QUALITY CONTROL MANUAL FOR FACTORY FABRICATION OF POLYOLEFIN GEOMEMBRANE

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The Liner Company

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Preface

EPI is committed to not only satisfying all appropriate industry and customer specifications, but also continuing to establish new standards of product and service excellence.

Our management and employees regularly assess all aspects of our design, fabrication, shipping, and testing procedures to assure we are meeting this commitment.

We are also committed to continuing to be an industry leader in the use of new technology and independent research and development.

The Liner Company

"ENHANCING OUR ENVIRONMENT BY PRESERVING WATER RESOURCES FOR FUTURE GENERATIONS"

TABLE OF CONTENTS

1. SCOPE

This manual presents EPI's basic quality control system for the fabrication, packaging and testing of the Polyolefin geomembrane liners. As appropriate, the policies and procedures are also applied for projects involving other geomembrane materials.

1.01 QUALITY STANDARDS

The products and services of EPI meet or exceed ASTM Standard Specifications and that of the Geosynthetic Institute (GRI).

The testing procedures are consistent with or exceed the requirements of the American Society for Testing and Materials (ASTM) as appropriate.

Laboratory testing equipment is certified and traceable to the standards of the National Institute of Standards and Traceability (NIST).

EPI shall also adhere to the standards as called for in site specific contract plans, specifications and CQC\CQA documents consistent with ASTM and GRI specifications Listed within this document.

1.02 ADHERENCE TO STANDARDS

The procedures herein will be adhered to at all times. The material here supersedes all previous procedures relating to quality control.

The supply of these materials will be in strict accordance with the Engineer's specifications and engineering drawings. Deviation from these standards and procedures described in this manual will only be as required to meet the project plans and specifications according to the terms and conditions of the contract.

Conformance to the established policies and procedures described herein will be monitored by internal audits on a random basis.

1.03 WARRANTIES

EPI will provide the OWNER, as part of the project documents, a specific written warranty. This document will warrant the quality of the geomembrane materials, factory seams and workmanship.

EPI will certify in writing that when the material is installed properly, meets the requirements of the project and the specifications, and that with approved conditions and materials the sheet material can be warranted by the material manufacturer for up to twenty years. Warranties are material and project specific.

1.04 DISPOSITION OF SAMPLES AND TESTED MATERIALS

After testing, all samples, specimens and test reports are the property of EPI.

Additional samples and test material may be taken by EPI for testing at its own laboratory, for its own use and information.

Additional samples and test material may be made available to an independent testing laboratory or the OWNER's representative at the OWNER's expense.

2. IN - FACTORY QUALITY CONTROL (Fabricated Geomembranes)

2.01 RAW MATERIALS INSPECTION

a) EPI requires each manufacturer to furnish written certification that all material meets or exceeds Project Specifications and QUALITY CONTROL MANUAL FOR FACTORY FABRICATION OF POLYOLEFIN GEOMEMBRANE.

b) Prior to factory seaming, all roll goods will be unwound and visually inspected for contaminants, defects, undispersed raw materials and edge and surface uniformity.

c) All defects or impurities will be removed from the roll prior to being fabricated into panels, or the roll will be rejected.

e) Material will be rejected for poor "layflat" edges or "racetracking" caused by inconsistent sheet thickness.

f) Material certification(s) will be supplied by the manufacturer for the properties specified or per the respective geomembrane specification listed in section 2.02

2.02 RAW MATERIALS TESTING

Raw material testing on these materials is performed by the manufacturers and a certification will be supplied for each lot of material. However, tests may be conducted by EPI on samples from each lot of geomembrane roll goods received to verify compliance with material specifications in the following areas:

a) GRI GM13 - High Density Polyethylene (HDPE),
b) GRI GM-17 - Linear Low-Density Polyethylene (LLDPE),
c) GRI GM-18 - Unsupported Polypropylene (UPP or PP) and Reinforced Polypropylene (RPP),
d) GRI GM-22 - Test Methods, Required Properties and Testing Frequencies for Scrim Reinforced Polyethylene Barriers Used in Exposed Temporary Applications”
e) GRI GM- 30 “Test Methods, Test Properties and Testing Frequency for Coated Tape Polyethylene (cPE)

f) For materials not listed see the manufactures recommendations or specification sheets

2.03 FABRICATION AND IN-FACTORY SEAMING

The sheets will be factory seamed into maximum sized panels and custom designed for the specific project so as to minimize field seams. The following practices will be an integral part of the fabrication process:

a) The factory seam process will typically be accomplished by the use of thermal fusion welding. The weld width of single track shall be a minimum of one- and one-half inches (1.5”) and for dual track welds each track shall be a minimum of one-half inch (1/2”) with a channel centered between the two tracks being a minimum of three eights of an inch (3/8”).

b) Each individual strip of material is numbered to correspond with shop fabrication drawings to assure accurate size.

c) Each panel fabricated is logged by serial number, size, date fabricated, material lot number, roll number and fabrication crew.

d) Prior to unrolling the roll goods, a thickness measurement will be taken at the beginning of each roll and recorded on the Factory Seam Q.C.Inspection Records Form # Q-112-C

e) Roll goods as received from the supplier shall be unrolled side by side parallel to each other. The panels as laid out shall be overlapped no less than two inches and no more than six inches. The panels then shall be welded together with a thermal fusion welding machine. During the unrolling and seaming process visual inspection shall be made of the liner surface for imperfections such as holes, pits and undisbursed raw material.

f) Repairs shall be made by cutting a patch from the parent material which will extend a minimum of six inches beyond the area to be repaired. Patches shall be welded using the appropriate methods for the chosen material. Wrinkles or fishmouths in seams shall be cut out so that the material is flat, then overlapped and welded back together, then a patch shall be placed over the repair.

g) Butt splices shall be produced in the same manner as factory seams.

h) Raw material rolls and fabricated panels on cores shall be handled with the use of a lift/fork truck and with a pick pole or a core pipe and/or sling and chains; each fork truck shall be equipped with a set of slings for lifting rolls when necessary.

2.04 FACTORY SEAM REQUIREMENTS

For High Density Polyethylene (HDPE), Low Density Polyethylene, Linear Low Density Polyethylene (LLDPE), Unsupported Polypropylene (UPP) and Reinforced Polypropylene

(RPP) refer to Geosynthetic Institute (GI) GM19 standard for seam specifications. For materials not listed see the manufactures recommendations.

2.05 IN - FACTORY SEAM TESTING

1. NON - DESTRUCTIVE TESTING
    a. All completed factory seams are 100% visually inspected by two people. Every seam is inspected for full seam continuity over their entire full length. Any areas that do not meet the specified requirements that cannot be repaired shall be removed and repaired. Any areas that do not meet the specified requirements shall be repaired per section 4.
    b. Trial welds shall be made at a minimum of
        i. Every three Hours
        ii. At any time, the welder has been or is to be shut off except as noted in this section of (2.05, c, iii)
        iii. Prior to and after any time changes are to be made to the machine
        iv. At completion of the day's production or at completion of the project
        v. If the welder has been sitting idle for more than 45 minutes
        vi. Prior to and after any welder maintenance if performed during production
        vii. Any time the Quality Control department deems it necessary
        viii. All production seaming must be bounded by passing destructive test samples consisting of, at a minimum, a pre-production test and a post-production test

    c. When a pre-qualifying sample is run to verify machine setting prior to production in another area of the shop the pre-qualifying sample may be used for the startup sample as long as:
        i. Proper digital paperwork is provided (form Q-112-C)
        ii. There is no more than 45 minutes between testing and production start
        iii. The power supply changeover is performed as quickly as possible to minimize the interruption of the power supply, and that the welder is unplugged no longer that 30 seconds

    d. Sampling procedures in section 2.05-1, meet or exceed ASTM D7982

2. DESTRUCTIVE TESTING

Representative destructive tests will be performed to verify that the seam strength requirements of the specifications are met. Samples shall be made at a minimum of once per factory panel fabricated and the following quality assurance tests will be performed on each sample:

- thickness
- shear strength
- peel adhesion

The sample shall be cut into ten one - inch wide by eight - inch long specimens. For EPI's standard statistical program, five peel and five shear specimens are removed. To be acceptable, five of five test specimens for peel and five of five test specimens for shear strength must meet the minimum peak load requirements of factory seams as follows:

Shear Strength

One-inch strips cut with the weld centrally located are tested by stressing the weld in a "shear" configuration. That is, the top sheet is stressed in relation to the bottom sheet in a direction away from the weld. The test result to be reported is the average of the peak loads recorded for each of the five specimens.
This result must meet the minimum peak load requirements stated in the material specifications. A failure occurs when the weld separates or the material breaks at a peak load less than the specification. With some materials it may be necessary to use a two inch wide specimen with some reinforced materials.

Peel Adhesion

One-inch strips cut with the weld centrally located are tested by stressing the seam in a "peel" configuration. That is, the top sheet is stressed perpendicular to the lower sheet in an effort to peel the weld apart. Each specimen will be peeled until failure. The test result to be reported is the average of the peak loads recorded for each of the five specimens. This result must meet the minimum peak load requirements stated in the material specifications. A failure occurs when the weld separates at a peak load less than the specification without film tearing bond.

Testing shall be performed on a tensile testing machine also known as a Tensiometer. These machines shall be third party calibrated on a regular basis.

Each seam sample test will be identified by EPI serial number. These tests shall be performed in EPI's laboratory.

Record all factory fabricated panel information on the “Factory Seam Q.C. Inspection Records and summary, In-Process inspection for Thermal seams”. Form number Q-112-C.

Prior to delivery of the geomembrane at the site, EPI will provide to the customer, manufacturer material certifications and/or a copy of quality control test results for

all panels to be used, verifying conformance with this specification and the requirements as represented in the Project specification.

3. WELDING EQUIPMENT

Thermal Welding - The welding equipment consists of a self driven machine with a visual display showing temperature and speed settings. Welders must be able to maintain temperatures to melt the material being welded. They will either have a heated metal wedge or hot air that is guided between the two sheets of material to be welded thus melting the surface of the sheet. The two melted sheets then pass through a set of adjustable nip rollers and squeeze the surfaces together to form a continuously bonded sheet. These machines shall have guides to control the amount of material inserted in the machine to control the overlap of the two sheets. The weld width of single track shall be a minimum of one and one half inches (1.5”) and for dual track welds each track shall be a minimum of one half inch (1/2”) with a channel centered between the two tracks being a minimum of three eighths of an inch (3/8”).

Handheld Welder – The handheld welder consists of a hot air gun capable of producing temperatures hot enough to melt the material being welded. This unit should have a flat 1 to 2 inch wide by 1/8 to 1/4 inch open nozzle. This unit is used in conjunction with a roller to melt the surface of the sheet and then roll the two melted surfaces together to form a bond between the two sheets. Each type of material should be evaluated for the capabilities of the handheld welder to meet the individual materials seaming specification.

Extrusion Fillet Seaming – This seaming technique involves extruding molten resin at the edge of an overlapped geomembrane on another to form a continuous bond. A depreciated method called “extrusion flat” seaming extrudes the molten resin between the two overlapped sheets. In all types of extrusion seaming the surfaces upon which the molten resin is applied must be suitably prepared, usually by a slight grinding or buffing.

4. REPAIRS

When there is a repair, the resulting hole will be repaired with a patch that extends a minimum of six inches in all directions beyond the hole and the patch will be rounded on all corners. The patch will be applied in the appropriate manner based on the type of geomembrane.

2.06 STATISTICAL PROCESS CONTROL (SPC)

EPI follows a consistent Statistical Process Control (SPC) Program of inspection and testing throughout the factory fabrication process. The statistics developed through this program give EPI the ability to interpret information and predict changes needed in the fabrication process before unwanted results occur.

EPI maintains Average and Range (XBAR&R) process control charts on all results obtained from seam shear and peel tests conducted in EPI's laboratory. The results shown on these charts are reviewed regularly with EPI management personnel, each fabricator and with the Quality Improvement Team.

EPI maintains histograms of the results of tests performed on samples taken from each lot of geomembrane material received. These tests include visual inspection, thickness, tensile strength, elongation and modulus of elasticity.

EPI's Quality Control Program monitors statistical data and address assignable causes by identifying the cause and effect. Corrective actions are taken as necessary.

3. SHIPPING AND HANDLING

3.01 PREPARATION FOR SHIPMENT

a) Factory fabricated geomembrane panels are accordion folded and then rolled up for shipment. Cores can be made out of wood, cardboard or steel. Geomembrane panels may also be double accordion folded onto a wooden pallet.

b) Each panel will be prominently and indelibly marked with the panel size and serial number for proper deployment location according to shop drawings.

c) If the material is to be palletized, pallets have a protective layer (i.e.: cardboard or excess liner) on the surface of the pallet and between the liner and the banding to prevent damage to the liner.

d) All panels will be packaged with a cover or outer wrap to protect the panel from weather and ultraviolet light.

3.02 TRANSPORTING PANELS TO THE JOB SITE

Fabricated geomembrane panels will be packaged and shipped by appropriate means so that no damage is caused.

Materials will be shipped in either an enclosed trailer or on a flat bed trailer and delivered to the site only after the required submittals have been approved and received by EPI from the ENGINEER, OWNER or CUSTOMER.

3.03 STORAGE

As a general guideline sufficient space will be allocated by the OWNER to store the geomembrane upon its arrival. Proper on – site security is the responsibility of the OWNER.

The panels must remain stored in their original unopened containers in a dry area protected from damage.

For additional information on Shipping, Handling and Storage follow:

For Fabricated Panels:

Follow ASTM D7865 Standard Guide for Identification, Packaging, Handling, Storage and Deployment of Fabricated Geomembrane Panels

For Rolled Goods:

Follow D4873 Identification, Storage, and Handling of Geosynthetic Rolls

4. SAFETY POLICY

Environmental Protection, Inc. is committed to the protection of the health and safety of its workers and will take all reasonable measures to achieve this goal. Therefore, the Company is committed to the prevention of personal injury, occupational disease and the protection from accidental loss of all of its resources, including employees, the environment and its physical assets.

In order to fulfill this commitment to protect both people and property, the Company will provide and maintain a safe and healthy work environment according to acceptable industry standards and in compliance with legislative requirements. The Company will strive to eliminate any foreseeable hazards which may result in fires, explosions, security losses, property damage, accidents, personal injuries and/or illnesses.

Environmental Protection, Inc. has the ultimate responsibility to ensure that every reasonable precaution is taken to protect its employee's health and safety by working in compliance with the law and with safe work practices and procedures established by the Company.

Managers and supervisors will be held accountable for the health and safety of the employees under their supervision. It is each supervisor's responsibility to comply with, and promote among their workers, the corporate philosophy of health and safety protection and loss control.

In addition to complying with established standards, striving for loss prevention is a company priority objective. Control of losses can only be achieved through the combined efforts of all the employees of Environmental Protection, Inc. Identification of areas where potential losses may occur is the responsibility of all managers, supervisors and employees. By working together, hazards which have the potential to result in fire, explosions, security losses, property damage or personal injuries / illnesses can be minimized and incidents can be avoided.

4.01 SAFETY AND HEALTH PROGRAM

EPI's comprehensive safety and health program includes:

1. Safety meetings topics for all employees covering:

   a) Personal Protective Equipment
   b) Hazardous Materials "Right to Know"
   c) Emergency Action Plan
   d) Lockout Tagout Procedures
   e) Bloodborne Pathogens
   f) Housekeeping
   g) Communicable Disease
   h) Accident Reporting
   i) Fire Extinguishers/Fire Prevention, Fire Safety
   j) Lifting Back Safety
   k) HI - LO Safety
   l) Fire Drills
   m) Natural Disasters
   n) Environmental Emergencies
   r) Slip and Falls

2. Specialized training as required, including

   a) CPR \ Cardiopulmonary Resuscitation
   b) First Aid Procedures
   c) Hazardous Materials Handling Training

3. Documented and implemented policies covering:

   a) Lockout Tagout
   b) Safety Glass Requirements
   c) Hazard Communication Plan "Right to Know"
   d) Emergency Action Plan
   e) General Housekeeping
   f) Accident Reporting

4. Designated safety program leadership and coordination including:

   a) Company Safety Director
   b) TQM / Safety Team
   c) New Employee Orientation
   d) Quarterly Safety Inspections
   e) Safety Recognition Awards
   f) Voluntary Government Agency Inspections and Environmental Testing
   g) Preparation and Publication of Appropriate Safety Reports

REFERENCES

1. ASTM D4873 - Identification, Storage, and Handling of Geosynthetic Rolls

2. ASTM D6392 - Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

3. ASTM D7408 - Standard Specification for Non-Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams

4. ASTM D7747 - Standard Test Method for Determining Integrity of Seams Produced Using Thermo-Fusion Methods for Reinforced Geomembranes by the Strip Tensile Method

5. ASTM D7865 - Standard Guide for Identification, Packaging, Handling, Storage and Deployment of Fabricated Geomembrane Panels

6. GRI GM13 - Standard Specification for “Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

7. GRI GM17 - Standard Specification for Test Methods, Test Properties and Testing Frequency for Linear Low-Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

8. GRI GM18 - Standard Specification for Test Properties, Testing Frequency and Recommended Warrant for Flexible Polypropylene (fPP and fPP-R) Nonreinforced and Reinforced Geomembranes"

9. GRI GM 19 - Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

10. GRI – Geosynthetic Research Institute standards can be supplied upon request or at http://www.geosynthetic-institute.org/specifications.htm

APPENDIX A