives was held to explore the interest and feasibility of an NSF standard covering polymeric membrane liners for land disposal of solid wastes.

At the first few meetings, it became clear that an NSF standard would serve a very useful purpose for national, state and local regulatory agencies responsible for safe containment of hazardous and toxic materials; to FML manufacturers and fabricators who produce the FML; to engineers who design such installations; and to private and governmental organizations who would have a use for such liners. Further, it was determined that the NSF standard for FML should cover the broad use of polymer lining materials encompassing not only solid waste disposal sites, but a broad range of containment of hazardous and toxic fluids and the retention of fresh water for a variety of uses such as reservoirs, canals and recreational ponds.

The scope of the standard was to cover the existing and recently developed polymer linings which could be installed as prefabricated linings which may or may not require field seaming to form the finished lining. The objective of the standard was to establish a reliable and dependable means of industry furnishing an FML of known and consistent quality. Suitability of any particular FML for a specific application remains the responsibility of the user.

Following the normal NSF procedure, a Joint Committee was established to write the standard and furnish NSF technical information for appropriate policy on the use of the standard.

One of the major tasks of the Joint Committee has been to establish the requirements for various materials. These requirements now appear as the materials properties tables in the standard. At first, there was an attempt to generate a general, all inclusive standard requirement for all FML based upon the service needs of the FML. However, it was soon recognized that the engineering requirements would vary from application to application. More important is the fact that good FML of different chemical composition would have different physical properties. Consequently, the standard has been prepared on the basis of key tests which charactertize a good quality FML of a particular chemical composition. As a result, the requirements for a good 30 mil PVC plastic liner are different from a 30 mil EPDM rubber liner.

Selection of the properties to be listed was based upon current knowledge in the field of important parameters for which reasonable test methods had been established or could readily be devised. In general, the test methods selected are based upon test procedures established by the American Society for Testing and Materials (ASTM) or other widely recognized standards setting organizations. In some cases, these have been modified to reflect the technical knowledge and experience of the Joint Committee. In a few selected uses, special tests have been developed to meet a special need.

The properties, test methods, and required values appearing in the material properties tables were specifically chosen as those that are critical in the characterization of the individual FML. There are differences from one material to another in the tests required, test methods used and the values required. This is because the chemical nature and physical properties of different membrane materials are not the same. Hence, the material property tables should be dealt with separately as properties, methods and values that are critical to one FML may not be critical in describing another type.

Two important qualities for FML have not been included in the requirements set forth in this standard. These are impermeability and puncture resistance. For these properties, either they are not appropriate for a materials requirement or a good test does not exist.

An important basic FML property is impermeability. However, the inherent impermeability of the lining material itself is so great as to make the property meaningless in evaluating a material for use as an FML. In actual use, flexible membrane liners do not leak unless there is a hole in the liner, a failure of a seam, or the liner is degraded by the particular service condition. Falling head or constant head permeameters are typically used in the laboratory to determine permeability of soils. However, for FML, such measurement of permeability is a measure more of vapor transport than of fluid permeability or porosity. Therefore, a permeability test is not included in the materials properties tables.

The resistance of an FML to the attack of the chemicals to be contained is an obviously important concern. There is a wide variety of different chemicals which are to be contained in industrial and municipal applications. The response of different FML materials is quite different to many chemicals. The environmental conditions of temperature, phase separation, etc., vary from case to case. There is no test method universally accepted for precisely establishing the chemical resistance of any FML materials. For these reasons, standard requirements for FML have not been included and NSF makes no representations as to the chemical resistance. Guidelines are given in Appendices C, D and E for selection and evaluation of possible FML materials for applications requiring the containment of fluids other than fresh water.

A committee will be formed to recommend procedures, conditions, chemicals and methods of evaluation for chemical resistance of FML and guidelines will be developed.

FML should have reasonable resistance to puncture from rapid point stress such as falling rock in earth cover operation or the dropping of tools during installation. The FML should also be resistant to prolonged point stress resulting from soil and fluid loading over occasional stone or hard dirt clods under the liner. The Joint Committee found that although some tests do exist which relate to puncture resistance, none is acceptable as standard requirement. Some are very useful as research and development tools in the comparative study of different materials or the aging of materials after field or artificial exposure. These tests, however, lack the ability to be reproducible from laboratory to laboratory and do not have sufficient consistency to have been accepted as a material standard.

In preparing the standard, the Joint Committee recognized that the successful application of an FML in a particular situation depended upon several factors beyond the use of a good quality FML. To assist in the successful use of the liner, some guidelines and recommendations are given in the appendices. Final acceptance of FML for any application covered under governmental regulation will be subjected to the approval of the appropriate federal, state and/or local regulatory agency having jurisdiction.

NOTE: The standard covers both existing and recently developed polymeric liners. The purpose of the standard is to provide a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

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SECTION 1. GENERAL

1.0 SCOPE: This standard covers flexible membrane liners used in the retention of waters and containment of pollutants or chemicals in an environmentally acceptable manner. The successful application of the flexible membrane liners covered by this standard depend upon appropriate site evaluation, design, materials selection, construction and operation and maintenance. Guidelines covering these factors are presented in Appendix C. The standard includes requirements for evaluation of flexible membrane liners and fabrication techniques. Accordingly, materials properties tables for the various membranes are provided to indicate requirements for liner characterization and evaluation; liner fabrication requirements are also developed to accommodate evaluation for the indicated applications. Special test methods or revisions of standard test procedures are included in Appendix A to provide uniformity and consistency in the analytical protocol supportive of the standard.

1.1 MINIMUM REQUIREMENTS: These standards are established as a guide to the evaluation of flexible membrane liners covered herein and are considered to be basic and minimum requirements.

1.2 REVIEWS AND REVISIONS: A comprehensive review of the standard shall be conducted at intervals of not more than five years to determine what changes, deletions or additions, if any, are necessary to maintain current and effective requirements consistent with new technology and progress. These reviews shall be conducted by appropriate representatives of regulatory, industry and user groups. Final adoption of any revision shall be in accordance with the procedures established by the NSF Joint Committee for Flexible Membrane Liners.

SECTION 2. DEFINITIONS

2.0 GENERAL: The definitions included in this section explain words or terms specifically used in this standard for which dictionary definitions either do not exist or are not applicable to the term as used within the context of this standard.

2.1 ALLOYS, POLYMERIC: A blend of two or more polymers such as a rubber and a plastic to modify a given property; e.g., tensile strength.

2.2 BONDED SEAM STRENGTH: Strength of a seam of liner material measured either in shear or dead load, or peel modes. Strength of the seams is reported either in absolute units; e.g., pounds per inch of width; or as a percent of the strength of the sheeting.

2.3 BREAKING FACTOR: Tensile force per unit of width at break measured in pounds per inch (Newtons per meter) and used to describe properties of membranes.

2.4 BREAKING STRENGTH: Tensile force to break measured in pounds (Newtons) on a supported membrane.

2.5 BUTYL RUBBER (IIR): A synthetic rubber based on isobutylene and a small amount of isoprene to provide sites for vulcanization.

2.6 CHLORINATED POLYETHYLENE (CPE): Family of polymers produced by the chemical reaction of chlorine with polyethylene. The resultant polymers presently contain 25 - 45% chlorine by weight and 0 - 25% crystallinity.

2.7 CHLOROSULFONATED POLYETHYLENE (CSPE): Family of polymers produced by the reaction of polyethylene with chlorine and sulfur dioxide. Present polymers contain 23.5 - 43% chlorine and 1.0 - 1.4% sulfur. A "low water absorption" grade is identified as significantly different from standard grades (see Table 11B).

2.8 CROSSLINKING: A general term referring to the formation of chemical bonds between polymeric chains to yield a three-dimensional polymeric structure. Crosslinking of rubbers is vulcanization.

2.9 ELASTICITY: The property of matter by virtue of which it tends to return to its original size and shape after removal of the stress which caused the deformation.

2.10 ELONGATION: Extension produced by a tensile stress.

2.11 ELONGATION AT BREAK: The extension of a uniform section of a specimen at rupture expressed as percent of the original length.

2.12 ELONGATION AT YIELD: The extension of a uniform section of specimen at yield expressed as percent of the original length.

2.13 ELASTOMER: See "Rubber".

2.14 ETHYLENE PROPYLENE DIENE TERPOLYMER (EPDM): A synthetic elastomer based on ethylene, propylene, and a small amount of nonconjugated diene to provide sites for vulcanization.

2.15 FABRIC REINFORCEMENT: A fabric, scrim, etc., used to add structural strength to a two or more ply polymeric sheet. Such sheeting is referred to as "supported".

2.16 FILM TEARING BOND: Failure of one of the parts of a ply by tearing, instead of separating from the other part of the specimen at the separation line.

2.17 HIGH DENSITY POLYETHYLENE (HDPE): A polymer prepared by low-pressure polymerization of ethylene as the principal monomer.

2.18 HYDROSTATIC RESISTANCE: Resistance to bursting using the flexible membrane liner as the diaphragm.

2.19 MEMBRANE: A prefabricated continuous sheet of flexible polymeric material.

2.20 MODULUS (FORCE) AT 100% ELONGATION: Stress at 100% elongation.

2.21 MODULUS OF ELASTICITY: The ratio of stress to strain below the yield point.

2.22 NITRILE RUBBER: A family of copolymers of butadiene and acrylonitrile that are oil resistant and can be vulcanized into oil resistant compounds.

2.23 PERMEABILITY: The capacity of a porous medium to conduct or transmit fluids. The amount of liquid moving through can be measured in a unit time, unit area, and unit pressure gradient not normalized for but directly related to thickness.

2.24 PLASTIC: A material that contains as an essential ingredient one or more polymeric substances of high molecular weight, is solid in its finished state and at some stage in its manufacture or processing into finished articles, can be shaped by flow.

2.25 PLASTICIZER: A material, frequently "solvent-like" incorporated in a plastic or rubber to increase ease of workability, flexibility or extensibility.

2.26 POLYETHYLENE-ETHYLENE PROPYLENE ALLOY (PE-EP-A): Blend of polyethylene and ethylene proplyene polymer resulting in a thermoplastic elastomer.

2.27 POLYMER: A macromolecular material formed by the chemical combination of monomers having either the same or different chemical composition. Plastics, rubbers and textile fibers are all high molecular weight polymers.

2.28 POLYVINYL CHLORIDE (PVC): A synthetic thermoplastic polymer made by polymerizing vinyl chloride monomer, or vinyl chloride/vinyl acetate monomers. Normally rigid, plasticizers are added to provide properties required for flexible membrane liners.

2.29 RUBBER: A polymeric material which, at room temperature, is capable of recovering substantially in shape and size after removal of a deforming force. Refers to both synthetic and natural rubber and is also called an elastomer.

2.30 SCRIM: A reinforcing fabric.

2.31 SEAMS:

2.31.1 ADHESIVE SEAMS: A chemical system is used to develop bond strength between two membrane surfaces. The chemical adhesive becomes an additional element to the seam system.

2.31.2 BODIED SOLVENT SEAMS: The parent material dissolved in a solvent is used to soften and bond the membrane materials.

2.31.3 DIELECTRIC SEAMS: High frequency dielectric equipment is used to generate heat and pressure on an overlap seam joint resulting in a homogeneous melt of the two membrane surfaces.

2.31.4 EXTRUSION WELDED SEAMS: A bond between the two flexible membrane sheets is achieved by heat extruding the parent material between or over the overlap areas followed by applied pressure.

2.31.5 SOLVENT SEAMS: Solvents are used to soften and bond the membrane surfaces.

2.31.6 TAPE SEAMS: A width of material to which a chemical adhesive has been applied is used to tape a seam joint. The tape provides the bond and the tensile strength of the joint.

2.31.7 THERMAL SEAMS: High temperature is produced between an overlap seam joint to melt the membrane surfaces, followed by a pressure system that results in the homogeneous bond of the two membrane surfaces.

2.31.8 VULCANIZED SEAMS: Overlapped unvulcanized sheets cured together using heat and pressure.

2.32 SPECIAL ENGINEERED (SE): Specifically designed for a particular end use or application.

2.33 SUPPORTED MEMBRANE: See "Fabric Reinforcement".

2.34 TEAR STRENGTH:The force required to tear a specimen. The value is determined by the specific test procedure being used.

2.35 THERMOPLASTIC: A material capable of being repeatedly softened by increase of temperature and reformed by decrease in temperature.

2.36 THERMOPLASTIC ELASTOMERS: Polymeric materials having elasticity characteristics similar to rubber and capable of being repeatedly softened and reformed.

2.37 TYPE: A designation relating to the strength of the fabric reinforcement.

2.38 UNSUPPORTED MEMBRANE: A polymeric membrane one or more plies thick without a reinforcing fabric layer or scrim.

SECTION 3. MATERIALS AND MEMBRANE MANUFACTURE

3.0 GENERAL: Flexible membrane liners shall meet the specific physical, chemical, taste and odor requirements as established herein for the intended application. Liners shall be free of pinholes, blisters, holes and contaminants which include, but are not limited to wood, paper, metal and nondispersed ingredients.

3.0.1 FORMULATION: The compounding ingredients used in producing membrane liners shall be first quality, virgin material meeting specific public health and safety requirements as well as providing durable and effective formulations for liner applications. Clean rework materials containing encapsulated scrim or other fibrous materials shall not be used in the manufacture of FML used in Containment Applications as defined in Item 3.3 only. Clean rework materials of the same virgin ingredients generated from the manufacturer's own production may be used by the same manufacturer, provided that the finished products meet the requirements of this standard.

3.0.2 MEMBRANE MATERIALS: The membrane materials covered by this standard include the following:

- Polyvinyl Chloride (PVC) - Table 1A
- Oil Resistant Polyvinyl Chloride (PVC-OR) - Table 1B
- Chlorinated Polyethylene (CPE) - Tables 2A and 2B
- Butyl Rubber (IIR) - Table 3
- Polychloroprene (CR) - Table 4
- High Density Polyethylene (HDPE) - Table 5
- Ethylene-Propylene Diene Terpolymer (EPDM) - Table 6
- Epichlorohydrin Polymers (CO) - Table 7
- Polyethylene Ethylene Propylene Alloy (PE-EP-A) - Table 8
- High Density Polyethylene Elastomeric Alloy (HDPE-A) - Table 9
- Chlorosulfonated Polyethylene (CSPE) - Table 10A
- Chlorosulfonated Polyethylene Low Water Absorption (CSPE-LW) - Table 10B
- Thermoplastic Nitrile - PVC (TN-PVC) - Table 11
- Thermoplastic EPDM (T-EPDM) - Table 12
- Ethylene Interpolymer Alloy (EIA) - Table 13
- Chlorinated Polyethylene Alloy (CPE-A) Tables 14A and 14B

Some materials are unsupported; others are supported with a reinforcing scrim. The scrim affects the physical properties of the membrane.

3.0.2.1 NEW MEMBRANE MATERIALS: New membrane materials will be added to the standard provided data (field experience and test data) to characterize the materials and assure satisfactory liner performance are provided. (A recommended protocol for developing the data is included in Appendix F.)

3.0.3 INSTALLATION CONDITION: Some materials are intended to be buried membranes; others are intended to be exposed membranes. Both membrane materials and factory seams for exposed linings shall pass the weathering test for a minimum of 1,000,000 Langleys given in Appendix A with a rating of 7 or better.[1]

3.0.4 SERVICE GRADE: The flexible membrane material shall be considered as industrial grade, not suitable for potable water applications unless it meets the requirements of Item 3.2.1, Potable Water Applications. Furthermore, the flexible membrane liner will not be considered oil resistant unless it meets the requirements as given in the Materials Properties Tables, Item 3.1.

[1]This requirement is to become effective three years after the implementation of this standard.

3.0.5 IDENTIFICATION/NAMING OF MATERIALS: In order to name any material by a specific polymer name, it must contain more than 50% of the total polymer content of that polymer. If no polymer is greater than 50% of the total polymer content, then it shall be called by the principle polymer with the term alloy, or the principle polymer shall be the first in the string of modifiers.

3.1 MATERIALS PROPERTIES: The materials properties tables present minimum requirements necessary to meet the provisions of the standard. Test methods shall comply with applicable American Society for Testing and Materials (ASTM) procedures or as amended (See Appendix A). Values contained in the tables characterize the materials and should not be used for direct application to indicate field performance. The information presented in the tables is based upon the properties of materials submitted for evaluation during the preparation of the standard.

TABLE 1A. MATERIAL PROPERTIES
POLYVINYL CHLORIDE (PVC)

Property	Test Method	Unsupported (U) 10	20	30	45
Gauge (Nominal)	—	10	20	30	45
Thickness, mils minimum	ASTM D1593 Para 8.1.3	9.3	19	28.5	42.75
Specific Gravity (minimum)	ASTM D792 Method A	1.20	1.20	1.20	1.20
Minimum Tensile Properties (each direction)	ASTM D882				
1. Breaking Factor (pounds/inch width)	Method A or B (1 inch wide)	23	46	69	104
2. Elongation at Break (percent)	Method A or B	250	300	300	300
3. Modulus (force) at 100% Elongation (pounds/inch width)	Method A or B	9	18	27	40
Tear Resistance (pounds, minimum)	ASTM D1004 Die C	3	6	8	11
Low Temperature, °F	ASTM D1790	-10	-15	-20	-20
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	5	5	5	5
Water Extraction (percent loss maximum)	ASTM D3083 (as modified in Appendix A)	-0.35	-0.35	-0.35	-0.35
Volatile Loss (percent loss maximum)	ASTM D1203 Method A	1.5	0.9	0.7	0.5
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)				
1. Breaking Factor		5	5	5	5
2. Elongation at Break		20	20	20	20
3. Modulus at 100% Elongation		20	20	20	20
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A	37	60	82	100
Factory Seam Requirements[1]					
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	18.4	36.8	55.2	83.2
Peel Adhesion (pounds/in. minimum)	ASTM D413 (as modified in Appendix A)	FTB[2] or 10 lb/in	FTB[2] or 10 lb/in	FTB[2] or 10 lb/in	FTB[2] or 10 lb/in
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)				
Peel Adhesion		-20	-20	-20	-20
Bonded Seam Strength		-20	-20	-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tearing Bond.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 1B. MATERIAL PROPERTIES

POLYVINYL CHLORIDE (PVC-OR)
OIL RESISTANT GRADE

Property	Test Method	Unsupported (U) 30
Gauge (Nominal)	—	30
Thickness, mils minimum	ASTM D1593 Para 8.1.3	28.5
Specific Gravity (minimum)	ASTM D792 Method A	1.20
Minimum Tensile Properties (each direction)	ASTM D882	
1. Breaking Factor (pounds/inch width)	Method A or B (1 inch wide)	69
2. Elongation at Break (percent)	Method A or B	300
3. Modulus (force) at 100% Elongation (pounds/inch width)	Method A or B	27
Tear Resistance (pounds, *minimum*)	ASTM D1004 *Die C*	8
Low Temperature, °F	ASTM D1790	0
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	5
Water Extraction (percent loss maximum)	ASTM D3083 (as modified in Appendix A)	-0.35
Volatile Loss (percent loss maximum)	ASTM D1203 Method A	0.5
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
1. Breaking Factor		5
2. Elongation at Break		20
3. *Modulus at 100% Elongation*		*20*
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A	82

Oil Resistance Requirements

See ASTM D471, Oil Extraction, 7 days, percent maximum change, machine direction

	Neats Foot	Gulf Harmony #68	Corn (Mazola)	ASTM No. 2
Weight @73.4±3°F	- 5	- 5	- 5	- 5
Weight @158±3°F	- 15	- 15	- 15	- 10
Tensile @73.4±3°F	+5	+10	+10	+10
Tensile @ 158±3°F	+15	+15	+15	+15
Elongation @ 73.4±3°F	- 10	- 10	- 10	- 10
Elongation @ 158±3°F	- 25	- 15	- 25	- 25

Factory Seam Requirements[1]

Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	55.2
Peel Adhesion (pounds/in. minimum)	ASTM D413 (as modified *in Appendix A)*	FTB[2] or *10 lb/in*
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
Peel Adhesion		-20
Bonded Seam Strength		-20

[1]Factory seam requirements are the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tearing Bond.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 2A. MATERIAL PROPERTIES

CHLORINATED POLYETHYLENE (CPE)

Property	Test Method	Unsupported (U) 20	30
Gauge (nominal)	—	20	30
Thickness, mils minimum	ASTM D1593 Para. 8.1.3	19	28.5
Specific Gravity (minimum)	ASTM D792 Method A	1.20	1.20
Minimum Tensile Properties (each direction)	ASTM D882		
1. Breaking Factor (pounds/inch width)	Method A or B	34	43
2. Elongation at Break (percent)	Method A or B	250	300
3. Modulus (force) at 100% elongation (pounds/inch width)	Method A or B	8	12
Tear Resistance (pounds, minimum)	ASTM D1004 Die C	3.5	4.5
Low Temperature, °F	ASTM D1790	-20	-20
Dimensional Stability (percent change maximum)	ASTM D1204 212°, 15 min.	16	16
Water Extraction (percent loss maximum)	ASTM D3083 (as modified in Appendix A)	-0.35	-0.35
Volatile Loss (percent loss maximum)	ASTM D1203 Method A	0.7	0.5
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)		
1. Breaking Factor		5	5
2. Elongation at Break		20	20
3. Modulus at 100% Elongation		20	20
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A	75	100
Factory Seam Requirements[1]			
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	27	34
Peel Adhesion (lbs/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2] or 10 lb/in	FTB[2] or 10 lb/in
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)		
Peel Adhesion		-20	-20
Bonded Seam Strength		-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

[3]Film Tearing Bond is acceptable.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 2B. MATERIAL PROPERTIES

CHLORINATED POLYETHYLENE (CPE)

Property	Test Method	Supported (S) 2-30	3-36	3-45
Gauge (nominal)	—	27	36	45
Thickness, mils minimum	ASTM D751			
1. Overall		32	34	41
2. Over Scrim	Optical Method (see Appendix A)	11	11	11
Breaking Strength (pounds, minimum)	ASTM D751	120	200	200
Tear Strength (pounds, minimum)	ASTM D751 (as modified in Appendix A)			
1. Initial		25	35	35
2. After Aging		20	25	25
Low Temperature, °F	ASTM D2136 ⅛ in. mandrel 4 hrs. Pass	-40	-40	-40
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 1 hr.	2	2	2
Volatile Loss (percent loss maximum)	ASTM D1203 Method A 30 mil sheet	0.5	0.5	0.5
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 30 mil sheet (as modified in Appendix A)			
a. Unsupported Sheet				
1. Breaking Strength		5	5	5
2. Elongation at Break		20	20	20
3. Modulus at 100% Elongation		20	20	20
b. Membrane Fabric Breaking Strength	ASTM D751 Method A	25	25	25
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A, Proc. 1	160	250	250
Ply Adhesion (each direction pounds/in. width minimum)	ASTM D413 machine method Type A	10	7	7
		Factory Seam Requirements[1]		
Bonded Seam Strength (factory seam, breaking strength, lbs min.)	ASTM D751 (as modified in Appendix A)	96	160	160
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	Ply sep in plane of scrim or 10 lbs./in.	Ply sep in plane of scrim or 10 lbs./in.	Ply sep in plane of scrim or 10 lbs./in.
Resistance to Soil Burial (percent change maximum in original value	ASTM D3083 (as modified in Appendix A)			
Peel Adhesion		-20	-20	-20
Bonded Seam Strength		-20	-20	-20

[1]Factory seam requirements are the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 3: MATERIAL PROPERTIES

BUTYL RUBBER (IIR)

Property	Test Method	Unsupported (U) 30	45	60
Gauge (nominal)	—	30	45	60
Thickness, mils minimum	ASTM D412	27	40.5	54
Specific Gravity	ASTM D792	1.20±.05	1.20±.05	1.20±.05
Minimum Tensile Properties (each direction)	ASTM D412			
1. Breaking Factor (pounds/inch width)		36.0	54.0	72.0
2. Elongation at Break (percent)		300	300	300
Tear Resistance (pounds, minimum)	ASTM D624 Die C	4	6	8
Low Temperature, °F	ASTM D746 Procedure B	-40	-40	-40
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 7 days	2	2	2
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)			
1. Breaking Factor		10	10	10
2. Elongation at Break		20	20	20
Water Absorption (percent change, maximum)	ASTM D471 158°F, 168 hours	2	2	2
Durometer A Hardness (points)	ASTM D2240 5 second reading	60±10	60±10	60±10
Ozone Resistance	ASTM D1149 100 hours, 50 pphm 104°F, 20% extension	No Cracks 7X	No Cracks 7X	No Cracks 7X
Heat Aging	ASTM D573 7 days at 240°F			
1. Elongation (percent, minimum)		210	210	210
2. Breaking Factor (pounds/inch width, minimum)		25.2	37.8	50.4
Factory Seam Requirements[1]				
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	28.8	43.2	57.6
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2] or 6 lb/in	FTB[2] or 8 lb/in	FTB[2] or 10 lb/in
Dead Load				
Room Temperature 73°F 50% Bonded Seam Load	See Appendix A	Pass	Pass	Pass
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)			
Peel Adhesion		-20	-20	-20
Bonded Seam Strength		-20	-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tearing Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 4. MATERIAL PROPERTIES

POLYCHLOROPRENE (CR)

Property	Test Method	Unsupported (U) 30	45	60
Gauge (nominal)	—	30	45	60
Thickness, mils minimum	ASTM D412	27	40.5	54
Specific Gravity	ASTM D297	1.48±.05	1.48±.05	1.48±.05
Minimum Tensile Properties (each direction)	ASTM D412			
1. Breaking Factor (pounds/inch width)		45.0	67.5	90.0
2. Elongation at Break (percent)		250	250	250
Tear Resistance (pounds, minimum)	ASTM D624 Die C	4	6	8
Low Temperature, °F	ASTM D746 Procedure B	-30	-30	-30
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 7 days	2	2	2
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)			
1. Breaking Factor		10	10	10
2. Elongation at Break		20	20	20
Water Absorption (percent change, maximum)	ASTM D471 158°F, 168 hours	12	12	12
Durometer A Hardness (points)	ASTM D2240 5 second reading	60±10	60±10	60±10
Ozone Resistance	ASTM D1149 100 hours, 100 pphm 104°F, 20% extension	No Cracks 7X	No Cracks 7X	No Cracks 7X
Heat Aging	ASTM D573 70 hours at 212°F			
1. Elongation (percent, minimum)		150	150	150
2. Breaking Factor (pounds/inch width, minimum)		38.2	57.4	76.5
	Factory Seam Requirements[1]			
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	28.8	43.2	57.6
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2] or 6 lb/in	FTB[2] or 8 lb/in	FTB[2] or 10 lb/in
Dead Load				
Room Temperature 73°F 50% Bonded Seam Load	See Appendix A	Pass	Pass	Pass
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)			
Peel Adhesion		-20	-20	-20
Bonded Seam Strength		-20	-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 5. MATERIAL PROPERTIES

HIGH DENSITY POLYETHYLENE (HDPE)

Property	Test Method	Unsupported (U) 80	Unsupported (U) 100
Gauge (nominal)	—	80	100
Thickness, mils minimum	ASTM D1593 Para. 8.1.3	72	90
Specific Gravity (minimum)	ASTM D792 Method A	0.930	0.930
Minimum Tensile Properties (each direction)	ASTM D638		
1. Tensile Strength Yield (lb/in width)		120	150
2. Tensile Strength at Break (lb/in width)		120	150
3. Elongation at Yield (percent)		10	10
4. Elongation at Break (percent)		500	500
5. Modulus of Elasticity (lb/sq in)		80,000	80,000
Tear Resistance (lb, minimum)	ASTM D1004 Die C	40	50
Low Temperature, ° F	ASTM D746 Procedure B	-40	-40
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	±3	±3
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)		
1. Tensile Strength Yield		10	10
2. Tensile Strength at Break		10	10
3. Elongation at Yield		10	10
4. Elongation at Break		10	10
5. Modulus of Elasticity		10	10
Environmental Stress Crack (minimum, hours)	ASTM D1693 (as modified in Appendix A)	500	500
Factory and Field Seam Requirements[1]			
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	108	135
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2]	FTB[2]
Dead Load			
Room Temperature 73°F 50% Bonded Seam Load	See Appendix A	Pass	Pass
Elevated Temperature 158°F 25% Bonded Seam Load	See Appendix A	Pass	Pass
Resistance to Soil Burial	ASTM D3083		
Peel Adhesion	(as modified in	FTB[2]	FTB[2]
Bonded Seam Strength (percent change maximum in original value)	Appendix A)	-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 6. MATERIAL PROPERTIES

ETHYLENE-PROPYLENE DIENE TERPOLYMER (EPDM)

Property	Test Method	Unsupported (U) 30	45	60
Gauge (nominal)	—	30	45	60
Thickness, mils minimum	ASTM D412	27	40.5	54
Specific Gravity	ASTM D792	1.18±.03	1.18±.03	1.18±.03
Minimum Tensile Properties (each direction)	ASTM D412			
1. Breaking Factor (pounds/inch width)		42.0	63.0	84.0
2. Elongation at Break (percent)		300	300	300
Tear Resistance (pounds, minimum)	ASTM D624 Die C	4	6	8
Low Temperature, °F	ASTM D746 Procedure B	-55	-55	-55
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 7 days	2	2	2
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)			
1. Breaking Factor		10	10	10
2. Elongation at Break		20	20	20
Water Absorption (percent change, maximum)	ASTM D471 158°F, 168 hours	2	2	2
Durometer A Hardness (points)	ASTM D2240 5 second reading	60±10	60±10	60±10
Ozone Resistance	ASTM D1149 7 days, 100 pphm 104°F, 50% extension	No Cracks 7X	No Cracks 7X	No Cracks 7X
Heat Aging	ASTM D573 7 days at 240°F			
1. Elongation (percent, minimum)		210	210	210
2. Breaking Factor (pounds/inch width, minimum)		36.0	54.0	72.0
	Factory Seam Requirements[1]			
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	33.6	50.4	67.2
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2] or 6 lb/in	FTB[2] or 8 lb/in	FTB[2] or 10 lb/in
Dead Load	See Appendix A			
Room Temperature 73°F 60% Bonded Seam Load		Pass	Pass	Pass
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)			
Peel Adhesion		-20	-20	-20
Bonded Seam Strength		-20	-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 7. MATERIAL PROPERTIES

EPICHLOROHYDRIN POLYMERS (CO)

Property	Test Method	Unsupported (U) 60
Gauge (nominal)	—	60
Thickness, mils minimum	ASTM D1593 Para 8.1.3	54
Specific Gravity	ASTM D297	1.49±.06
Minimum Tensile Properties (each direction)	ASTM D412	
1. Breaking Factor (pounds/inch width)		90
2. Elongation at Break (percent)		210
Tear Resistance (pounds, minimum)	ASTM D624 Die C	8
Low Temperature, °F	ASTM D746	0
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 7 days	2
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
1. Breaking Factor		10
2. Elongation at Break		25
Oil Absorption (percent change, maximum)	ASTM D471 ASTM # 1 oil 158°F, 168 hours	10
Durometer A Hardness (points)	ASTM D2240 5 second reading	70±8
Ozone Resistance	ASTM D1149 7 days, 100 pphm 104°F, 20% extension	No Cracks 7X
Heat Aging	ASTM D573 7 days at 240°F	
1. Elongation (percent, minimum)		125
2. Breaking Factor (pounds/inch width, minimum)		60.0
	Factory Seam Requirements[1]	
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	57.6
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2] or 10 lb/in
Dead Load	See Appendix A	
Room Temperature 73°F 50% Bonded Seam Load		Pass
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
Peel Adhesion		-20
Bonded Seam Strength		-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 8. MATERIAL PROPERTIES

POLYETHYLENE ETHYLENE PROPYLENE ALLOY (PE-EP-A)

Property	Test Method	Unsupported (U) 20
Gauge (nominal)	—	20
Thickness, mils minimum	ASTM D412	17
Specific Gravity	ASTM D792	0.92±.05
Minimum Tensile Properties (each direction)	ASTM D412 Die C	
1. Breaking Factor (pounds/inch width)		34
2. Elongation at Break (percent)		500
3. Modulus (force) at 100% elongation (pounds/inch width)		12.8
Tear Resistance (pounds, minimum)	ASTM D1004 Die C	5
Low Temperature, °F	ASTM D746	-76
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	4
Water Extraction (percent loss maximum)	ASTM D1239 (as modified in Appendix A)	-0.35
Volatile Loss (percent loss maximum)	ASTM D1203 Method A	0.5
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
1. Breaking Factor		10
2. Elongation at Break		10
3. Modulus at 100% Elongation		10
Ozone Resistance	ASTM D1149 7 days, 100 pphm 104°F, 20% strain,	No Cracks 7X
Heat Aging	ASTM D573 14 days, 158°F	
1. Breaking Factor (pounds/inch width minimum)		33
2. Elongation at Break (percent)		425
	Factory Seam Requirements[1]	
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	27
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2]
Resistance to Soil Burial	ASTM D3083 (as modified in Appendix A)	
Peel Adhesion	(as modified in Appendix A)	FTB[2] or 8 lb/in
Bonded Seam Strength (percent change maximum in original value)		-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 9. MATERIAL PROPERTIES

HIGH DENSITY POLYETHYLENE ELASTOMERIC ALLOY (HDPE-A)

Property	Test Method	Unsupported (U) 30	40	60
Gauge (nominal)	—	30	40	60
Thickness, mils minimum	ASTM D1593 Para. 8.1.3	27	36	54
Specific Gravity (Minimum)	ASTM D792 Method A	0.930	0.930	0.930
Minimum Tensile Properties (each direction)	ASTM D638 Type IV Dumb-bell at 2 ips			
1. Tensile Strength Yield (pounds/inch width)		45	60	90
2. Tensile Strength at Break (pounds/inch width)		105	140	190
3. Elongation at Yield (percent)		20	20	20
4. Elongation at Break (percent)		600	600	600
5. Modulus of Elasticity (pounds/square inch)	ASTM D882	45,000	45,000	45,000
Tear Resistance (pounds, minimum)	ASTM D1004 Die C	15	20	30
Low Temperature, °F	ASTM D746 Procedure B	-40	-40	-40
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	2	2	2
Volatile Loss (percent loss maximum)	ASTM D1203 Method A	0.1	0.1	0.1
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)			
1. Tensile Strength Yield		10	10	10
2. Tensile Strength at Break		10	10	10
3. Elongation at Yield		10	10	10
4. Elongation at Break		10	10	10
5. Modulus of Elasticity		10	10	10
Ozone Resistance	ASTM D1149 7 days, 100 pphm 104°F, bent loop	No Cracks 7X	No Cracks 7X	No Cracks 7X
Environmental Stress Crack (hours minimum)	ASTM D1693 (as modified in Appendix A)	500	500	500
	Factory and Field Seam Requirements[1]			
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	60	80	120
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2]	FTB[2]	FTB[2]
Dead Load	See Appendix A			
Room Temperature 73°F 50% Bonded Seam Load		Pass	Pass	Pass
Elevated Temperature 158°F 25% Bonded Seam Load		Pass	Pass	Pass
Resistance to Soil Burial	ASTM D3083 (as modified in Appendix A)			
Peel Adhesion		FTB[2]	FTB[2]	FTB[2]
Bonded Seam Strength (percent change maximum in original value)		-10	-10	-10

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 10A. MATERIAL PROPERTIES
CHLOROSULFONATED POLYETHYLENE (CSPE)

Property	Test Method	Supported (S) Type 1-30	Type 1-45	Type 2-36	Type 2-45	Type 3-36	Type 3-45
Gauge (nominal)	—	30	45	36	45	36	45
Plies, Reinforcing	—	1	2	1	1	1	1
Thickness, mils minimum	ASTM D751						
1. Overall		27	41	32	41	34	41
2. Over Scrim	Optical Method (Reference Appendix A)	11	11	11	11	11	11
Breaking Strength-Fabric (pounds, minimum)	ASTM D751 Method A	60[1]	90[1]	120	125	200	200
Tear Strength (pounds, minimum)	ASTM D751 (As modified in Appendix A)						
1. Initial		10	16	25	30	60	70
2. After Aging		5	5	20	25	25	25
Low Temperature, °F	ASTM D2136 ⅛ in. mandrel, 4 hrs., Pass	-40	-40	-40	-40	-40	-40
Dimensional Stability (each direction percent change maximum)	ASTM D1204 212°F, 1 hr.	7.5	5	2	3	2	2
Volatile Loss (percent loss maximum)	ASTM D1203 Method A, 30 mil sheet	0.5	0.5	0.5	0.5	0.5	0.5
Resistance to Soil Burial (percent change maximum in original values)	ASTM D3083 30 mil sheet (as modified in Appendix A)						
a. Unsupported sheet							
1. Breaking Strength		5	5	5	5	5	5
2. Elongation at Break		20	20	20	20	20	20
3. Modulus at 100% Elongation		20	20	20	20	20	20
b. Membrane Fabric Breaking Strength	ASTM D751 Method A	25	25	25	25	25	25
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A, Procedure 1	80	140	160	180	250	250
Ply Adhesion (each direction pounds/in. width minimum)	ASTM D413 Machine Method Type A	10	10	10	10	7	7
Factory Seam Requirements[2]							
Bonded Seam Strength (factory seam, breaking factor, lb, width)	ASTM D751 (as modified in Appendix A)	80	96	96	100	160	180
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)						
Peel Adhesion		20	20	20	20	20	20
Bonded Seam Strength		-25	-25	-25	-25	-25	-25

[1]Type 1 gauge liner has two values. Coating is stronger than fabric and gives a breaking strength value of 100 pounds for nominal 30 mil and 120 pounds for nominal 45 mils with 150% minimum elongation at break for both.

[2]Factory seam requirements are the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 10B. MATERIAL PROPERTIES
CHLOROSULFONATED POLYETHYLENE (CSPE-LW)
LOW WATER ABSORPTION

Property	Test Method	Supported (S) Type 1-30	Type 2-36	Type 2-45	Type 2-60	Type 3-36	Type 3-45	Type 3-60
Gauge (nominal)	—	30	36	45	60	36	45	60
Plies, Reinforcing	—	1	1	1	2	1	1	1
Thickness, mils minimum	ASTM D751							
1. Overall		27	32	41	55	34	41	55
2. Over Scrim	Optical Method (Reference Appendix A)	11	11	11	11	11	11	11
Breaking Strength-Fabric (pounds, minimum)	ASTM D751 Method A	60[1]	120	125	300	200	250	300
Tear Strength (pounds, minimum)	ASTM D751 (As modified in Appendix A)							
1. Initial		10	25	30	100	60	70	80
2. After Aging		5	20	25	40	25	25	25
Low Temperature, °F	ASTM D2136 1/8 in. mandrel, 4 hrs., Pass	-40	-40	-40	-40	-40	-40	-40
Dimensional Stability (each direction percent change maximum)	ASTM D1204 212°F, 1 hr.	7.5	2	3	4	2	2	4
Volatile Loss (percent loss maximum)	ASTM D1203 Method A, 30 mil sheet	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Resistance to Soil Burial (percent change maximum in original values)	ASTM D3083 30 mil sheet (as modified in Appendix A)							
a. Unsupported sheet								
1. Breaking Strength		5	5	5	5	5	5	5
2. Elongation at Break		20	20	20	20	20	20	20
3. Modulus at 100% Elongation		20	20	20	20	20	20	20
b. Membrane Fabric Breaking Strength	ASTM D751 Method A	25	25	25	25	25	25	25
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A, Procedure 1	80	160	180	300	250	250	300
Ply Adhesion (each direction pounds/in. width minimum)	ASTM D413 Machine Method Type A	10	10	10	10	7	7	7
Water Absorption (percent weight gain maximum 30 mil unsupported sheet)	ASTM D471							
	14 days @ 70°F	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	30 days @ 70°F	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	14 days @ 158°F	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30 days @ 158°F	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Factory Seam Requirements[2]								
Bonded Seam Strength factory seam, breaking factor, lb, width)	ASTM D751 (as modified in Appendix A)	80	96	100	180	200	250	275
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in	Ply sep in plane of scrim or 10 lb/in
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)							
Peel Adhesion		-20	-20	-20	-20	-20	-20	-20
Bonded Seam Strength		-25	-25	-25	-25	-25	-25	-25

[1]Type 1 liner has two values. Coating is stronger than fabric and gives breaking strength values of 100 pounds for nominal 30 mil with 150% minimum elongation at break.

[2]Factory seam requirements are the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 11. MATERIAL PROPERTIES
THERMOPLASTIC NITRILE - PVC (TN-PVC)
Oil Resistant Grade

Property	Test Method	Supported (S) Type 1-30
Gauge (nominal)	—	30
Thickness, mils minimum	ASTM D751	
1. Overall		27
2. Over Scrim	Optical Method (Reference Appendix A)	11
Breaking Strength - fabric (pounds, minimum)	ASTM D751 Method A	50[1]
Tear Strength (pounds, minimum)	ASTM D751 (As modified in Appendix A)	
1. Initial		8
2. After Aging		5
Low Temperature, °F	ASTM D2136 ⅛ in. mandrel, 4 hrs., Pass	-20
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 1 hr.	7.5
Volatile Loss (percent loss maximum)	ASTM D1203 Method A 30 mil sheet	1.0
Resistance to Soil Burial (percent change maximum in original values)	ASTM D3083 30 mil sheet (as modified in Appendix A)	
a. Unsupported Sheet		
1. Breaking Strength		20
2. Elongation at Break		20
3. Modulus at 100% Elongation		30
b. Membrane Fabric Breaking Strength	ASTM D751 Method A	25
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A, Procedure 1	80
Ozone Resistance	ASTM D1149 (As modified, 7 days, 100 pphm 104°F, ⅛ in. bent loop)	No Cracks 7X
Ply Adhesion (each direction pounds/in. width minimum)	ASTM D413 Machine Method Type A	8

Oil Resistance Requirements
See ASTM D471, Oil Extraction, 7 days, percent maximum change

	Neats Foot	Gulf Harmony #53	Corn (Mazola)	ASTM No. 2
Weight @73±3°F	-2	-2	-2	-2
Weight @158±3°F	-5	-5	-5	-5
Tensile @73.4±3°F	+10	+10	+10	+5
Tensile @150±3°	+25	+10	+20	+15
Elongation @73.4±3°F	-20	-10	-20	-30
Elongation @158±3°F	-30	-15	-30	-30

Factory Seam Requirements[2]		
Bonded Seam Strength (factory seam, breaking factor, lb minimum)	ASTM D751 (as modified in Appendix A)	64
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	Ply sep in plane of scrim or 12 lb/in
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
Peel Adhesion		-20
Bonded Seam Strength		-25

[1]Type 1 liner has two values. Coating is stronger than fabric and gives breaking strength values of 80 pounds with 120% minimum elongation at break.
[2]Factory seam requirements are the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 12. MATERIAL PROPERTIES

THERMOPLASTIC EPDM (T-EPDM)

Property	Test Method	Supported (S) Type 1-30	Type 2-36
Gauge (nominal)	—	30	36
Thickness, mils minimum	ASTM D751		
1. Overall		27	33
2. Over Scrim	Optical Method (Reference Appendix A)	11	11
Breaking Strength (pounds, minimum)	ASTM D751 Method A	50[1]	100
Tear Strength (pounds, minimum)	ASTM D751 (As modified in Appendix A)		
1. Initial		10	25
2. After Aging		5	20
Low Temperature, °F	ASTM D2136 ⅛ in. mandrel, 4 hrs., Pass	-20	-20
Dimensional Stability (each direction percent change maximum)	ASTM D1204 212° F, 1 hr.	7.5	2
Volatile Loss (percent loss maximum)	ASTM D1203 Method A 30 mil sheet	0.5	0.5
Resistance to Soil Burial (percent change maximum in original values)	ASTM D3083 30 mil sheet (as modified in Appendix A)		
a. Unsupported Sheet			
1. Breaking Strength		10	10
2. Elongation at Break		20	20
3. Modulus at 100% Elongation		30	30
b. Membrane Fabric Breaking Strength	ASTM D751 Method A	25	25
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A, Procedure 1	80	160
Ozone Resistance	ASTM D1149 7 days, 100 pphm 104°F, ⅛ in. bent loop	No Cracks 7X	No Cracks 7X
Ply Adhesion (each direction pounds/in. width minimum)	ASTM D413 Machine Method Type A	8	8
	Factory Seam Requirements[2]		
Bonded Seam Strength (factory seam, breaking factor, lb, minimum)	ASTM D751 (as modified in Appendix A,	64	80
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	Ply sep in plane of scrim or 12 lb/in	Ply sep in plane of scrim or 12 lb/in
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)		
Peel Adhesion		-20	-20
Bonded Seam Strength		-25	-25

[1]Type 1 liner has two values. Coating is stronger than fabric and gives breaking strength values of 80 pounds, with 150% minimum elongation.

[2]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 13. MATERIAL PROPERTIES

ETHYLENE INTERPOLYMER ALLOY (EIA)

Property	Test Method	Supported (S) Type 4-30	Supported (S) Type 5-30
Gauge (nominal)	—	30	30
Thickness, mils minimum	ASTM D751		
1. Overall		27	27
2. Over Scrim	Optical Method (Reference Appendix A)	9	7
Breaking Strength (pounds, minimum)	ASTM D751 Method A	300	400
Tear Strength (pounds, minimum)	ASTM D751 (As modified in Appendix A)		
1. Initial		60	125
2. After aging		40	75
Low Temperature, °F	ASTM D2136 ⅛ in. mandrel, 4 hrs., Pass	-30	-30
Dimensional Stability (each direction, (percent change, maximum)	ASTM D1204 212°F, 1 hr.	2	2
Volatile Loss (percent loss maximum)	ASTM D1203 Method A 30 mil sheet	-1.0	-1.0
Resistance to Soil Burial (percent change maximum in original values)	ASTM D3083 30 mil sheet (as modified in Appendix A)		
a. Unsupported Sheet			
1. Breaking Strength		10	10
2. Elongation at Break		20	20
3. Modulus at 100% Elongation		20	20
b. Membrane Fabric Breaking Strength	ASTM D751 Method A	25	25
Hydrostatic Resistance (pounds/sq. in., minimum)	ASTM D751 Method A, Procedure 1	500	500
Ozone Resistance	ASTM D1149 7 days, 100 pphm 104°F, ⅛ in. bent loop)	No Cracks 7X	No Cracks 7X
Ply Adhesion (each direction pounds/in. width minimum)	ASTM D413 Machine Method Type A	FTB[2] or 8 lb/in	FTB[2] or 8 lb/in
Water Extraction	ASTM D3083, Para. 9.6 (as modified in Appendix A)	-0.35%	-0.35%
Water Absorption (percent gain, maximum)	ASTM D471 14 days @ 158°F 14 days @ 70°F	5 1	5 1
	Factory Seam Requirements[1]		
Bonded Seam Strength (factory seam, breaking strength, lb minimum)	ASTM D3083 (as modified in Appendix A)	240	320
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	10 lb/in	10 lb/in
Dead Load	See Appendix A		
Room Temperature 73°F 50% Bonded Seam Load		Pass	Pass
Elevated Temperature 158°F 25% Bonded Seam Load		Pass	Pass
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)		
Peel Adhesion		-20	-20
Bonded Seam Strength		-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 14A. MATERIAL PROPERTIES

CHLORINATED POLYETHYLENE ALLOY (CPE-A)

Property	Test Method	Unsupported (U) 30
Gauge (nominal)	—	30
Thickness, mils minimum	ASTM D751	28.5
Specific Gravity (minimum)	ASTM D792 Method A	1.28
Minimum Tensile Properties (each direction)	ASTM D882	
1. Breaking Factor (pounds/inch width)	Method A or B	45
2. Elongation at Break (percent)	Method A or B	300
3. Modulus (force) at 100% elongation (pounds/inch width)	Method A or B	25
Tear Resistance pounds, minimum)	ASTM D1004 Die C	6
Low Temperature, °F	ASTM D1790	-10
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	7
Water Extraction (percent loss maximum)	ASTM D1239	-0.35
Volatile Loss (percent loss maximum)	ASTM D1203 Method A	0.7
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
1. Breaking Factor		5
2. Elongation at Break		20
3. Modulus at 100% Elongation		20
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A	85
	Factory Seam Requirements[1]	
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	36
Peel Adhesion (lbs/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2] or 10 lb/in
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)	
Peel Adhesion		-20
Bonded Seam Strength		-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

TABLE 14B. MATERIAL PROPERTIES
CHLORINATED POLYETHYLENE ALLOY (CPE-A)

Property	Test Method	Supported (S) Type 3-36	Type 3-45
Gauge (nominal)	—	36	45
Thickness, mils minimum	ASTM D751		
1. Overall		34	41
2. Over Scrim	Optical Method (see Appendix A)	11	11
Breaking Strength (pounds, minimum)	ASTM D751	200	250
Tear Strength (pounds, minimum)	ASTM D751 (as modified in Appendix A)		
1. Initial		60	70
2. After Aging		25	25
Low Temperature, °F	ASTM D2136 1/8 in. mandrel 4 hrs. Pass	-40	-40
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 1 hr.	2	2
Volatile Loss (percent loss maximum)	ASTM D1203 Method A 30 mil sheet	0.7	0.7
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 30 mil sheet (as modified in Appendix A)		
a. Unsupported Sheet			
1. Breaking Strength		5	5
2. Elongation at Break		20	20
3. Modulus at 100% Elongation		20	20
b. Membrane Fabric Breaking Strength	ASTM D751 Method A	25	25
Hydrostatic Resistance (pounds/sq. in. minimum)	ASTM D751 Method A, Proc. 1	250	250
Ply Adhesion (each direction pounds/in. width minimum)	ASTM D413 mach. method Type A	7	7
	Factory Seam Requirements[1]		
Bonded Seam Strength (factory seam, breaking strength, lb minimum)	ASTM D751 (as modified in Appendix A)	160	200
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	Ply sep in plane of scrim or 10 lbs/in	Ply sep in plane of scrim or 10 lbs/in
Resistance to Soil Burial (percent change maximum in original value	ASTM D3083 (as modified in Appendix A)		
Peel Adhesion		-20	-20
Bonded Seam Strength		-20	-20

[1]Factory seam requirements are the responsibility of the fabricator. Factory seams are further discussed in Item 4.2.

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturers regarding installation requirements, exposure conditions, performance expectations, and experience factor.

3.2 RETENTION APPLICATIONS: Flexible membrane liners covered by this standard which are intended for retention of waters shall be suitable for a variety of municipal, industrial, agricultural, recreational and wildlife uses. Here the emphasis is upon the retention of the water by prevention of losses through seepage during transportation in canals or during storage or use in reservoirs. The water retained in these applications is considered a valuable resource and not a contaminant to the environment.

3.2.1 POTABLE WATER APPLICATIONS: Materials used for flexible membrane liners suitable for use in lining canals and reservoirs for potable water shall meet the physical requirements given in Item 3.1 and the specific requirements on chemical/taste and odor given in Item 3.2.1.1 and for tracers given in Item 3.2.1.2. Flexible membrane liners used for potable water applications shall contain only materials that are regulated, prior sanctioned, generally recognized as safe or nonmigratory ingredients.

3.2.1.1 CHEMICAL/TASTE AND ODOR: Chemical/taste and odor evaluations of membrane materials shall be conducted in accordance with the procedures set forth in Appendix A, and the extractant water therefrom shall not exceed the maximum contaminant levels established in the U.S. Environmental Protection Agency's Interim Primary Drinking Water Regulations - 1975 and the limits of acceptance as shown in Table 3.2-1.

TABLE 3.2-1

CHEMICAL AND PHYSICAL ANALYSES

Parameter	Max. Per. Level mg/l
Antimony	0.05
Arsenic	0.05 [2]
Barium	1.0 [2]
Cadmium	0.01 [2]
Chromium (Hexavalent)	0.05 [2]
Lead	0.05 [2]
Mercury	0.002[2]
pH	
Phenolic Substances	0.05
Selenium	0.01 [2]
Solids Dissolved (Total)	70.
Tin	0.05
TTHM	0.1

TASTE AND ODOR EVALUATIONS

Characteristic	Permissible Level
Odor	80
Taste	Satisfactory

[2]Established in the National Interim Primary Drinking Water Treatment Regulations, USEPA, 1975 (Published in Federal Register, Vol. 40, No 248, December 14, 1975).

3.2.1.2 TRACERS: The addition of innocuous tracers to materials covered by this standard may be required.

3.2.2 RECREATIONAL APPLICATIONS[3]: Flexible membrane liners for recreational water applications in canal and reservoirs for swimming, fishing and boating shall meet the physical requirements presented in Item 3.1.

3.2.3 NONRECREATIONAL APPLICATIONS[3]: Flexible membrane liners for nonrecreational applications, canals, ponds and reservoirs used in the transport and/or storage of waters for industrial, commercial, fisheries, landscaping or agricultural purposes shall meet the physical requirements presented in Item 3.1.

3.3 CONTAINMENT APPLICATIONS: Flexible membrane liners for containment applications other than those referenced in Items 3.2.1, 3.2.2 and 3.2.3, such as hazardous waste and nonhazardous waste landfills and surface impoundments, shall meet the physical requirements in Item 3.1. Considerations should be given to site specificity and chemical compatibility as covered in Appendices C and D.

SECTION 4. FABRICATION

4.0 GENERAL: This section covers factory fabrication of flexible membrane liner materials so as to give a fabricated part which conforms to the requirements set forth in Section 3 of this standard for the appropriate intended application. Repairs as well as primary seams are included and all shall meet the same physical property requirements.

4.1 MATERIALS: Flexible membrane liner materials shall meet the physical property requirements per applicable sections of the standard and shall have been qualified for the product being fabricated.

4.2 SEAMS: The seam joint is a critical part of any flexible membrane liner system. Seam joints are constructed in a controlled factory environment (factory seams) to fabricate panel sizes that can be adequately handled in field installation. Large factory fabricated panels are joined together with seam joints constructed in an uncontrolled outside field environment (field seams). The quality of both the factory and field seams are equally critical to the successful performance of a flexible membrane liner. Factory seam joints shall meet the physical property requirements listed in Item 3.1.

4.2.1 TYPES OF SEAM JOINTS: There are many techniques used to provide effective factory and field seams as follows:

- Adhesive Seams
- Bodied Solvent Seams
- Dielectric Seams
- Extrusion Welded Seams
- Solvent Seams
- Tape Seams
- Thermal Seams
- Vulcanized Seams

4.2.2 FACTORS AFFECTING STRENGTH OF SEAM JOINTS: Any seam joint technique should provide adequate initial seam strength to meet installation and service requirements. However, many factors affect seam joints that can affect the long term performance of the seam. The seam joint may be exposed to a long term aging, to moisture environment, to soil environment, to a chemical environment, and to a constant stress under load both at normal temperatures and at elevated temperatures. Considerations should be given to site specificity and chemical compatibility as covered in Appendices C and D.

[3]Recommendations and precautions are given in Appendix B for the use of flexible membrane liners where a specific aquatic environment is required.

4.3 POTABLE WATER APPLICATIONS: Joining or bonding materials used in factory seams for potable water applications shall meet the applicable requirements set forth in Section 3.

SECTION 5. IDENTIFICATION

5.0 GENERAL: The identification method is to identify the materials contained within the standard. The code consists of three parts: the first part covers the flexible membrane liner material; the second part covers the installed condition of buried or exposed; and the third part covers the general intended service. (See Appendix E for examples of the identification system)

5.1 MATERIAL: This group consists of the following:

5.1.1 FLEXIBLE MEMBRANE LINER MATERIAL CHEMICAL COMPOSITION: Flexible membrane liner material chemical composition referenced in Item 3.0.2 shall be used.

5.1.2 UNSUPPORTED - SUPPORTED MATERIAL TYPE: The following designations shall be used:

U - Unsupported
S - Supported

5.1.3 MEMBRANE TYPE: For supported materials, membrane type, principally influenced by the type of reinforcement used. The number designations for flexible membrane liner material type referenced in the materials properties table, Item 3.1, shall be used.

5.1.4 FLEXIBLE MEMBRANE LINER THICKNESS: The nominal gauge referenced in the material properties tables in Item 3.1 shall be used.

5.2 INSTALLATION CONDITION: Some flexible membrane liner materials are intended to be buried; others may be exposed or buried. The requirements are given in Item 3.0.3. The following designations shall be used:

Bu - Buried
Ex - Exposed or Buried

5.3 GENERAL INTENDED SERVICE: The designation is to show the particular service grade of the material as covered in Item 3.0.2. The following designations shall be used:

PW - Potable Water Grade
In - Industrial Grade, not for Potable Water Applications
OR - Oil Resistant Grade, satisfies specific requirements for oil resistant material

APPENDIX A

Special Test Methods and Revision of Standard Test Procedures

TABLE OF CONTENTS

Part 1

Water Extraction

ASTM D3083 Paragraph 9.6 modified to be::

A. Apparatus

1. Balance: An analytical balance

2. Containers: Pint jars or cans with a diameter of at least 2.5 inches (6.5 cm) (one container for each specimen)

3. Oven

4. Desiccator

B. Materials

Water: Freshly prepared distilled or deionized water.

C. Test Specimens

The test specimens for plastic films shall be in the form of squares 50 ± 0.25 mm (2 inches) on each side. At least three specimens of each sample shall be tested with each chemical reagent.

D. Conditioning

Condition the test specimens at 73.4 ± 3.6°F (23 ± 2°C) in a desiccator for not less than one hour prior to test.

E. Procedure

1. Maintain the water at the test temperature for at least 4 hours before the specimens are immersed.

2. After being weighed, immerse the specimens in the water, one specimen to each container. Each jar shall contain 400 ml. Suspend the specimen freely in a vertical position, but fully covered by the liquid. To prevent each specimen from floating or curling, it may be necessary to attach small weights, such as paper clips.

3. Cover the jars containing the specimens and keep at 122 ± 3.6°F for 24 hours.

4. Remove the specimens from the liquids and gently wipe with a soft cloth or absorbent tissue. Dry the specimens for 24 hours in a desiccator at 73.4 ± 3.6°.

5. It is realized that there may be an increase in weight of the test specimen due to water absorption. It is necessary to determine if a correction factor is needed, and the value of the correction factor. Prepare and condition control specimens in the same manner as for the standard test, but expose them for only 5 mintues and dry as specified in Section E.5. If the control sample has a weight gain the calculated percent weight gain of the control is the correction factor that is used to adjust the value obtained in the test.

F. Calculations

1. The percentage loss in weight from extraction, expressed as percentage weight loss compared to the original specimen weight, shall be calculated as follows:

Weight loss, percent = $(W_1 - W_2)/W_1 \times 100$ where:

W_1 = weight of specimen after the conditioning period and,
W_2 = weight of specimen at the end of the test.

2. The values obtained for the three specimens for percentage weight loss shall be averaged and this value reported as the percentage weight loss of the sample being tested.

Part 2

Bonded Seam Strength

Unsupported Materials:

ASTM D3083, Paragraph 9.3 is modified to permit either Method A or Method B of ASTM D882.

A specimen 1 inch wide is used with a grip separation of 4 inches plus the width of the seam. The seam is to be centered between the clamps. The rate of grip separation will be 20 inches per minute or as specified in the materials properties tables.

Supported Materials:

ASTM D751 Section A Grab Method shall be modified as follows:

Section 10.1 - Last sentence shall be changed to read: "the distance between the clamps at the start of the test shall be 6 inches plus the seam width. Seam is to be centered between the clamps."

Sections 11 and 12 of ASTM D751 shall be revised to be:

11. Test Specimens

    Specimens 100 mm (3.93 in.) in width and not less than 200 mm (7.87 in.) plus the seam width in length shall be cut from the membrane for test. One set of five specimens will be required.

12. Procedure

    12.1 Test Conditions

    Heat-sealed test specimens shall be conditioned for a minimum of 24 hours at 23°C (73.4°F).

    Adhesive seamed specimens shall be conditioned for a minimum of 12 days at 23° (73.4°F). After this period, if it appears that the adhesive seam is not dry and suitable for testing, the seams may be placed in a circulating oven at 70°C (158°F) for 3 hours and allowed to rest at 23° (73.4°F) for 48 hours before retesting.

    12.2 Procedure

    Place the specimen symmetrically in the clamps of the machine (see Figure 1) with the longer dimension parallel to and the shorter dimension at right angles to the direction of application of the force.

    The rate of loading shall be at the rate of 12 ± 0.5 in./min. (5 ± 0.1 mm/s).

    Record the maximum stress applied to the specimen at yield or breakage.

SEAM STRENGTH

MODIFIED ASTM D 751 GRAB METHOD

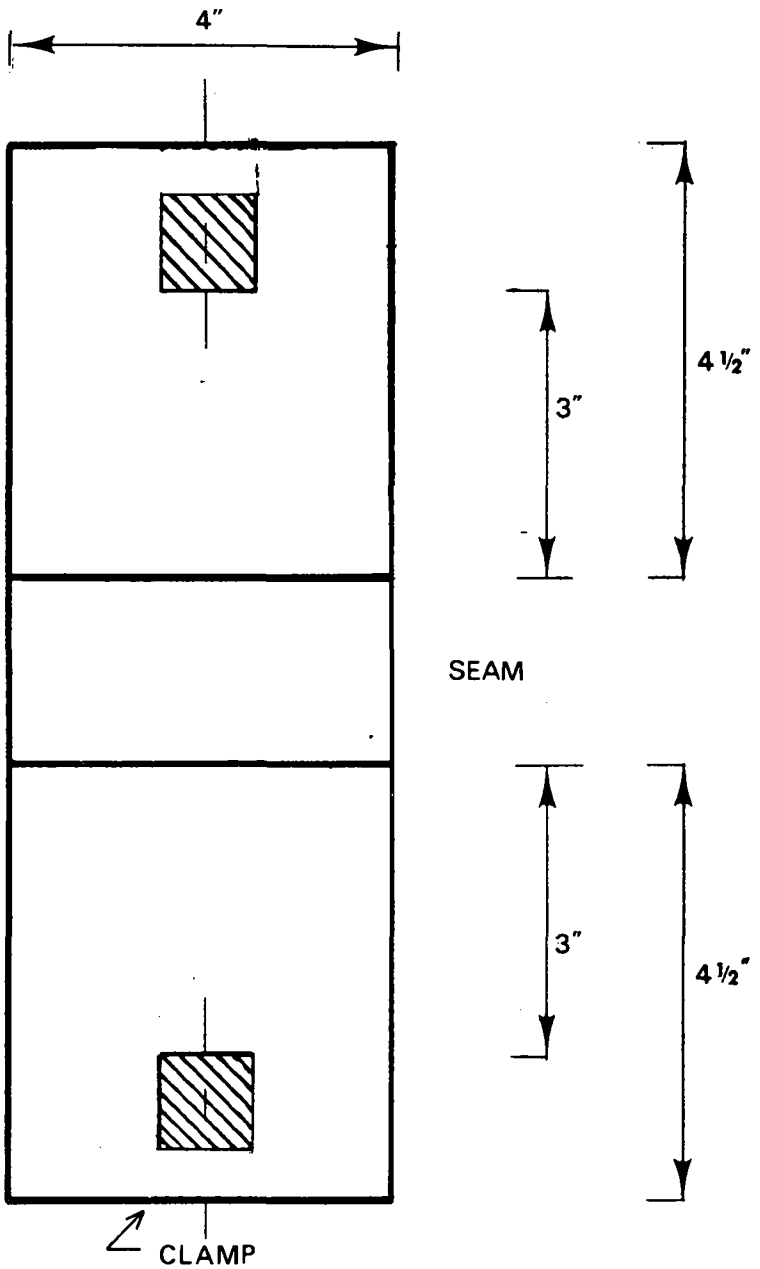


FIG. 1

Part 3

Soil Burial

ASTM D3083, Paragraph 9.5 is modified to be:

The test value of the after-exposure specimen shall be based upon the precut sample dimension.

The test method used to determine before and after exposure tensile properties shall be the test method specified in the materials properties tables for the tensile properties of the material.

Specimens are to be prepared and buried vertically to a depth of 5 inches and exposed as specifed in ASTM D3083, Paragraph 9.5.

Tests for Unsupported Materials

Testing shall be conducted on specimens prepared from the actual flexible membrane liner.

Tests for Supported Materials:

Fabric: Testing shall be conducted on specimens of the fabric used in the supported sheet. Six specimens (4 inches wide by 6 inches long) shall be prepared, three in the warp direction and three in the fill direction. When testing the fabric by itself (no polymeric membrane coating) before and after soil burial, it will be necessary to make sure slippage does not occur. This can be done by using tape, sandpaper or cloth material, special jaws, etc., It is also important to note that consecutive fibers that are grabbed in one jaw correspond to exactly the same fibers grabbed in the other jaw.

Sheet Material: Testing shall be conducted on 30 mil unsupported sheet prepared from the sheeting or coating compound used to produce the supported flexible membrane liner.

Tests for Factory Seams

Testing shall be conducted on specimens prepared from actual flexible membrane liner factory fabricated seams with sealed edges.

Part 4

Peel Adhesion

ASTM D413 shall be modified to be:

Strip specimen Type A, 180° peel, modified to be 1 inch sample width pulled at a rate of 2 inches/ minute. Use bonding technique employed in seam joint construction.

Part 5

Tear Strength

ASTM D751 shall be modified to be:

Tear strength of supported materials shall be determined using Method B - Tongue Tear Method. The test specimen shall be 8 x 8 inches. For oven aging tear strength, initial values and values after aging in an oven at 212°F for 30 days shall be determined.

PART 6

OPTICAL METHOD FOR MEASURING THICKNESS OF MATERIAL OVER SCRIM (SUPPORTING FABRIC)

A. Scope and Application

This is a method for measuring the thickness of a membrane over the reinforcing fabric.

B. Principle

The thickness of membrane material over reinforcing fabric can be observed with a standard reflectance microscope. Measurement is made with a calibrated eyepiece.

C. Accuracy

Measurements are accurate to ±0.5 mils when the thickness is about 20 mils.

D. Apparatus

1. Microscope, 60X with reticle
2. Light source

   If light source on the microscope is not adequate, a small tensor lamp can also be used.
3. Stage Micrometer (0.001 inch divisions)

E. Procedure

1. Calibration

   a. Place a standard reflectance stage micrometer in the plane of the sample.

   b. Turn on the microscope light source.

   c. Position the reticle eyepiece and the micrometer such that the scales are superimposed. Focus the reticle by turning the eyepiece. Focus the sample and reticle by turning the vertical adjustment knob.

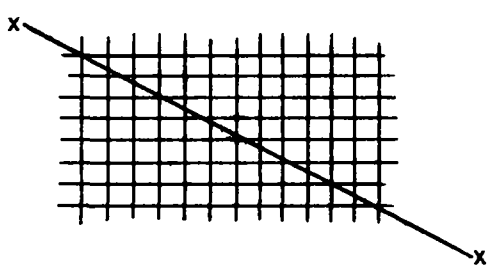
   d. Locate a point at which both scales line up. Count the number of micrometer divisions between that point and several reticle divisions away. Measure to the nearest 0.5 mil.

      The calibration may be optimized by increasing the number of divisions measured.

   e. Repeat the calibration three times and average the results.

2. Sample Analysis

   a. Carefully center a sharp, single edge razor or equivalent over the fiber intersections along the x - x line.



b. Make a clean bias cut *completely* through the liner.

c. Remove the razor cut section and mount in common putty with the cut surface facing upward.

d. Observe the cut surface with the eyepiece reticle. Measure the thickness of the liner on either side of the thread intersection by counting the number of reticle divisions (to the nearest one-half division).

e. Sample two or three areas of the liner and average the results.

F. Calculations

1. Calibration

A calibration example is given below:

In the above example, 4.5 micrometer divisions (MD) are equal to 4 reticle divisions (RD).

4 (RD) = 4.5 (MD)
1 (RD) = 4.5/4 (MD)
1 (RD) = 1.1 (MD)

One micrometer division is equal to one mil, therefore:

1 RD = 1.1 mils

This calculated value (1.1 mils in the example) is the calibration factor.

2. Sample

Multiply the number of reticle divisions by the calibration factor. Report results to the nearest 0.5 mil.

PART 7
Chemical/Taste and Odor
A - Review Procedures
for
Ingredients Intended for NSF Listed
Potable Water Formulations

SECTION I. GENERAL

A. GENERAL: The ingredient review procedures detailed below include those for:

1. ACCEPTANCE of a new ingredient[1] and a generically similar ingredient[2]
2. QUALIFICATION of a new compound or material or change in formulation
3. MONITORING of a listed product

---

[1]New Ingredient - any chemical or substance not previously accepted for use in products intended for application in potable water liners.

[2]Generically Similar Ingredient - an ingredient that is not considered a "new ingredient" and while generically similar to an accepted ingredient, it may vary in composition due to manufacturing process, source of materials, potential trace contaminants, etc.

B. ACCEPTANCE STAGE - NEW INGREDIENTS: Samples shall be submitted of liner formulated to contain the ingredient of interest at twice the recommended maximum use level. Consult NSF if the physical characteristics are significantly modified at twice the recommended maximum use level.

1. Samples shall be exposed by NSF using the standard (multiple) exposure procedure.

2. No level of a constituent of interest greater than 10 times the MCL (NSF Standard 54, Table 3.2-1) shall be measurable in water from the first exposure; and no greater than the MCL (NSF Standard 54, Table 3.2-1) shall be measurable in water from the third exposure.

3. If the basic constituent of the ingredient is not on the FDA list of sanctioned materials or the EPA List of Accepted Ingredients, 90-day animal feeding study[3] and Ames test data shall be conducted and the data submitted to NSF. The protocol for the 90-day animal feeding study shall include feeding levels at effect, no known effect, and an intermediate level.

4. If the ingredient is accepted in the U.S. Code of Federal Regulations, Title 21 Food and Drugs Regulations, the applicable section shall be referenced.

5. The ingredient supplier shall provide the chemical abstracts registry number.

6. The ingredient supplier shall submit the chemical description of the ingredient including molecular structure, and percent of components. A list of known contaminants shall be provided and the amounts in ppb. NSF shall be notified of ingredient(s) containing known carcinogens with appropriate references cited.

7. A complete literature review may be required to support application for acceptance.

8. The ingredient manufacturer shall certify that the ingredient is suitable for use in a potable water product.

9. If the extraction test and 90-day feeding study (if required) as well as the other information submitted by the ingredient supplier are acceptable, the ingredient shall be accepted for use in products listed under NSF Standard No. 54 for potable water applications.

C. ACCEPTANCE STAGE — GENERICALLY SIMILAR INGREDIENT: Samples shall be submitted of liner formulated to contain the ingredient of interest at twice the recommended maximum use level. Consult NSF if the physical characteristics are significantly modified at twice the recommended use level.

1. Samples shall be exposed by NSF using the standard (multiple) exposure procedure.

2. No level of a constituent of interest greater than 10 times the MCL (NSF Standard 54, Table 3.2-1) shall be measurable in water from the first exposure; and no level greater than the MCL (NSF Standard 54, Table 3.2-1) shall be measurable in water from the third exposure.

3. If the ingredient is accepted in the U.S. Code of Federal Regulation, Title 21 - Food and Drugs, the applicable section shall be referenced.

4. The ingredient supplier shall provide the chemical abstracts registry number.

5. The ingredient supplier shall submit the chemical description of the ingredient including molecular structure and percent of components. A list of known contaminants shall be provided and the amounts in ppb. NSF shall be notified of ingredient(s) containing known carcinogens with appropriate references cited.

6. A complete literature review may be required to support application for acceptance.

7. The ingredient supplier shall certify that the ingredient is suitable for use in a potable water product.

[3]It is suggested that the protocol for the feeding study be reviewed by toxicologists for their suggestions prior to the beginning of any actual animal feeding studies.

8. If the extraction test as well as the other information submitted by the ingredient supplier is acceptable, the ingredient shall be accepted for use in products listed under NSF Standard 54 for potable water applications.

D. QUALIFICATION STAGE: To qualify a new material, compound or product, or to change an ingredient in an accepted formula, the formulation and a sample shall be submitted for evaluation.

1. Samples shall be exposed by NSF using the standard (multiple) exposure procedure.

2. No level of a constituent of interest greater than 10 times the MCL (NSF Standard 54,Table 3.2-1) shall be measurable in water from the first exposure; and no level greater than the MCL (NSF Standard 54, Table 3.2-1) shall be measurable in water from the third exposure.

E. MONITORING STAGE (LISTED PRODUCTS): Samples of listed products shall be selected randomly by NSF personnel during unannounced visits to production facilities. Samples may be taken during production or from inventory.

1. Sample shall be extracted by NSF under standard (multiple) exposure procedures.

2. Levels measured shall not be greater than the established MCL specified for "monitoring."

ACCEPTANCE	**QUALIFICATION**	**MONITORING**
(New Ingredient or Generically Similar)	*(New Product or Change in Formulation)*	
Twice Recommended Maximum Use Level	Recommended Maximum	Use Level
Multiple Exposure	Multiple Exposure	Multiple Exposure
pH 5.0	pH 5.0	pH 5.0
MCL[4]: 1st extraction ≤10 X MCL[4] 3rd extraction ≤ MCL[4]	MCL[4]: 1st extraction ≤10 X MCL[4] 3rd extraction ≤ MCL[4]	3rd extraction ≤MCL[4]

B - Laboratory Procedures for Sample Preparation Extractant Water Exposure Taste and Odor

SECTION I. SAMPLES

A. REQUIREMENTS:

Liner: Use a "standard" ratio equivalent to 50 cm^2 surface area of liner sample to 1 liter of extractant water for all exposures.

Joining Materials: Use a "standard" ratio equivalent to 2.5 cm^2 surface area to 1 liter of extractant water.

[4]Maximum Contaminant Level, U. S. Environmental Protection Agency's National Interim Primary Drinking Water Regulations - 1978 and NSF limits of acceptance as shown in NSF Standard 54, Table 3.2-1.

B. SAMPLE PREPARATION:

Liners: Cut a portion of the liner into four individual circles 3¼ inches in diameter. Place the samples in a labeled stainless steel backet and wash in cold water utilizing a "detergent wash" and a "distilled water rinse" (EL detergent 101 and El detergent additive 601 are used for washing; Economics Laboratories, Inc., St. Paul, MN 55102). Finally, rinse the samples in an organic-free[1] water, and place in a laminar flow hood until they are dry and/or to be exposed.

Joining Materials: Coat one-fourth of the surface (on one side) of two standard laboratory glass slides (1 x 3 inch) with the adhesive, solvent, or bodied solvent. Allow the specimens to cure for 48 hours at ambient temperature. Wash the sample as for liners.

SECTION II. EXTRACTANT WATER

A. CHEMICAL CHARACTERISTICS: Prepare "standard" extractant water to contain 100 mg/l hardness (as $CaCO_3$) and 0.5 mg/l chlorine in organic-free water[1]. Adjust pH to 5.0 ± 0.2 with CO_2.

B. REAGENTS: Buffer Stock Solution: Dissolve 3.36 g sodium bicarbonate ($NaHCO_3$) in organic-free water.[1] Make up to one liter. Make fresh daily.

Hardness Stock Solution: Dissolve 4.44 g chloride (anhydrous $CaCl_2$) in organic-free water[1]. Make up to one liter. Make fresh daily.

Chlorine Stock Solution: Add 7.3 ml sodium hypochlorite (5 percent NaOCl) to 200 ml distilled water. Make fresh weekly. Keep in tightly stoppered bottle. Determine the strength of the chlorine stock solution by diluting 1 ml to 1 liter with standard extractant water, and immediately analyze for total available residual chlorine. Reference this determination as "A." Determine the volume of Cl_2 stock solution necessary to add to the exposure water with the formula:

$$Cl_2 \text{ stock solution (ml)} = \frac{0.5\ B}{A}$$

where:
A = ppm Cl_2 equivalent per ml of Cl_2 stock solution
B = liters of standard extractant water

C. WATER: Prepare "standard" extractant water by adding stock reagent solutions to organic-free water[1], as shown in Table A-I.

Table A-I

"Standard" Extractant Water

Organic-free Water[1] (liters)	Buffer Stock Solution (ml)	Hardness Stock Solution (ml)	Chlorine Stock Solution (ml)
1	25	25	0.5
6	150	150	3.0
12	300	300	6.0
15	375	375	7.5

Bubble with CO_2 until pH 5.0 ± 0.2 is attained.

[1]Organic-free water is defined as water free of interference when employed in the procedure described herein.

SECTION III. EXPOSURE

A. VESSEL EXPOSURES, LINER: Use 2 one quart "Mason" type jars to expose 50 cm^2 of liner sample in 1 liter of "standard" water. When cut as a lid liner, approximately 30 cm^2 of liner material will be exposed. Therefore, the volume of water used must be determined to maintain the required 50 cm^2/liter surface area to water volume ratio.

JOINING MATERIALS: Coat one-fourth of the surface (on one side) of two standard laboratory glass slides (1 x 3 inch) with the adhesive, solvent, or bodied solvent to obtain approximately 10 cm^2 of exposed surface. Allow the specimens to cure for 48 hours at ambient temperature. The specimens shall be immersed in 4 liters of extractant water to obtain a surface area to water volume ratio of 2.5 cm^2/l.

B. EXPOSURE CONDITIONS, GENERAL: All tests for acceptance, qualification and routine monitoring shall be conducted with the multiple exposure procedure.

1. 24±1 hour at 37±0.5°C
2. 24±1 hour at 37±0.5°C
3. 72±4 hours at 37±0.5°C

Controls: Place equivalent volume of formulated water in extraction vessel and expose as a control. Include one control for each combination of extraction vessel and/or exposure condition in the daily sample run.

Liners: Use A "Wide Mouth" one quart "Mason" type jar to expose each of the four specimens. Place a 11.6 cm length of 1¼ inch glass rod in each exposure jar (to displace the exposure water enough to fill the jar). Fill the jar with extractant water and seal without a head space utilizing the sample specimen as a cap liner. During the course of the exposure period, lay the exposure vessel upside down.

Joining Materials: Place one of the prepared slides on the bottom of each of two, two quart "Mason" type jars. Fill the jars with extractant water and seal without a head space utilizing an aluminum foil lined cap.

SECTION IV. RECOVERY OF WATER FOLLOWING EXPOSURE

A. TRIHALOMETHANE SAMPLE: Obtain an exposure water sample from one of the jars immediately after opening. Specifically, place 2.5 to 3 mg ACS Reagent Grade sodium sulfite in a 40 ml vial. Overflow it with the exposure water sample and seal without a head space utilizing a Teflon lined cap.

B. CHEMICAL, TASTE AND ODOR SAMPLE: Separate water from exposed samples immediately after exposure vessels are removed from the elevated temperature environment by pouring through filter paper (white, crepe, VWR Grade 6.5) into a ground glass stoppered bottle. Combine the waters from each of the four liner specimens or two joining materials samples into one bottle.

SECTION V. TASTE AND ODOR EVALUATION

ODOR TEST:

A. GENERAL REQUIREMENTS: Final extractant water exposed to liners shall have a threshold odor number less than 80. A paired sample technique in which the stronger odor in each pair is identified shall be used in determining threshold odor levels.

B. TEST PROCEDURES: The NSF odor procedure is a modification of the paired sample technique described in American Society for Testing and Materials (ASTM) Special Technical Publiation 434: *Manual on Sensory Testing Methods,* prepared by ASTM Committee E-18. The modified procedure permits the panel member to identify the member of the sample/control pair containing the strongest odor versus identification of the control bottle in the pair. Statistical basis for the paired sample technique is noted.

Odor Pairs: (Sample/Control)

Sample: Dilute the sample 1 to 80 by combining 2.5 ml of the final extractant with 197.5 ml of odor-free water in a BOD bottle.

Control: Dilute the control 1 to 80 by combining 2.5 ml of the final extractant with 197.5 ml of odor-free water in a BOD bottle.

Generate a second pair of the same by duplicating the above.

(Note: Odor-free water is prepared by passing distilled water through activated carbon.)

Numbers of Samples: No less than 4 and no more than 14 odor pairs shall be evaluated at any time.

Panel: Use panel of at least 10 members prescreened to eliminate persons who are unusually sensitive or insensitive to tastes and odors.

Preselect a random arrangement of the odor pairs for evaluation. For any given sample insure that the control is located once on the left and once on the right of the sample within its two odor pairs.

Hold BOD bottles containing samples and paired controls in a water bath at 22°C.

A minimum of 10 panel members shall examine each pair in turn to determine which member of the pair has the strongest odor.

C. RESULTS: Data from all panel members are summed and reported as to the number of times the sample was selected as the member of the pair which contained th stronger odor. Table A-II is then used to determine the confidence level (%) that the sample has the stronger odor. A sample fails the odor test when that confidence level reaches 99% or greater.

TABLE A-II

CONFIDENCE LEVELS[3]

No.[1] \ No. of responses	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
10	N.S.[2]														
11	N.S.	N.S.													
12	75.00	60.00	N.S.												
13	90.00	75.00	60.00	N.S.											
14	95.00	75.00	75.00	60.00	N.S.										
15	97.50	90.00	75.00	75.00	60.00	N.S.									
16	98.00	97.50	90.00	75.00	75.00	60.0	N.S.								
17	99.50	98.00	95.00	90.00	75.00	75.00	60.00	N.S.							
18	99.50	99.50	97.50	95.00	90.00	75.00	75.00	N.S.	N.S.						
19	99.95	99.50	99.50	97.50	95.00	90.00	75.00	75.00	60.00	N.S.					
20	99.95	99.95	99.50	99.00	99.00	95.00	90.00	75.00	60.00	60.00	N.S.				
21		99.95	99.50	99.50	99.00	97.50	95.00	90.00	75.00	60.00	60.00	N.S.			
22		99.95	99.95	99.50	99.50	99.00	97.50	95.00	90.00	75.00	60.00	60.00	N.S.		
23			99.95	99.95	99.50	99.50	97.50	97.50	95.00	75.00	75.00	60.00	60.00	N.S.	
24			99.95	99.95	99.95	99.50	99.00	97.50	97.50	90.00	75.00	75.00	60.00	60.00	N.S.
25				99.95	99.95	99.95	99.95	99.00	97.50	95.00	90.00	90.00	75.00	60.00	60.00
26				99.95	99.95	99.95	99.95	99.50	99.00	97.50	95.00	90.00	75.00	75.00	60.00
27					99.95	99.95	99.95	99.50	99.50	99.00	97.50	95.00	90.00	75.00	75.00
28					99.95	99.95	99.95	99.95	99.95	99.50	99.00	97.50	95.00	90.00	75.00
29						99.95	99.95	99.95	99.95	99.50	99.50	99.00	97.50	95.00	90.00
30						99.95	99.95	99.95	99.95	99.50	99.50	99.50	97.50	97.50	95.00
31							99.95	99.95	99.95	99.95	99.50	99.50	99.50	97.50	97.50
32							99.95	99.95	99.95	99.95	99.95	99.50	99.50	99.00	97.50
33								99.95	99.95	99.95	99.95	99.95	99.50	99.50	99.00
34								99.95	99.95	99.95	99.95	99.95	99.95	99.50	99.50
35									99.95	99.95	99.95	99.95	99.95	99.50	99.50
36									99.95	99.95	99.95	99.95	99.95	99.95	99.50

[1]Number of times sample identified as strongest odor in sample/control pair

[2]N.S. = No significant difference.

The confidence levels given in Table A-II are described as 1-p, where p is the probability of getting at least the specified number of correct identifications of the control, given that the control is identical to the sample (e.g., 99 percent confidence level means that 1 percent of the time, at least the specified number is expected when there is no difference in the odor of the sample and control).

Confidence levels in Table A-II are obtained from the percentiles of the "t" distribution. This distribution is parameterized by the sampling degrees of freedom. The degree of freedom is 19 for the test procedure using ten panel members and two pairs containing the sample and control.

The t-value is computed by the formula:

$$t = \frac{F - 0.5}{\sqrt{\frac{.5 \times .5}{19}}} = \sqrt{19}\,(2F - 1)$$

where F = the fraction of correct choices, t can be evaluated for different numbers of correct identifications of the control:

Number Correct	t-value	Confidence Level (%)
14	1.74	90.0
15	2.18	97.5
16	2.62	98.0
17	3.05	99.50
18	3.49	99.50
19	3.92	99.95

These are the entries for No. responses equal to 20 in Table A-II; the other entries in Table A-II were obtained in a like manner.

TASTE TEST:

D. TEST PROCEDURES: Place 200 ml final extractant water (i.e., water from final exposure period) for each sample in separate BOD bottles. Place 200 ml control water in BOD bottle.

Maintain all bottles - extractant water and control - at room temperature.

Arrange samples and control in random order for evaluation by panel.

Do not indicate to the panel which bottle contains control water.

A panel member shall pour taste samples into 25 ml beaker and record taste as "sweet," "sour," "bittler" or "salty."

Panel member shall rinse mouth with odor-free water before proceeding to the next taste sample.

E. RESULTS: If panel consistently reports the taste of a particular sample to be more disagreeable than taste of the control, sample fails the taste test.

SECTION VI. CHEMICAL METHODS

A. HEAVY METALS

1. GENERAL: The determination of heavy metals in extractant water is accomplished, using atomic absorption analysis. This technique is based on the quantum mechanical principle that atoms absorb light at energy levels corresponding to characteristic orbital energies of the atom. By measuring the attenuation of a monochromatic light beam passing through the sample atoms, the concentration of metal in the sample can be determined using Beer's Law.

   NSF employs an external standard technique for calibration and sample determination. Three standard solutions are made in concentrations corresponding to the region in which the samples are expected to lie. Standards are run concurrently with samples to insure quality control and to indicate any significant deviations in instrumental response. The concentrations of the samples are then obtained from graphs of absorbance versus concentration for the standards.

   A study of testing results for several routine analyses was made to determine reproducibility and levels of detection obtained on average working days in the NSF laboratories. This study was done without the prior knowledge of laboratory personnel.

   Detection limits were determined as twice the noise level of the recorder output for an analysis. Reproducibility was determined to be the standard deviation of the absorbance values obtained for a specific concentration of a standard. Arithmetic mean values of the standard were then plotted against concentration, and a least squares line drawn. Detection limits and reproducibility values were then determined from this graph. This procedure was followed for each metal. The results are shown in Table A-III.

   Updating analytical procedures is a continuous process at NSF.

   All standards and samples are made in the matrix of NSF formulated extractant water[2].

[1]Reference ASTM Special Technical Publication 434: *Manual on Sensory Testing Methods,* sponsored by ASTM Committee E-18 on Sensory Evaluation of Materials and Products.

[2]NSF Standard No. 14, Appendix A, Section 2.

TABLE A-III

DETECTION LIMITS AND REPRODUCIBILITY OF METALS ANALYSES

Metal	MCL[1] (mg/l)	Reproducibility at MCL (mg/l)	DL[2] (mg/l)	Reproducibility at lowest standard (mg/l)
Antimony	0.05	±0.0007	0.007	±0.0005
Arsenic	0.05	±0.0007	0.004	±0.0008
Barium	1.0	±0.05	0.008	±0.004
Cadmium	0.01	±0.0002	0.0005	±0.0001
Chromium	0.05	±0.002	0.005	±0.002
Lead	0.05	±0.0009	0.002	±0.0007
Mercury	0.002	±0.0004	0.0003	±0.0004
Selenium	0.01	±0.001	0.003	±0.0005
Tin	0.05	±0.002	0.005	±0.0009

[1]maximum contaminant level (MCL)

[2]detection limit (DL)

2. EQUIPMENT:

Perkin-Elmer Model No. 560 atomic absorption spectrophotometer

E.D.L. Power Supply, P.E. No. 040-0354

Perkin-Elmer Graphite Furnace, H.G.A. 2200

Perkin-Elmer PRS-10 Printer Sequencer

Perkin-Elmer AS-1 Auto Sampling System

Burner Control Box, P.E. No. 057-0262

Perkin-Elmer Hitachi 200 Recorder

Acetylene Gas Tank and Regulator

Argon Gas Tank and Regulator

Nitrous Oxide Gas Tank and Regulator

Inorganic 1000 ppm metal standards in matrix of dilute hydrochloric acid

Eppendorf micro-pipets

3. PROCEDURE, (Atomic Absorption Spectrophotometer) AAS:

Atomization Method - graphite furnace (except mercury)

Sample Matrix - 0.1 ml of Suprapur® HNO_3 in 50 ml of extractant water

Slit - Alternate

Gain — Set between 35 - 40 units

Source — Set to specifications of lamp being used

Signal — Absorbance

Mode — Continuous

Recorder - Absorbance

Background Corrector - AA (Background correction not used routinely)

Recorder Chart Expansion - Set as desired

The lamp is allowed its specified warm up time

Standards are made by adding appropriate aliquots of 1000 ppm standards to the correct matrix. Controls are made with the same matrix but with no exposure to plastics and no addition of the standard.

After proper alignment, each standard is analyzed at least two times. Following this, controls and samples are analyzed two times. Standards are interspersed in the analysis with a total standard frequency of no less than 5 percent of analysis time. Following the completion of the sample run, each standard is rerun. If the instrument response has changed, all questionable samples are rerun immediately followed by a series of standards.

4. METHODS:

Antimony (Sb):

Standards — 0.1, 0.05, 0.02 mg/l

Graphite Furnace Settings

	Temperature °C	*Time* Sec.
Dry	110	20
Char	825	22
Atomization	2700	6

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas interrupt — 3 sec.
Sample volume 20 2μl

Instrumental Parameters

- Slit — 0.2 mm
- Source — HCL, P.E. No. 303-6010
- Wave length — 217.6 nm

Photometric Range - 0.5

Arsenic (As):

Standards — 0.100, 0.050, 0.020 mg/l

Graphite Furnace Settings

	Temperature °C	*Time,* Sec.
Dry	110	20
Char	250	20
Atomization	2700	6

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas interrupt — 3 sec.
Sample volume 20 μl

Instrumental Parameters

- Slit — 0.7
- Source — EDL, P.E. No. 303-6211
- Wave length — 193.7 nm

Photometric Range - 0.5

Barium (Ba):

Standards — 0.100, 0.050, 0.020 mg/l

Graphite Furnace Settings

	Temperature °C	*Time,* Sec.
Dry	110	23
Char	1100	36
Atomization	2700	5

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas flow reduction rate - 110 cc/min for 3 sec.
Sample volume — 20 μl

Instrumental Parameters

- Slit — 0.2
- Source — HCL, P.E. No. 303-6012
- Wave length — 553.6 nm

Photometric Range - 0.5

Cadmium (Cd):

Standards - 0.0100, 0.0050 0.0020 mg/l

Graphite Furnace Settings

	Temperature °C	Time, Sec.
Dry	110	20
Char	280	32
Atomization	2100	6

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas interrupt - 3 sec.
Sample volume - 20 μl

Instrumental Parameters

- Slit - 0.2
- Source - HCL, P.E. 303 .601b
- Wave length - 228.8 nm

Photometric Range - 1.0

Chromium (Cr):

Standards - 0.100, 0.050 0.020 mg/l

Graphite Furnace Settings

	Temperature °C	Time, Sec.
Dry	110	20
Char	1100	32
Atomization	2700	6

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas interrupt - 3 sec.
Sample volume - 20 μl

Instrumental Parameters

- Slit - 0.7
- Source - HCL, P.E. 303-6021
- Wave length - 357.9 nm

Photometric Range - 1.0

Lead (Pb):

Standards - 0.050, 0.030, 0.010 mg/l

Graphite Furnace Settings

	Temperature °C	*Time,* Sec.
Dry	110	20
Char	700	20
Atomization	2300	6

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas interrupt - 3 sec.
Sample volume - 20 μl

Instrumental Parameters

- Slit - 0.7
- Souce - HCL, P.E. 303-6111
- Wave length - 217.0 nm

Photometric Range - 0.2

Mercury (Hg):

Sample Matrix - sample water treated in accordance with Perkin-Elmer instructions for Mercury Analysis System No. 303-0830

Standards - 0.010, 0.0050, 0.0020 mg/l

Atomization Method - Perkin-Elmer Flameless Mercury Analysis System 303-0830

Instrumental Parameters

- Slit - 0.7
- Souce - HCL, P.E. 303-6044
- Wave length - 253.7 nm

Photometric Range - 0.5

Selenium (Se):

Standards - 0.050, 0.020, 0.0050 mg/l

Graphite Furnace Settings

	Temperature, °C	*Time,* Sec.
Dry	110	20
Char	370	36
Atomization	2700	5

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas interrupt - 3 sec.
Sample volume - 20 μl

Instrumental Parameters

- Slit - 0.7
- Source - EDL, P.E. 303-6262
- Wave length - 196.0 nm

Photometric Range - 0.2

Tin (Sn):

Standards - 0.100, 0.050, 0.020 mg/l

Graphite Furnace Settings

	Temperature °C	*Time* Sec.
Dry	110	30
Char	700	32
Atomization	2700	5

Purge gas - Argon
Purge gas flow rate - 300 cc/min
Purge gas interrupt - 3 sec
Sample volume - 20 μl

Instrumental Parameters

- Slit - 0.7
- Source - EDL, P.E. 303-6274
- Wave length - 224.6 nm

Photometric Range - 0.5

5. QUALITY CONTROL: Any liner sample which fails any chemical parameter is retested to assure that the problem is associated with the sample versus the analysis or analytical technique.

   In accordance with the 15th Edition of *Standard Methods for the Examination of Water and Wastewater,* the NSF laboratory utilizes two methods of quality control, internal and external. The internal method includes standard solutions and controls which correct for chemical interference in the extractant water. Standards and controls comprise 15% of the analytical time for heavy metals determinations; i.e., one in six randomly spaced controls.

   External quality control samples are analyzed on an average of once every three months, either as EPA reference standards or solutions of NSF extractant water spiked with metals at concentrations which approximate a "typical" liner sample. The quality control samples are prepared by personnel other than those involved in the analysis and are coded in a manner which simulates actual liner samples. The analyst receives the quality control sample, along with actual liner samples, with no knowledge of its status as a quality control sample.

B. TOTAL TRIHALOMETHANES (TTHM)

1. GENERAL: Total trihalomethanes (TTHM) [chloroform ($CHCl_3$) bromodichloromethane ($CHCl_2Br$) chlorodibromothane ($CHClBR_2$), and bromoform ($CHBr_3$)] in extractant water are determined using gas chromatography.

   10 ml of the sample's final exposure water are extracted with 2 ml of pentane and analyzed in accordance with the procedures outlined for the liquid/liquid extraction method (Federal Register/Vol. 44, No. 231/November 29, 1979, p. 68683).

   Three standards ranging from 5—100 ppb are prepared and then extracted in the same way. 4 μl of each are injected into the gas chromatograph equipped with a linearized electron capture detector. After calibration, 4 μl of each sample's extract are analyzed for TTHM content.

2. EQUIPMENT:

   Perkin-Elmer Sigma 3 B Gas Chromatograph

   Perkin-Elmer Sigma 10B Data Station

Perkin Elmer Auto Sampler (AS-100)

Electron Capture Detector (E.C.D.)

Column - 4 mm ID (6' x ¼" OD) 10% Squalane Chrom W-AW80/100 NOC

Nitrogen 4.5 grade

Compressed air Grade E

40 ml screw cap vials with Teflon faced silicone septa, Pierce #13075 and #13733

Sample vials with septa and aluminum seals for auto sampler

Extraction bottles and caps Sci/Spec #B 69110

Syringes
- 10, 25 and 100μl
- 5 and 10 cc with luer-lok tip

Gas stoppered volumetric - 25 and 100 ml

3. REAGENTS:

Pentane, suitable for TTHM GC analysis

Methanol, reagent grade

Chlorine reducing agent: Sodium thiosulfate

Standards
Chloroform, reagent grade
Bromodichloromethane, reagent grade
Chlorodibromomethane, reagent grade
Bromoform, reagent grade
Carbon tetrachloride, reagent grade

Organic-free water[1]

4. INSTRUMENT PREPARATION:

Pneumatic Settings
Carrier gas:
Nitrogen - 80 psi
Auto sampler:
Air - 40 psi
Nitrogen - 5 psi

Temperature Settings
Oven - 67°C
Injection port - 150°C
Detector - 350°C

Total analysis time - 13 minutes

Flow rate through column - 70 cc/min plus 5 cc makeup.

[1]Note: Organic-free water is defined as water free of interference when employed in the procedure described herein.

Part 8

Ply Adhesion

ASTM D413 Section &. Procedure, Paragraph 9.1 Strip Specimens - Type A, 180 degree peel - . . .The next sentence shall be deleted and substituted in its place:

The cut strip shall be 1 inch wide measured to the nearest 0.01 inch.

ASTM D413 Section 12,Calculations, Paragraph 12.2 shall be modified to be:

For the machine method the value of adhesion is determined by taking the average of the five highest peaks shown on the autographic chart and is reported as the adhesion value as follows:

N/m (lbf/in) = force/actual width

If other than a 1 inch strip is tested show both the force and the actual width in the report.

Part 9

Accelerated Weathering Test

A. GENERAL

The test will be the Equatorial Mount with Mirrors for Acceleration plus water spray (EMMAQUA). Minimum specimen size will be 5 inches wide x 4 inches long. (Maximum width is 5 inches x 55 inches long within target area.)

Minimum number of specimens will be one for each FML type that is recommended for outdoor exposure.

The EMMAQUA Test machine is covered by U. S. patents. The testing service is provided by:

Desert Sunshine Exposure Test Inc.
Box 185
Black Canyon Stage
Phoenix, Arizona 85029

B. Exposure Rating Table

The following table rates the state of condition for the FML after exposure due to crazing.

Crazing is the phenomenon manifested by slight breaks or checks in the surface. The break should be called a "crack" if the underlying surface is visible. For precision evaluation, crazing is described as microscopic crazing as observed with a stated magnification of 10 power.

5. ANALYTICAL PROCEDURE

TTHM and CCl_4 are measured in accordance with the method for "Analysis of Trihalomethanes in Drinking Water by Liquid/Liquid Extraction," Federal Register/Volume 44, No. 231/November 29, 1979, p. 68683.

C. OTHER CHEMICAL PARAMETERS

1. PHENOLS: Phenols are measured in accordance with *Standard Methods for the Examination of Water and Wastewater,* 15th Edition, page 510 (4-aminoantipyrine method with preliminary distillation step).

2. TOTAL AVAILABLE RESIDUAL CHLORINE: Total available residual chlorine is measured in accordance with the method outlined in *Standard Methods for the Examination of Water and Wastewater*, 15th Edition, page 286 (Amperometric Titration Method, Procedure 4c).

EXPOSURE RATING TABLE

Rating No.		Number of Checks[1]	Width of Checks[2]
9		S	Maximum
8	Microscopic	M	width
7	(10 X magnification)	L	.006 in.
6		S	Maximum
5	Naked eye at close range	M	width
4	(12 inches)	L	.015 in.
3		S	Not
2	Naked eye at distance	M	Acceptable
1	(3 feet)	L	
0	Complete failure		

[1]S = Small
M = Medium
L = Large

[2]When bent around ½ inch diameter mandrel.

Materials which have a rating of 7, 8 and 9 will be considered to have passed.

Materials which have a rating of 4, 5 and 6 will be required to make the proper corrections in the compound within three months after notification of the results and resubmitted for testing.

If, after the second submission, the material fails to obtain a minimum ranking of 7, the material in question will lose its NSF listing until such time the material meets the requirement.

A transparent crack width gauge, similar to that shown in Figure 1 along with a 10 power microscope may be used to measure the crack width.

CRACK WIDTH GAGE

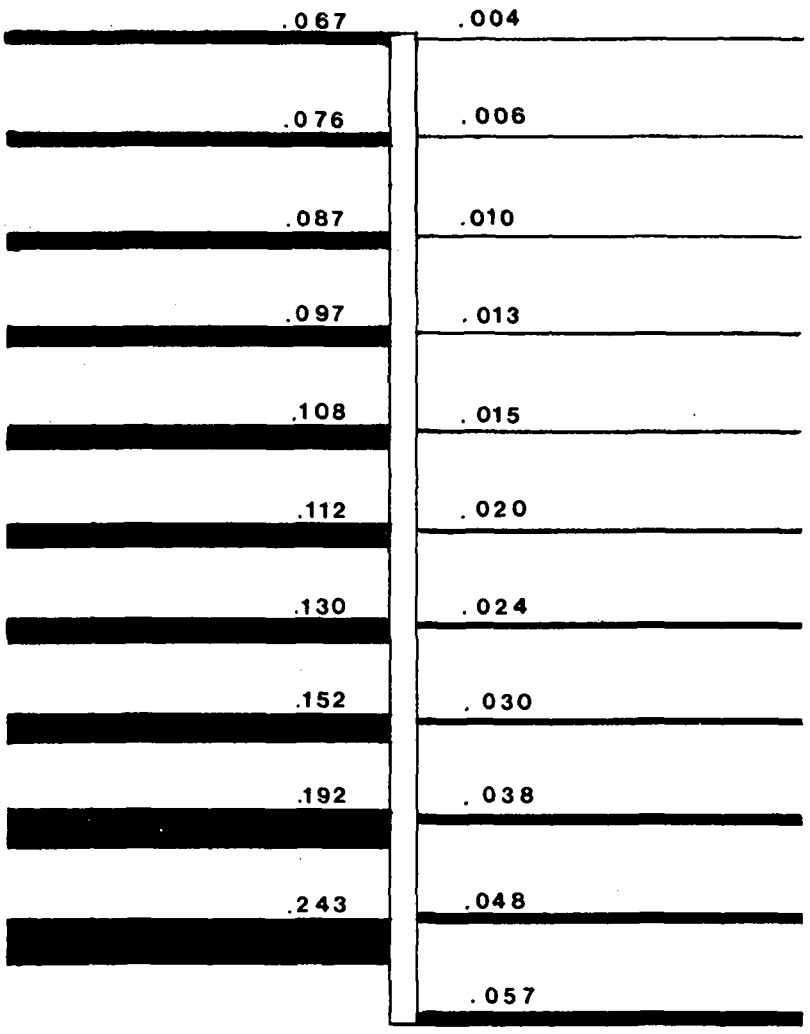


FIG.1

Part 10

Dead Load Seam Strength

A. Scope

To determine the ability of factory seam joints to withstand constant stress under load at room temperature (73°F).

B. Test Specimen

The supported specimen size shall be a 4-inch width of the seam joint and a 12-inch length, sufficient to fit in the clamps of the testing machine. The unsupported specimen size shall be a 1 inch width of the seam joint and an 8 inch length.

C. Procedure

The clamping mechanism will grip a 1 inch wide section and should be centered in the width of the test specimen, above and below the seam joint. The clamps shall not grip any portion of the overlap area of the seam joint.

1. Room Temperature Test: A designated load shall be applied to seam joint after it is fastened in the clamps. This load shall be equal to a percentage of the Bonded Seam Strength Value indicated in the Materials Properties Tables. The load shall be maintained for 4 hours at a temperature of 73°F. The stressed sample must be closely observed. Excessive elongation may require clamp adjustent to maintain consistent loading. When elongation reaches 50% of the original jaw separation, no additional adjustment need be made. Retain existing load for balance of test duration.

2. A "failure" will be noted when the seam joint separates entirely

D. Reporting of Results

The results shall be reported by indicating the designated load, the temperature, the time duration of the test, the length of the overlap seam, and a "pass" or "fail" designation.

PART 11

Dead Load Seam Strength at Elevated Temperature

A. Introduction

Sun exposure and high air temperatures sometimes result in the portion of an exposed FML above the water (or contained fluid) surface to reach temperatures over 120°F. If seams are improperly made and/or the FML material formula will not allow good seams to be made, then the lining may separate under temperatures and forces sometimes encountered in actual service. The dead load seam strength test at elevated temperature is designed to identify seams which are likely to be subjected to failure under such conditions.

The temperature selected for the test should be consistent with the thermal physical/chemical properties of the FML and the anticipated service condition. The temperature and load given in this test method may need to be revised. The FML material manufactuer should be consulted if changes in the test conditions appear appropriate.

B. Test Specimen

Unsupported Materials: The specimen shall be 1 inch wide, and at least 8 inches long. The seam shall be located in the center of the specimen and across the full width of the specimen.

Supported Materials: The specimen shall be 4 inches wide and at least 12 inches long. The seam shall be in the center of the specimen and across the full width of the specimen.

C. Procedure

The clamping mechanism will grip the full 1-inch width of an unsupported specimen. The grip separation shall be 4 inches plus the seam width.

A 1-inch wide section of a supported specimen in the center of the width of the test specimen should be gripped. The grip separation shall be 6 inches plus the seam width. The clamps shall not grip any portion of the overlap area of the seam joint.

The load equal to 25 percent of the required bonded seam strength should be applied to the seam joint after it is fastened in the clamps. The load shall be maintained for 4 hours at the temperature specified in the table for the particular material.

The stressed sample must be closely observed. Excessive elongation may require clamp adjustment to maintain consistent loading. When elongation reaches 50 percent of the original jaw separation, no additional adjustment need be made. Retain existing load for balance of test duration.

A "failure" will be noted when the seam joint separates entirely.

D. Reporting of Results

The results shall be reported by indicating the designated load, the temperature, the time duration of the test, the length of the overlap seam, and a "pass" or "fail" designation.

For example: 25 percent Bonded Seam Strength 158°F, 4 hours, 4 inch seam length, Pass.

Part 12

Environmental Stress Crack Resistance

ASTM D1693 shall be modified to be:

Condition C to be used with 100°C using 100% Igepal. Samples shall be 80 mils or finished product if thicker.

APPENDIX B

RECOMMENDATIONS AND PRECAUTIONS

APPENDIX B

RECOMMENDATIONS AND PRECAUTIONS

Aquatic Environmental Considerations

In selecting flexible membrane liners for use in fishing ponds, agriculture, fish hatcheries, certain recreational reservoirs, etc., attention should be given to aquatic environmental considerations. If there is an established history of successful use of a particular flexible membrane liner material for the intended purpose, the material can be expected to be used without adverse aquatic environmental effects. Where such a history of successful application has not been established, special attention should be given to the needs for studies designed for the specific application. An analysis of the aquatic situation and the flexible membrane liner being considered may dictate the need for specific studies. The needs will vary widely depending upon the specific application. Therefore, no specific studies are proposed in this standard. The user of the flexible membrane liner is advised to contact specialists in the field, if necessary, for guidance in establishing the need for and procedures for any special tests.

APPENDIX C

CONSIDERATIONS FOR SITE EVALUATION, MATERIAL SELECTION, CONSTRUCTION, OPERATION, AND MAINTENANCE

APPENDIX C

CONSIDERATIONS FOR SITE EVALUATION, MATERIAL SELECTION, CONSTRUCTION, OPERATION, AND MAINTENANCE

PURPOSE: These considerations are intended to address the application of a membrane liner. The purpose of this appendix is to make users of flexible membrane liners aware of important parameters that must be examined through site evaluation, material selection, construction, operation and maintenance.

I. SITE CONSIDERATIONS AND PREPARATION:

A. GENERAL: The supporting surface slopes and foundation to accept the liner should be stable and structurally sound. Particular attention should be paid to the potential of sink hole development and differential settlement. The design should incorporate gas venting provisions. Removal of organics contained in the subgrade is recommended.

B. GROUNDWATER: Lateral and/or vertical movement of groundwater should be considered. When a landfill or surface impoundment area is to be lined with a flexible membrane, it should be constructed above the maximum high water table. If this cannot be achieved, pressure relief provisions should be included.

C. SURFACE DRAINAGE: Runoff should be diverted from the area surrounding the lined landfill or surface impoundment.

D. COMPACTION: Flexible membrane linings should not be used as a structural component. Flexible liners should be installed over properly compacted slopes and supporting surfaces to reduce stresses which may be induced in the liner after placement.

E. SLOPES: Embankment design will effect the choice of liners. Specific attention should be given to the angle and length of slopes. (See Section II.C.1.)

G. SOIL STABILIZERS: Soil stabilizers (e.g., cementatious or chemical binding agents and geotextiles), when used to control erosion below the liner should not adversely affect the membrane. Cementatious or chemical binding agents may be potentially abrasive agents.

II. MATERIAL SELECTION:

A. COMPOSITION OF CONTAINED LIQUIDS AND/OR SOLIDS:

1. GENERAL: Membrane material selection is dependent on the nature of the contained liquid and/or solids. Characteristics of importance are chemical composition, temperature, and pH. A detailed analysis should be made for all potential constituents, especially organic compounds.

2. CHEMICAL COMPOSITION: The chemical composition of a liquid/solid to be contained should be known before liner selection is made. If the chemical composition of the liquid/solid to be contained is not known, it is recommended a sample of the liquid/solid be made available by the owner for the determination of liquid/solid liner compatibility. Liner compatibility should be verified by liner manufacturers prior to liner material selection (see Section II.B.). If phase separation of the solid/liquid occurs, the liner compatibility should be determined for each identified phase. The selection of the liner material should also consider the possibilities of concentration build-up; e.g., by evaporation or separation, components that tend to accumulate, synergistic effects and shock loadings.

The intended user should provide the manufacturer with a sample of the solids to be contained and/or a chemical analysis of the waste, along with site and service conditions so that the manufacturer can provide to the intended user a letter characterizing the chemical resistance of the candidate liner material to the waste provided or described. The letter should explain how the chemical resistance of the liner to the material was determined; e.g., direct exposure tests, historical data and/or field applications. The purpose of the letter is to aid the user in determining the acceptability of the candidate liner for his intended use. Site specific conditions must also be considered in the selection of the liner.

3. TEMPERATURE: The influent and operational temperature of the solid/liquid to be contained should be considered before liner material selection. It is recommended that the chemical resistance of a liner material to a solid/liquid be performed at the maximum temperatures. The possibility of shock temperature loadings should be evaluated.

4. CONCENTRATION: Compatiblity testing should be performed at or near the concentration of the solid/liquid to be contained. However, if the possibility exists for concentration build-up and/or dilution and/or shock loadings, these situations should also be evaluated.

5. pH CONDITIONS: The acid/alkaline nature of solid/liquid to be contained can have an adverse affect on the membrane liner. The acid/alkaline properties of a solid/liquid should be characterized before liner material selection.

B. BURIED LININGS: Certain lining materials whose properties might be adversely affected during the projected use period due to the effects of heat, ultraviolet radiation (U.V.) or other factors associated with weathering should only be used as buried membrane liners. Generally speaking, maximum side slopes of 3:1 are suitable for earth covering, but some covering materials like gravels will stay on somewhat steeper side slopes. Conversely, sandy soil backfilled materials may require a flatter slope. Earth covering should be of materials which will not cause puncturing of the lining; i.e., silts, sands, rounded gravels and should have good erosion-resistance. If silts and sands are used for covering materials, gravels or other erosion-resistant materials are frequently placed at the waterline to minimize erosion.

   All flexible membrane lining materials benefit from being covered. These benefits include weathering (i.e., U.V., heat, wind, etc. effects) as well as damage from animal life or severe or unusual climatic conditions (such as hail, hurricanes, etc.).

   Care must be taken during covering operations to prevent mechanical damage to the liner. Critical aspects of a backfilling operation include stability of the subgrade, surface preparation, depth of backfill and surface-loading caused by earthmoving equipment during earthen placement. Proper preparation of the subgrade and the use of clean fill for the cover material is required to prevent puncture, tearing or abrasion of the membrane. It is recommended that the site engineer provide for visual inspection during earth covering (backfilling) operations.

   NOTE: Linings designed to be buried may be used in an exposed condition for a limited time. The user should consult with the manufacturer.

C. EXPOSED LININGS: Certain linings may be suitable for exposed applications, particularly where steeper banks and sediment-free systems are desired. It can also serve to facilitate inspection. In these cases, consideration should be given to design features including ground stability, membrane attachment, slope angles, venting and wind uplift.

D. BIOLOGICAL STRESSES: Membrane liners, scrims and adhesives that are susceptable to biological attack, as determined by, but not limited to, soil burial testing, should be formulated by the manufacturer to resist this attack. Problems of an animal or botanical nature may be controlled by fencing, soil sterilization, or mechanical protection in those areas where the problem could exist.

E. SUPPORTED OR UNSUPPORTED MEMBRANE MATERIALS:

1. UNSUPPORTED LININGS: Unsupported linings have high elongation and can conform to irregular surfaces and follow settlements. The tensile strength, tearing, and other physical properties of some exposed liners may be altered by temperature extremes and aging.

2. SUPPORTED LININGS: Fabric reinforcement, such as nylon or polyester scrims, are used in linings to improve tensile strength, tear resistance, burst strength and dimensional stability. Reinforcement decreases the elongation of linings so that they may not follow settlement.

3. COMBINATION LINER SYSTEMS: A number of lining materials can be used in combination. For example, a reinforced side slope lining may be used with an unreinforced bottom

lining or, a side slope lining may be of a different thickness than a bottom lining. Combinations of dissimilar materials may be used, but care should be taken to insure the integrity of seams and the compatibility of liner materials.

F. REPAIRABILITY: See Section VI.E.8.

III. POTABLE WATER APPLICATIONS: Materials used in the manufacture of membrane liners for potable water applications should conform to the following requirements:

A. CHEMICAL/TASTE AND ODOR: Chemical/taste and odor evaluations of membrane liner materials should be conducted in accordance with procedures set forth in Appendix A. The extractant water therefrom should not exceed the maximum contaminant levels established in the U.S. Environmental Protection Agency's National Primary Drinking Water Standards of 1978 and Federal Register publication 40CFR Part 141. Limits of acceptance as required by this standard are shown in Table C-I.

TABLE C-I. MAXIMUM PERMISSIBLE CONTAMINANT LEVELS

Contaminant	Max. Per. Level* mg/l(ppm)
Antimony	0.05
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (Hexavalent)	0.05
Lead	0.05
Mercury	0.002
pH	
Phenolic Substances	0.05
Silver	0.05
Selenium	0.01
TTHM	0.1

Taste and Odor Evaluation	
Characteristic	Permissible Level
Odor	80
Taste	Satisfactory

*In finished product

B. MATERIAL REQUIREMENTS: Materials shall conform with the requirements set forth in Sections 3 and 4 of the standard.

IV. WASTEWATER/SLUDGE APPLICATIONS: Surface impoundments and/or landfills receiving municipal wastewater liquids or sludges require special consideration. This type of waste could contain industrial wastes. Since some of these wastewaters/sludges exhibit increased biological activity and promote chemical attack, care should be taken in the final membrane selection.

V. SOLID AND HAZARDOUS WASTE APPLICATIONS:

A. GENERAL: Landfills and surface impoundments receiving solid or hazardous wastes when lined and/or covered require consideration of the nature and stability of the materials contained and/or released with time. Moisture, when accumulated to permit leaching, will expose the liner to changing environmental conditions; the choice of membrane type and seaming system may be affected by elevated temperature and other factors. This exposure may be anticipated to occur throughout the life of the liner and will be brought about by inherent physical, chemical and microbiological processes as well as the landfill management techniques employed.

B. OTHER CONSIDERATIONS: Although landfills may contain residential-type wastes, some sites may only receive contributions of commercial and/or industrial wastes which may be classified as hazardous. Selected waste systems may be classified as special (reference the December 18, 1978 Federal Register). The nature and characteristics of the waste materials and the anticipated release of constituents must be considered in the selection of the liner and cover as well as the methods of operation and maintenance of the site.

VI. CONSTRUCTION OF SITE:

A. SURFACE CONDITION:

1. PREPARATION OF EARTH SUBGRADE: The prepared subgrade should be of soil types no larger than Unified Soil Classification System (USCS) sand (SP) to a minimum of 6 inches below the surface and free from loose earth, rock, fractured stone, debris, cobbles, rubbish and roots. The surface of the completed subgrade should be properly compacted, smooth, uniform and free from sudden changes in grade.

2. MAINTENANCE OF SUBGRADE: The earth subgrade shall be maintained in a smooth, uniform and compacted condition during installation of the lining.

B. CLIMATIC CONDITIONS:

1. TEMPERATURE: The desirable temperature range for membrane installation is 5°C to 40°C. Lower or higher temperatures may have an adverse effect on transportation, storage, field handling and placement, seaming and backfilling where required.

2. WIND: Wind may have an adverse effect on liner installation such as interfering with liner placement, alignment of seams, and cleanliness of seam area; mechanical damage may result.

3 PRECIPITATION: When field seaming is adversely affected by moisture, portable protective structures and/or other methods should be used to maintain a dry sealing surface.

C. EROSION CONTROL: Wind and wave action may cause erosion where protective soil cover is used on the liner. Protective measures should be considered.

D. STRUCTURES: Penetration of a flexible liner by any designed means should be avoided. Where structures are necessary, such as:

- pipes (both horizontal and vertical)
- vertical support columns
- inlets, outlets
- sumps
- divider walls

it is essential to obtain a secure, liquid-tight seal between the structure and the flexible liner. Liners should be attached to structures with a mechanical type seal supplemented by a chemically compatible caulking or adhesives to effect a liquid-tight seal. The highest order of compaction should be provided in the area adjacent to the structure to compensate for any settlement.

E. LINER PLACEMENT:

1. SHOP DRAWINGS: Shop drawings with panel sizes, layout, and details should be prepared.

2. PACKAGING, TRANSPORTATION, HANDLING AND STORAGE: Packaging, transportation, handling and storage procedures should be planned to prevent material damage. Material should be stored in a secured area and protected from adverse weather.

3. SITE INSPECTION: A site inspection should be carried out by the owners representative and the installer prior to liner installation to verify grades, measurements, structures and surface conditions.

4. DEPLOYMENT: Panels should be positioned to minimize handling. Seaming should follow as close as practical. Bridging or stressed conditions should be avoided with proper slack allowances for shrinkage. Panels should be secured following deployment to prevent movement.

5. ANCHORING TRENCHES: The liner should be secured in a backfilled trench.

6. FIELD SEAMING: Field seaming should be performed when weather conditions are favorable. The contact surfaces of the materials should be clean of dirt, dust, moisture, or other foreign materials. The contact surfaces should be aligned with sufficient overlap and bonded in accordance with the suppliers recommended procedures. Wrinkles should be smoothed out and seams should be inspected by nondestructive testing techniques to verify their integrity. Seam samples should be taken to verify seam integrity or on-site seam samples can be made with identical liner material, adhesive and technique which need not be taken from an actual field seam.

7. VENTING: Where it is anticipated that gas will accumulate under the liner, a gas relief system may be required. Various methods or combinations are used depending upon the severity such as:

   •Liner Weighted by Protective Cover
   •Gas Relief System Under Liner:
   - perforated pipe
   - open granular filled trenches
   - open granular fill over subgrade
   - geotextile drainage fabric over subgrade
   - sloped bottom

   These systems should be constructed to permit gas escape from under the liner. Consideration should be given to use a soil cover as a complement to the gas relief system under the liner.

8. INSPECTION AND REPAIR: As seaming occurs during installation, the field seams should be inspected and any faulty area repaired. It is important that traffic on the lined area be minimized. Any necessary repairs to the liner should be patched using the same type of lining material and following the recommended procedure of the supplier

9. FINAL INSPECTION AND ACCEPTANCE: As completed, the liner installation should be tested for functional integrity. All joints, seams and mechanical seals should be checked both during and after installation. A variety of testing methods can be used such as:

   - hydrostatic test
   - vacuum
   - ultrasonics
   - air jet

   Final acceptance should be between responsible parties as contracted on each individual installation.

F. OPERATION AND MAINTENANCE: The owner should be provided with guidelines for operation and maintenance of the liner system, which should include recommendations on subjects such as:

   - Frequency and documentation of inspection
   - Testing and repair of liner
   - Monitoring of waste characteristics
   - Monitoring of observation wells
   - Animal and plant control
   - Erosion control
   - Security and safety
   - Unacceptable practices

APPENDIX D

Recommended Test Method for Estimating Long-Term Performance of Membrane Liners in a Chemical Environment

APPENDIX D

Recommended Test Method for Estimating Long-Term Performance of Membrane Liners in a Chemical Environment

A. INTRODUCTION

These test methods are for the initial and long-term evaluation of flexible membrane liner materials intended to contain chemicals in a pit, pond, lagoon or landfill-type installation. The effects upon the physical properties of the liner materials will be determined. Data from these tests will assist in deciding whether a liner material should be used in a given chemical environment.

In selecting a liner material for a given chemical environment, it is advantageous for the user to work with flexible membrane liner manufacturers. The user should provide the manufacturer/fabricator with a sample of the material to be contained and/or its chemical analysis along with the specific site and service conditions. The manufacturer can then provide the user a letter characterizing the chemical resistance of flexible membrane liner to the materials to be contained. The letter should explain how the chemical resistance of the liner material was determined; e.g., direct exposure tests such as described in this appendix. Other useful data could include historical data and/or field applications. The purpose of the letters from manufacturers is to assist the user in determining the acceptability of various materials for the intended use.

The test method is based upon ASTM D543 and ASTM D471 which specify the particular physical properties to be measured for plastics and rubber, respectively.

The scope of this appendix is to cover general test methods which may be of assistance in selecting a flexible membrane liner where other than fresh water is to be contained. Specific applications may require additional tests related to the particular environment. Some tests in this appendix may not be applicable to certain other applications. Some installations may not require long term evaluation testing per Appendix D if the manufacturer can provide similar test data and/or service experience for similar applications.

B. INITIAL EVALUATION

Specimens are exposed in the test environment for 1, 3 and 7 days at 23°C and 50°C. At least three specimens shall be used for each material being tested, at each temperature and for each chemical environment to be involved. Data on weight, dimensions and visual changes are obtained as described in Procedure I (Section I).

C. LONG-TERM EVALUATION

Sets of three test specimens are immersed in the chemical environment for each flexible membrane liner material being tested, at each temperature, and for each set of physical properties being tested. For example:

Property	No. of Specimens
Tensile, Modulus & Elongation	3
Weight & Dimensions	3
Ply Adhesion	3
Tear Test	3
Factory Seams	3
Visual	any/all of above samples

The weight and dimensional changes shall be determined after immersion in the chemical environment for 1, 7, and 14 days, and 1, 2 and 4 months at 23°C and 50°C. The changes in tensile (breaking strength), modulus, elongation and tear shall be determined after immersion for 1 day, 7 days, 1 month and 4 months. This data will assist in determining the properties after long-term service. The specific nature of the FML being tested should be considered when interpreting the data.

D. SIGNIFICANCE

1. The limitations of the results obtained from this test should be recognized.

2. Correlation of test results with the actual performance or serviceability of FML materials is necessarily dependent upon the similarity between the testing and end-use conditions. For applications involving continuous immersion, the data obtained in short time tests are of interest only in eliminating the most unsuitable materials or indicating a probable relative order of resistance to chemical reagents.

3. The selection of test conditions should take into account the manner and duration of contact with the chemical environment, the temperature of the system, and other performance factors involved in the particular application. If the highest expected temperature in service exceeds the 50°C recommended in this appendix, then use the higher temperature.

4. Note should be taken of the fact that different ratios or even trace amounts of different materials in the immersion liquid may affect the FML in an entirely different manner if concentrated or localized even for short periods of time in repeat tests or in actual application. Trace amounts of deleterious chemicals can be cumulative; this may require a repeated supply of chemical liquid to show the true immersion effect.

E. APPARATUS

1. Balance - a chemical balance accurate to 1 mg.

2. Micrometers - Micrometers capable of measuring dimensions of test specimens to 0.025 mm (0.001 in).

3. Room or enclosed space capable of being maintained at the standard laboratory atmosphere, at temperature 23 ± 2°C and relative humidity of 50 ± 5% (ASTM D618).

4. Containers - Suitable containers for immersing specimens in chemical reagents. They must be resistant to the corrosive effects of the reagents being used. Safety precautions must be taken when using highly volatile reagents at elevated temperatures.

5. Oven or Constant-temperature Bath - Capable of maintaining temperature within ± 2°C of the specified test temperatures.

6. Testing Devices - Testing devices for determining specified strength properties of specimens before and after immersion, conforming to the requirements prescribed in the ASTM methods of test for the specific properties being determined.

F. TEST ENVIRONMENTS

The FML liner material should be immersed in the actual chemical process solutions to be provided by the plant involved. If this is not possible, a synthesized solution may be used and must include all chemicals, especially solvents, even though they are present in small quantities. See Section D.4 concerning special studies with aggressive trace materials.

Caution: In all cases, it is necessary to determine whether the solution is homogenous or consists of more than one phase. When a multiphase solution exists, test samples must be placed in each of the phases. Each phase should be in a separate container. Past experience indicates that a solvent has limited solubility in an aqueous system and may form a separate layer either on top or bottom of the liquid. It is likely that the solvent phase may adversely affect the liner material while the aqueous phase may not. If highly volatile chemicals are part of the solution being tested, the solution should be changed at equal time intervals (weekly or monthly) so as to compensate for any escaping components of the chemical environment.

G. TEST SPECIMENS

The type and dimensions of test specimens to be used for original and immersion testing shall be those described in Section J.3. for each type of FML. Specimen surface area greatly affects the

weight change due to immersion in chemical reagents. Thickness influences percentage dimension change as well as percentage change in mechanical properties. Consequently, comparison of materials should be made only on the basis of results obtained from specimens of identical dimensions and like methods of specimen preparation. The number of specimens used shall be as stated in Sections B and C. The specimens shall be as follows: specimens from sheet material shall be cut from a representative sample of material in a manner depending upon the tests to be performed and the thickness of the sheet as follows:

1. Weight and dimension changes - Standard specimens shall be in the form of bars 76.2 mm (3 in) in length by 25.4 mm (1 in) in width by the thickness of the material. 2 inch by 1 inch specimens or 2-inch diameter discs can be alternates.)

2. Mechanical property changes - Standard machined, sheared, or cut tensile specimens shall be used according to the methods of test prescribed.

H. CONDITIONING

1. Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 percent relative humdiity for not less than 40 hours prior to test.

2. Test conditions - Conduct tests at the standard temperatures of 23 ± 2°C (73.4 ± 3.6°) and 50 ± 2°C (122 ± 3.6°F). In cases where the FML material will have a chemical environment at elevated temperatures, the immersion testing shall be run at the elevated temperature if higher than the above.

I. PROCEDURE I - WEIGHT AND DIMENSION CHANGES

1. Weigh each conditioned specimen separately and measure its thickness at the center and its length and width to the nearest 0.25 mm (0.001 in). In the case of laminates, edge swelling is not uncommon under certain conditions. Consequently, it may be necessary to measure thickness both at the center and at the edges and report the percentage change separately for each position.

2. Place specimens in appropriate containers for the chemicals being used and allow the specimens to be totally immersed in fresh chemical for the appropriate time in the standard laboratory atmosphere. Suspend the specimens to avoid any contact with the walls or bottom of the container. For specimens of thin sheeting or those having a lower density than the chemical, it may be necessary to attach small weights such as nichrome wire to prevent floating or curling. Several specimens of a given material may be immersed in the same container provided sufficient reagent is allowed for the total surface area exposed and the specimens do not touch each other. The quantity of chemical solution shall be approximately 40 ml/in^2 of total specimen surface area.

   For test at other than room temperatures, it is recommended that the test temperature be 50°C or at the highest expected service temperature, whichever is the highest. It is important that the test solution be at the elevated test temperature before the specimens are immersed. In the event that the liner is expected to impound certain substances in trace quantities which can be aggressive to FML materials, special investigations should be instituted by the testing agency.

3. Stir the test solutions every 24 hours by moderate manual rotation of the containers or other suitable means. In making tests for longer periods of time than 7 days, the containers should be stirred once each day during the first week, and once each week thereafter. Where the field service condition will involve aeration or other continuous agitation, the containers should be stirred daily.

4. After the test period, individually remove each specimen from the chemical solution, blot excess material, dip into acetone or other suitable solvent, wipe and dry with lint-free material, immediately weigh in a weighing bottle, remeasure its dimensions and place back into chemical environment until next time period. When dealing with an oily material, it may be necessary to follow the following procedure: wipe and dry with lint-free material; dip into detergent solution; wipe and dry with lint-free material; dip into water and then acetone or

other suitable solvent; wipe and dry with lint-free material; dip into water and then acetone; wipe and dry with lint-free material; and weigh and measure immediately. Some specimens may become tacky due to dissolved material on the surface or solvent absorbed throughout the specimen. Take care in wiping such specimens not to disturb or contaminate the surface.

5. Observe the appearance of each specimen after exposure to chemical reagent. Observe and report appearance on the basis of examination for evidence of blistering, loss of gloss, developed texture, decomposition, discoloration, swelling, tackiness, crazing, bubbling, cracking, softening, solubility, etc. For some materials, absorption of the reagent over the immersion period is nearly balanced by the removal of soluble constituents. This type of behavior may be revealed by comparing the initial conditioned weight of the specimen with its weight when dried for 7 days at 23°C and 50 percent relative humidity, after removal from the chemical reagent. (A final weight lower than the initial weight may indicate removal of soluble constituents. However, only for particular combinations of reagent and test specimen can this weight difference be considered as due strictly to the removal of soluble constituents.) If this drying out procedure is used, it should be tried after all test-time periods have elapsed.

J. PROCEDURE II - MECHANICAL PROPERTY CHANGES

1. Immerse and handle the mechanical test specimens in accordance with the instructions given under Procedure I (Sections 2, 3 and 4).

2. Determine the mechanical properties of identical nonimmersed and immersed specimens in accordance with the standard methods for the physical property test described. Make mechanical property tests as nonimmersed and immersed specimens prepared from the same sample or lot of material in the same manner and run under identical conditions. Test immersed specimens immediately after they are removed from the test solution. Where specimens are exposed to test solutions at elevated temperatures, they shall be placed in another container of the reagent at the standard laboratory temperature for approximately one hour to effect cooling prior to testing.

3. Test samples for materials with fiber scrim support - The effect of chemicals on the liner material without support material must be determined because it is the main chemical barrier while the function of the scrim is to provide added mechanical properties. Most of the time, the liner material without support will have to be a laboratory-milled sample of the same formulation, milled to a thickness of 20 or 30 mils. The processing conditions of laboratory-prepared samples should be as close as possible to actual factory conditions.

   All samples containing a fiber scrim support must be flood-coated along all exposed edges with a solution recommended by the FML manufacturer. This solution will typically contain 5 - 15% solids dissolved in a solvent (or mixture of solvents). The solids content is usually the FML formula or simply the base polymer used.

   The physical properties after immersion are determined using the original unimmersed thickness or cross-sectional area, as described in ASTM D471.

4. Test samples for material with no scrim - These test samples are designed to measure the mechanical and physical properties of the liner material. Tests shall be conducted as prescribed and the properties after immersion are determined using the original unimmersed thickness or cross-sectional area, as described in ASTM D471.

5. Condition of samples before physical testing - After the samples have been removed from the test solution, they should be kept saturated with the test solution until just before testing. If the test solution contains organic solvents, the coupons should be wrapped in aluminum foil during this interval to prevent loss of solvent. In many cases, a material that has been degraded by solvent will regain almost all its original properties after the solvent has evaporated away. The time between removal from solution and testing should be kept as short as practical.

6. Test data required:

Crosslinked elastomers unsupported - ASTM D412 (Method A)

- Breaking strength, pounds/inch width
- Elongation at break, percent
- Modulus at 100 percent elongation

Thermoplastics, unsupported

Materials without a yield point - ASTM D882

- Breaking strength, pounds/inch width
- Elongation at break, percent
- Modulus at 100 percent elongation, pounds/inch width

Materials with a yield point - ASTM D638

- Breaking strength at yield and break, pounds/inch width
- Elongation at yield and break, percent
- Modulus of elasticity, pounds/inch width
- Tear, unsupported FML - ASTM D1004

Supported flexible membrane liners

Supported finished FML material - ASTM D751

- Breaking strength, Grab Method, pounds or Strip Method, pounds/inch width

Ply adhesion, all supported FML - ASTM D413, Machine method, strip specimen, Type A, 180° peel, pounds/inch width

Visual inspection, unsupported and supported FML - Procedure I (Sections 1 thourgh 5)

K. Procedure III - Effect of Strain on Mechanical Properties

1. Standard specimens shall be in the form of bars 75.2 mm (3 inches) in length and 25.4 mm (1 inch) in width by thickness of the material.

2. Form a bent loop from the standard specimen by folding the specimen together and holding the ends together with a suitable fastener or adhesive which is resistant to the test solution. Approximately 2 inches of the specimen shall be in contact with itself.

3. The specimens should be conditioned and immersed as in Procedure I (Section I).

4. After immersion periods of 7 days for initial evaluation and 4 months for long-term evaluation, the specimen shall be inspected for visible deterioration as described in Procedure I.

5. This test is qualitative in character and to be used to identify materials which are highly susceptible to deterioration in the chemical solution when strained.

L. Procedure IV - Factory Seams

All seaming methods and techniques should be evaluated in the chemical environment in which they are to be employed. Samples are to be prepared and tested using methods as prescribed in ASTM D3083 (as modified in Appendix A) for unsupported FML and ASTM D751 (Appendix A) for supported FML. These methods provide for the testing of seams in the shear direction. It should be noted that testing in the peel direction (as in ASTM D413) can be a more sensitive test for

determining chemical resistance of seams. Samples should be immersed for 7 days for the short-term initial evaluation and 4 months for the long-term test. Samples containing a fabric scrim support must be flood-coated as described earlier (Section J.3.)

M. Report

The report shall include the following:

1. Procedure I

   a. Complete identification of the material tested including type source, manufacturer's code, form and previous history.

   b. Temperature of tests.

   c. Test solutions

   d. Duration of immersion

   e. Initial length, width and thickness of each specimen, in inches, measured to the nearest 0.025 mm (0.001 in)

   f. Initial weight of each specimen in grams to ± 0.005 g

   g. Length, width and thickness after immersion

   h. Weight after immersion

   i. Average percentage increase or decrease in length and width, and in the thickness, taking the dimensions of the conditioned specimen as 100 percent.

   j. Averge percentage gain or loss in weight calculated to the nearest 0.01 percent, taking the conditioned weight as 100 percent.

   k. General appearance of specimens after immersion.

2. Procedure II

   Items 1 through 4 as for Procedure I and the following:

   a. Specimen type and dimensions

   b. Method of test

   c. Mechanical properties of identical nonimmersed and immersed specimens

   d. Average pecentage increase or decrease in mechanical properties, taking the properties of the conditioned nonimmersed specimens as 100 percent.

3. Procedure III

   General appearance of specimens after exposure

4. Procedure IV

   a. Original bonded seam strength

   b. Bonded seam strength after immersion

   c. Average change in bonded seam strength using original bonded seam strength as 100 percent

APPENDIX E

IDENTIFICATION SYSTEM

APPENDIX E

IDENTIFICATION SYSTEM

The code in Section 5 of the standard consists of three parts: the FML material; installation condition; and general intended service. Thus the code could be considered three-part sequence x/y/z.

Example 1: PVC, 30 mil suitable for potable water use

x: Material - PVC
Unsupported = U
Thickness - Nominal Gauge 30 mils = 30

or x = PVC-U-30

y: PVC is to be buried =
Bu

z: Material evaluated suitable for potable water = PW

Identification is PVC-U-30/Bu/PW

Example 2: Supported CPE, Type 2, not evaluated for potable water use

x: Material - CPE
Supported = S
Type - 2
Thickness - Nominal Gauge 36 mils = 36

or x = CPE-S-2-36

y: CPE is evaluated suitable for exposed service = Ex

z: Material evaluated not suitable for potable water = In

Identification is CPE-S-2-36/Ex/In

APPENDIX F

RECOMMENDED PROTOCOL
FOR
DEVELOPING TESTING AND FIELD EXPERIENCE DATA
FOR
NEW MATERIALS

APPENDIX F

RECOMMENDED PROTOCOL FOR DEVELOPING TESTING AND FIELD EXPERIENCE DATA FOR NEW MATERIALS

This protocol is to provide guidance for developing the testing and field experience data for submittal for the purpose of adding new materials or additional types or gauges to the standard. Additions to the standard will require balloting on the proposed changes by the NSF Joint Committee for Flexible Membrane Liners, Council of Public Health Consultants, and final adoption by the NSF Board of Trustees. It may be necessary to have a review of the data by the Industry Advisory Committee or a technical review committee, as appointed by NSF, prior to balloting at the Joint Committee level.

The following basic information is to be provided:

1. A recommended materials properties table shall be submitted which will include details of the test method and values along with the test data to substantiate the recommended table. (It is recommended that data on other potential tests also be provided to substantiate that they are not appropriate for the particular material.) The recommended material properties should characterize the material and a satisfactory liner as manufactured from the material.

2. For an exposed liner, data shall be submitted as evidence of compliance with Item 3.0.3 (EMMAQUA, 1,000,000 Langleys rating of 7 or better).

3. Evidence of production on full-scale equipment shall be provided.

4. Evidence of a monitored field installation that has experienced seasonal variations (minimum one year) shall be provided. The installation shall include both factory and field seams.

5. The data of testing conducted on the liner exposed for at least one year shall be provided. The testing should be of the material properties of the recommended table and should include testing of the seams. (EMMAQUA testing and 120-day soil burial are excluded.)

General guideline for the reviewing process: The specified minimum test values to be stated in the proposed material properties table should be based on actual test results of unexposed FML. These minimums should be within 25% of the actual test values. Exception to this requirement may exist depending on the precision, accuracy or nature of the test. In addition, the data for the exposed FML should correlate with the data for the unexposed FML.

In addition to the basic submittal as detailed, it is recommended that additional data and information for weathering (other than EMMAQUA) and chemical resistance be provided to support a request for an addition to the standard.

APPENDIX G

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