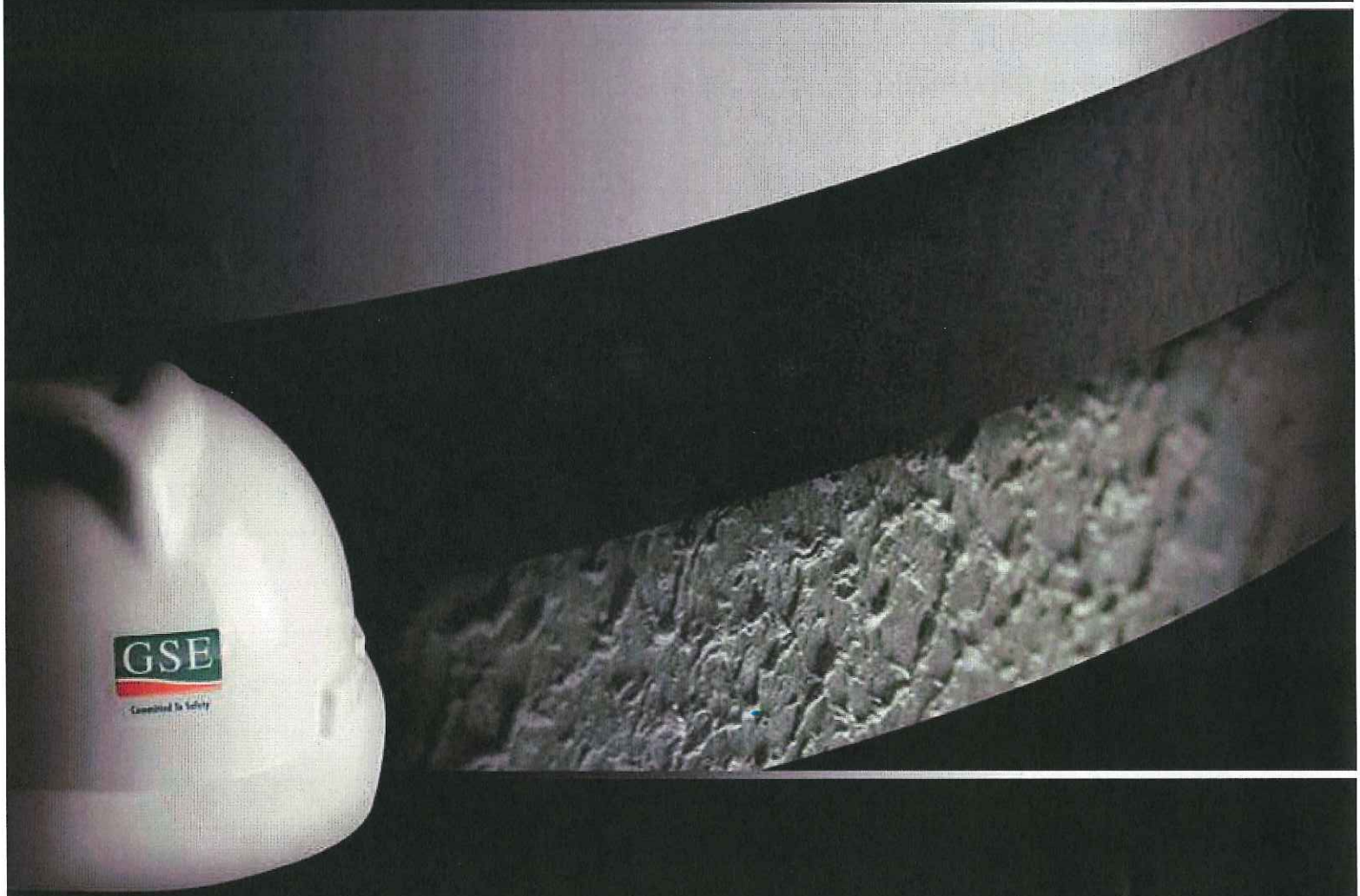
Installation Quality Assurance Manual



Geomembrane Products

GSE

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1.0 INTRODUCTION

This manual provides an overview of the GSE Installation Quality Assurance procedures consistent with industry accepted practices to ensure that the geomembrane products installed will best perform for its intended purpose. In addition, all installation work will be performed in strict accordance per the customer's specifications. Please read the procedures below completely before you begin. If you need further clarification, contact the GSE Installation Department for assistance. Remember safety first and use safe practices always on every project.

2.0 STANDARD TEST METHODS

ASTM D 6392: Standard Test Methods For Determining The Integrity Of Non-Reinforced Geomembrane Seams Produced Using Thermo Fusion Methods

ASTM D 5820: Standard Practice For Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

ASTM D 5641: Standard Practice For Geomembrane Seam Evaluation By Vacuum Chamber

ASTM D 6497: Standard Guide For Mechanical Attachment of Geomembrane to Penetrations or Structures

ASTM D 7240: Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

GRI Standard GM13: Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

GRI Standard GM14: Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes

GRI Standard GM17: Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

GRI Standard GM19: Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

3.0 MATERIAL DELIVERY

A. Upon arrival on site, the GSE QA personnel will inventory all materials on the job site.

B. Roll numbers of geomembrane will be logged on the Inventory Check List (Appendix A) and cross-referenced with the Bill of Lading for materials supplied by GSE.

C. Copies of the Inventory Check List and signed Bill of Lading should be sent to the GSE's corporate headquarters while the QA personnel retains the original copies.

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D. Any visible damage to roll materials should be noted on the roll and Inventory Check List.

4.0 EARTHWORK

A. The general contractor is responsible for preparing and maintaining the subgrade. The subgrade should be prepared and maintained per the job specifications.

B. The GSE site manager shall be responsible for assuring that the subgrade surface has been properly prepared for deployment of geosynthetics. After each day's deployment the Subgrade Surface Acceptance form (Appendix B) will be signed by all parties.

5.0 PANEL PLACEMENT

A. Each panel will be assigned a number as described below.

1. When there is one layer, panels may be designated with only a number, i.e...1, 2, 3, 4 etc.

2. When two or more layers are required, use a letter and number, i.e....
   Primary Liner P1, P2, P3, P4 etc...
   Secondary Liner S1, S2, S3, S4 etc...
   Tertiary Liner T1, T2, T3, T4 etc...

B. This numbering system should be used whenever possible. Agreement to a panel numbering system should be made at the pre-construction meeting. However, it is essential that GSE and the owner representative and third party QA inspector agree.

C. Panel numbers shall be written in large block letters in the center of each deployed panel. The roll number, date of deployment and length (gross) should be noted below the panel number. All notes should be made, so that they are easily visible from a distance. On long panels it is beneficial to write information on both ends.

D. Panel numbers shall be logged on the GSE Panel Placement Log (Appendix C) along with the roll number and other information neccessary to complete the form.

E. If there is a partial roll left after deployment, it is important to write the last four digits of the roll number in several locations on the roll along with the estimated length for future identification.

F. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

1. Unroll geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage. GSE Conductive should be installed with Conductive layer facing down.

2. Place temporary ballast, such as sangbags, on geomembrane that will not damage the geomembrane and to prevent wind uplift.

3. Personnel walking on geomembrane shall not engage in activities or wear shoes that could

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damage it. Smoking is not be permitted on the geomembrane.

4. Do not allow heavy vehicular traffic directly on geomembrane. Rubber tired and tracked ATV's and equipment are acceptable if contact pressure is less than 8 psi.

   a. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.

   b. Prior to driving on any geomembrane layer, please check for sharp edges, embedded rocks, or other foreign objects that may protrude in the tires and tracks.

   c. Path driven on geomembranes shall be as straight as possible with no sharp turns, sudden stops or quick starts.

   d. Areas where driving occurs shall be continuously and thoroughly inspected throughout the deployment process by the contractor and the third party CQA.

6.0 TRIAL WELDS

A. Seaming apparatus shall be allowed to warm up a minimum of 10 minutes before performing trial welds.

B. Each seaming apparatus along with GSE welding technician will pass a trial weld prior to use. Trial welds to be performed in the morning and afternoon, as a minimum, as well as whenever there is a power shutdown.

C. Fusion or wedge welds will always be performed or conducted on samples at least 6.0 ft long. Extrusion welds will be done on samples at least 3.0 ft long.

Note: Always perform trial welds in the same conditions that exist on the job. Run the trial welds on the ground, not the installed liner. Do not use a wind break unless you are using one on the job.

D. Operating temperatures should be monitored while welding. The welding technician should verify that the equipment is capable of maintaining temperature while welding.

E. Sampling Procedure
   1. Cut five 1.0 in wide specimens from the trial weld sample. Specimens will always be cut using a 1.0 in die cutter, so the peel values may be used for qualitative analysis.

   2. When cutting coupons from the trial weld samples, the inside and outside tracks on the coupon should be identified to assist in troubleshooting problems in case the weld fails. The outside track will be defined as the track, which would be peeled if pulling the overlap exposed in a typical installation, or the seam that is closest to the edge of the top sheet. The inside track is the seam closest to the edge of the bottom sheet.

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F. Cutter

1. Only cut one sample at a time to avoid damaging the die cutter.

2. Samples should be free of sand and grit prior to cutting sample.

3. Inspect the die edge weekly for nicks, dents or signs of dullness. Dullness of the cutting edge may damage the units.

4. Remove die when edge has been dulled and lightly reshape it with a medium hand file. When wear is excessive return it for a replacement die.

5. When the cutting board becomes deeply scored and/or interferes with coupon cutting it should be replaced.

6. To adjust the depth of the die cut into the cutting board, after replacing the cutting board or sharpening the die, 0.015 in washer shims can be added or removed between the cutting ram and the ram extension. Only add shims when cutting is difficult due to lack of depth of cut.

G. Trial Weld Testing

1. Allow coupons to cool prior to testing. Avoid separating the coupons while hot as failure of the sheet may be initiated and false readings indicated.

2. In extreme heat the coupons may need to be cooled, using water or an insulated cooler prior to peel testing. Lab conditions specify 70 degrees (plus or minus 4 degrees) Fahrenheit. Coupon temperatures greater than 70 degrees may result in lowered strengths.

3. Visually inspect the coupons for squeeze-out, footprint, pressure and general appearance.

4. Each of the five coupons will be tested in peel on the field tensiometer at a separation rate of 2 in per minute (for HDPE). Shear tests, in addition to the peel tests, will be performed.

H. Pass/Fail Criteria

1. Criteria for passing trial welds will be as follows:
   a. Seam must exhibit film tear bond (FTB). Trial welds should have no incursion into the weld.

   b. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 1 for HDPE smooth or textured sheet (@ 2 in/min).

   c. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 2 for LLDPE smooth or textured sheet (@ 20 in/min).

   d. Both tracks of fusion welded samples must pass for the trial weld to be considered acceptable. If any of the five coupons fail due to seam incursion (no FTB) or low strength values, the trial weld must be performed again.

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e. The GSE QA personnel will give approval to proceed with welding after observing and recording all trial welds.

2. All trial weld data will be logged on the GSE Trial Weld Log (Appendix E).

3. When logging fusion welded peel values on the GSE Trial Weld Log indicate the values. for the outside track first, followed by the inside track.

4. Speed and temperature settings will be recorded for each machine trial weld as appropriate.

7.0 GEOMEMBRANE FIELD SEAMING

A. The seam number takes the identity of the panels on each side. The seam between panels 1 & 2 becomes seam 1/2.

B. Welding technicians will record their initials, machine number, date and time at the start of every seam and on the GSE Seam Log (Appendix F). The technician should also periodically mark temperatures along the seam and at the end of the seam.

C. Approved processes for field seaming and repairing are fusion welding and extrusion welding. All welding equipment shall have accurate temperature monitoring devices installed and working to ensure proper measurement.

D. Fusion welding shall be used for seaming panels together and is not used for patching or detail work. The GSE site manager shall verify that:

1. The equipment used is functioning properly.

2. All work is performed on clean surfaces and done in a professional manner. No seaming will be performed in adverse weather conditions.

E. Extrusion welding shall be used primarily for repairs, patching and special detail fabricating and may be used for seaming. The GSE site manager shall verify that:

1. Equipment used is functioning properly.

2. Welding personnel are purging the extrusion welders of heat degraded extrudate prior to actual use.

3. All work is performed on clean surfaces and done in a professional manner. No seaming will be performed in adverse weather conditions.

F. For seam preparation, the welding technician shall verify that:

1. Prior to seaming, the seaming area is free of moisture, dust, dirt, sand or debris of any nature.

2. The seam is overlapped properly for fusion welding.

3. The seam is overlapped or extended beyond damaged areas at least 4.0 in when extrusion welding.

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4. The seam is properly heat tacked and abraded prior to extrusion welding.

5. Seams are welded with fewest number of unmatched wrinkles or "fishmouths".

G. No seaming will be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

8.0 FIELD DESTRUCTIVE TESTING

A. Destructive seam tests shall be performed to evaluate bonded seam strength. The frequency of sample removal shall be one sample per 500 ft of seam, unless site specifications differ. Location of the destructive samples will be selected and marked by the QA technician or third party QA inspector. Field testing should take place as soon as possible after seam is completed.

B. Samples should be labeled in numerical order, i.e. DS-1, DS-2 etc....This should carry thru any layer and or multiple ponds, do not start numbering from 1 again. The size of samples and distribution should be approximately 12 in x 39 in (Size may vary depending on job requirements) and distributed as follows:

1. 12 in x 12 in piece given to QA technician for field testing.

2. 12 in x 12 in piece sent to the GSE's corporate headquarters for testing, if required.

3. 12 in x 12 in piece given to third party for independent testing or to archive.

NOTE: All samples will be labeled showing test number, seam number, machine number, job number, date welded and welding tech number.

C. The sample given to the QA technician in the field shall have ten coupons cut and be tested with a tensiometer adjusted to a pull rate as shown below. The strength of four out of five specimens should meet or exceed the values below, and the fifth specimen must meet or exceed 80% of the value below.

1. Seam must exhibit film tear bond (FTB). Welds should have ≤ 25% incursion into the weld.

2. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 1 for HDPE smooth or textured sheet (@ 2 in/min).

3. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 2 for LLDPE smooth or textured sheet (@ 20 in/min).

D. All weld destructive test data will be logged on the GSE Destructive Test Log (Appendix G).

E. When logging fusion welded peel values on the GSE Destructive Test Log, indicate the values for the outside track first, followed by the inside track.

F. Test results will be noted in the GSE Destructive Test Log as Pass (P) or Fail (F).

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G. If a test fails, additional samples will be cut, approximately 10 ft on each side of the failed test, and retested. These will be labeled A (After) & B (Before). This procedure will repeat itself until a sample passes. Then the area of failed seam between the two tests that pass will be capped or reconstructed.

9.0 NON-DESTRUCTIVE TESTING

A. GSE shall non-destructively test all seams their full length using an air pressure or vacuum test. The purpose of this test is to check the continuity of the seam.

B. For air pressure testing, the following procedures are applicable to those seams welded with a double seam fusion welder.

1. The equipment used shall consist of an air tank or pump capable of producing a minimum 35 psi and a sharp needle with a pressure gauge attached to insert into the air chamber.

2. Seal both ends of the seam by heating and squeezing them together. Insert the needle with the gauge into the air channel. Pressurize the air channel to 30 psi. Note time test starts and wait a minimum of 5 minutes to check. If pressure after five minutes has dropped less than 2 psi then the test is successful (Thickness of material may cause variance).

3. Cut opposite seam end and listen for pressure release to verify full seam has been tested.

4. If the test fails, follow these procedures.
   a. While channel is under pressure walk the length of the seam listening for a leak.

   b. While channel is under pressure apply a soapy solution to the seam edge and look for bubbles formed by air escaping.

   c. Re-test the seam in smaller increments until the leak is found.

5. Once the leak is found using one of the proceedures above, cut out the area and retest the portions of the seams between the leak areas per 4a to 4b above. Continue this procedure until all sections of the seam pass the pressure test.

6. Repair the leak with a patch and vacuum test.

C. For vacuum testing, the following procedures are applicable to those seams welded with an extrusion welder.

1. The equipment used shall consist of a vacuum pumping device, a vacuum box and a foaming agent in solution.

2. Wet a section with the foaming agent, place vacuum box over wetted area. Evacuate air from the vacuum box to a pressure suitable to affect a seal between the box and geomembrane. Observe the seam through the viewing window for the presence of soap bubbles emitting from the seam.

3. If no bubbles are observed, move box to the next area for testing. If bubbles are observed, mark the area of the leak for repair per section 11.0 and re-test per section 9.0.

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Note: If vacuum testing fusion welded seams, the overlap flap must be cut off to perform the tests

4. All non-destructive tests will be noted in the GSE Non-Destructive Logs (Appendixes H-I).

D. For spark testing GSE Conductive geomembranes, ASTM D 7240 will be the procedure, unless otherwise instructed by the manufacturer.

10.0 DEFECTS & REPAIRS

A. All seams and non-seam areas of the geomembrane lining system shall be examined for defects.

B. Identification of the defect should be made using the following procedures:

1. For any defect in the seam or sheet that is an actual breach (hole) in the liner, installation personnel shall circle the defect and mark with the letter P along side the circle. The letter P indicates a patch is required.

2. For any defect that is not an actual hole, installation personnel shall circle the defect indicating that the repair method may be only an extruded bead and that a patch is not required.

3. Each suspect area that has been identified as repair shall be repaired in accordance with section 11.0 and in the non-destructively testing per section 9.0. After all work is completed, the GSE site manager will conduct a final walk-through to confirm all repairs have been completed and debris removed. Only after this final evaluation by the GSE site manager, the owner, and the agent shall any material be placed over the installed liner.

11.0 REPAIR PROCEDURES

A. Any portion of the geomembrane lining system exhibiting a defect that has been marked for repair may be repaired with any one or combination of the following procedures:

1. Patching - used to repair holes, tears, undispersed raw materials in the sheet.

2. Grind and Reweld - used to repair small sections of extrusion welded seams.

3. Spot Welding - Used to repair small minor, localized flaws.

4. Flap Welding - Used to extrusion weld the flap of a fusion weld in lieu of a full cap.

5. Capping - Used to repair failed seams.

B. The following conditions shall apply to the above methods:

1. Surfaces of the geomembrane which are to be repaired shall be prepared according to this section.

2. All surfaces must be clean and dry at the time of the repair.

3. All seaming equipment used in repairing procedures shall be qualified.

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4. All patches and caps shall extend at least 4 in beyond the edge of the defect, and all patches must have rounded corners.

5. All cut out holes in liner must have rounded corners of 3.0 in minimum radius.

C. Patches should be labeled in numerical order, i.e. RP-1, RP-2, etc... This should carry through any layer and/or multiple ponds, and do not start with the number 1 again.

12.0 AS-BUILT DRAWINGS

As-built drawings are available per these items:

A. As-built drawings will be provided at the completion of the project.

B. AutoCad as-built drawings will be provided in either a printed version or by email in a PDF file.

C. As-built drawings will include geomembrane panels and panel numbers with the last four digits of the roll number.

D. Panel numbers and the full roll numbers will correspond with the GSE Panel Placement Log.

E. All destructive testing and repair locations will be placed on the as-built drawings.

If you require further information, please contact the GSE Installation Department directly.

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Appendix A: Inventory Checklist

GSE Inventory Check List

Project: _____ Site Mgr.: _____ Date: _____

Project #: _____ QA Tech: _____ Page: _____ of _____

Material	Roll #	Used	Material	Roll #	Used	Material	Roll #	Used	Material	Roll #	Used

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Appendix B: Subgrade Surface Acceptance

Subgrade Surface Acceptance

Date: _____

Project: _____ **Site Manager:** _____

Project #: _____

Location: _____ **Partial:** _____ **Final:** _____

This document only applies to the acceptability of surface conditions for installation of geosynthetic products. GSE does not accept responsibility for compaction, elevation or moisture content, nor for the surface maintenance during deployment. Structural integrity of the subgrade and maintenance of these conditions are the responsibility of the owner or earthwork contrator.

_____

_____

_____

_____

_____

For GSE Lining Technology, Inc.:

_____

_____

For Owner / Contractor:

_____

_____

Acceptance Number: _____ Area Accepted: _____ s.f. Total Area Accepted to date: _____ s.f.

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Appendix C: Panel Placement Log

GSE Panel Placement Log

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Panel Number	Roll Number	Deployment Date	Width (Feet)	Length (Feet)	Square Feet	Square Feet (Cumulative)	A/T 1	A/T 2

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Appendix D: HDPE & LLDPE Seam Strength Properties

Table 1. HDPE Seam Strength Properties

Material (Mil)	Shear Strength (PPI)	Fusion Peel (PPI)	Extrusion Peel (PPI)
40	81	65	52
60	121	98	78
80	162	130	104
100	203	162	130

Table 2. LLDPE Seam Strength Properties

Material (Mil)	Shear Strength (PPI)	Fusion Peel (PPI)	Extrusion Peel (PPI)
40	60	50	48
60	90	75	72
80	120	100	96
100	150	125	120

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Appendix E: Trial Weld Log

GSE Trial Weld Log

Project Name: _____ Site Supervisor: _____ Fusion (ppi) Extrusion (ppi)

Location: _____ Type of Material: _____ Min. Peel _____ Min. Peel _____

Job Number: _____ Sheet Thickness: _____ Min. Shear _____ Min. Shear _____

Q.A. Tech.: _____

Trial No.	Date of Trial	Time of Trial	Technicians ID Number	Ambient Temp.	WELDER TYPE	Wedge Mass	Speed Preheat	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Pass Fail

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Appendix F: Seam Log

GSE Seam Log

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Seam Number	Time of Weld	Date of Weld	Type of Weld	Length of Seam	Machine Number	Technician ID Number

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Appendix G: Destructive Test Log

GSE Destructive Test Log

Project Name: _____ Site Supervisor: _____

Location: _____ Type of Material: _____

Job Number: _____ Sheet Thickness: _____

Q.A. Tech.: _____

Fusion (ppi)		Extrusion (ppi)	
Min. Peel	____	Min. Peel	____
Min. Shear	____	Min. Shear	____

Sample Number	Date Welded	Seam Number	Technician ID Number	Machine Type & No.	Location	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Pass/ Fail

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Appendix H: Non-Destructive Log - Vacuum Test

GSE Non-Destructive Log - Vacuum Test

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Repair Number	Weld Date	Machine Number	Tech ID	Location	Test Date	Tech ID	Pass/Fail

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Appendix I: Non-Destructive Log - Air Test

GSE Non-Destructive Log - Air Test

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Seam Number	Test Date	Technician ID Number	Air Pressure Test		Test Result (P or F)	Location
			psi start	psi finish		

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