Project Manual
for

Effluent Storage Pond
2016 Improvements
for
Yellowstone Mountain Club

March 2016

Montana Department of Environmental Quality

These plans and specifications have been reviewed and are in compliance with applicable rules and regulations promulgated and/or administered by the Montana Department of Environmental Quality and are hereby approved. These plans and specifications employ sound engineering design principles. All engineering details and operations performance are the responsibility of the design engineer and the owner.

Authorized Signature 3/16/16 Date

Note: Bid form shall not be removed from this bound copy.

- ☐ Bid Form Signed
- ☐ Addendums Acknowledged
- ☐ 10% Bid Security Enclosed

Prepared by:

Morrison Maierle

engineers · surveyors · planners · scientists

Bozeman, Montana

Name of Bidder_____

Address_____

Telephone No._____

Project No. 3017.133.040.000318 Set No._____

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TABLE OF CONTENTS
YELLOWSTONE MOUNTAIN CLUB
EFFLUENT STORAGE POND – 2016 IMPROVEMENTS

The *Montana Public Works Standard Specifications, Sixth Edition, April 2010, and the Big Sky Sewer District (BSCWSD) #363 Water & Sewer Extensions (June, 2001 or most recent update)* documents shall apply on this project with technical specifications listed below superseding.

SECTION TITLE

TECHNICAL PROVISIONS

GREEN PAPER

DIVISION 1 – GENERAL REQUIREMENTS

SECTION 01300 SUBMITTALS

DIVISION 2 - SITEWORK

SECTION 02110 GEOTEXTILE
SECTION 02120 GEOMEMBRANE
SECTION 02130 GEOCOMPOSITES
SECTION 02220 GENERAL EXCAVATION
SECTION 02222 EXCAVATION AND BACKFILL FOR STRUCTURES
SECTION 02223 ROCK EXCAVATION AND BLASTING
SECTION 02224 STORAGE POND EXCAVATION AND BACKFILL
SECTION 02231 AGGREGATE MATERIALS
SECTION 02723 CONVEYANCE PIPELINES
SECTION 02820 FENCES AND GATES
SECTION 02905 FINISHING GRADING, SEEDING AND LANDSCAPING

DIVIDION 3 – CONCRETE

SECTION 03100 CONCRETE FROMWORK
SECTION 03200 CONCRETE REINFORCEMENT
SECTION 03251 EXPANSION AND CONSTUCTION JOINTS
SECTION 03300 CONCRETE

APPENDIX A

WHITE PAPER

STANDARD DRAWINGS

Montana Department of Transportation Standard Drawing 607-25, Chain Link Fence
Morrison Maierle Standard Drawing 13402, Pressure Switch & Indicator Installation

APPENDIX B

GRI STANDARD SPECIFICATIONS

GT12: Test Methods and Properties fro Nonwoven Geotextiles Used as Protection (or Cushioning) Materials

TABLE OF CONTENTS
YELLOWSTONE MOUNTAIN CLUB
EFFLUENT STORAGE POND – 2016 IMPROVEMENTS

GM 13: Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

GM19: Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

APPENDIX C

Construction Quality Control Manual

Northwest Linings and Geotextiles HDPE/LLDPE Field Quality Control Manual

APPENDIX D

Pump / Pressure Grout Mix Design – Concrete Materials of Montana

END OF TABLE OF CONTENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Submittal procedures.

B. Construction progress schedules.

C. Proposed products list.

D. Shop drawings.

E. Product data.

F. Manufacturers' instructions.

G. Manufacturers' certificates.

1.02 SUBMITTAL PROCEDURES

A. Submittal Register: The Contractor shall submit to the Engineer a register indicating the required submittal data and his proposed submittal dates for all equipment and materials for which a submittal is required.

B. General Procedures:

1. Procedures and requirements for submittals are specified herein. Owner reserves the right to modify the procedures and requirements for submittals, as necessary to accomplish the specific purpose of each submittal. Direct inquiries to Engineer regarding the procedure, purpose, or extent of any submittal.

2. Review, acceptance, or approval of substitutions, schedules, shop drawings, lists of materials, and procedures submitted or requested by Contractor shall not add to the Contract amount, and additional costs which may result therefrom shall be solely the obligation of Contractor.

3. Owner is not precluded, by virtue of review, acceptance, or approval, from obtaining a credit for construction savings resulting from allowed concessions in the work or materials therefore.

4. Owner is not responsible to provide engineering or other services to protect Contractor from additional costs accruing from submittals.

5. Submittals processed by Engineer do not become Contract Documents and are not Change Orders; the purpose of submittal

review is to establish a reporting procedure and is intended for Contractor's convenience in organizing the work and to permit Engineer to monitor Contractor's progress and understanding of the design.

6. Submittals will be acted on by the Engineer as promptly as possible and returned to the Contractor not later than the time allowed for review in Paragraph SPECIFIC SUBMITTAL PROCEDURES. Delays caused by the need for resubmittal shall not constitute basis for claim or for an extension of contract time.

7. After checking and verifying all field measurements, make submittals to Engineer, in accordance with the submittal register for review.

   a. Submittals shall bear a stamp or specific written indication that Contractor has satisfied its responsibilities under the Contract Documents with respect to the review of the submittal.

   b. Data shown shall be complete with respect to quantities, dimensions, specified performance and redesign criteria, materials, and similar data to enable Engineer to review the information.

   c. Submitted data shall be fully sufficient in detail for determination of compliance with the Contract Documents.

8. Before submission of each submittal, determine and verify quantities, dimensions, specified performance criteria, installation requirements, materials, catalog numbers, and similar data with respect thereto; review and coordinate each submittal with other submittals, requirements of the work, and Contract Documents.

9. At the time of each submission, give Engineer specific written notice of each variation that the submittal may have from the requirements of the Contract Documents; in addition, make specific notation on each shop drawing submitted to Engineer for review and approval of each such variation.

10. Engineer's review will be only for conformance with the design concept of the project and for compliance with the information given in the Contract Documents, not extending to means, methods, techniques, sequences, or procedures of construction (except where a specific means, method, technique, sequence, or procedure of construction is indicated in or required by the Contract Documents) nor to safety precautions or programs incident thereto. The review of a separate item as such will not indicate review of the assembly in which the item functions.

11. Engineer's review of submittals shall not relieve Contractor from responsibility for any variation from the requirements of the Contract Documents unless Contractor has in writing called Engineer's attention to each such variation at the time of submission, and Engineer has given written approval of each such variation by a specific written notation thereof incorporated in or accompanying the shop drawing or sample approval; nor will any approval by Engineer relieve Contractor from responsibility for errors or omissions in the shop drawings or from responsibility for having complied with the provisions therein.

12. Where a shop drawing or sample is required by the Specifications, related work performed prior to Engineer's review and approval of the pertinent submission shall be the sole expense and responsibility of Contractor.

13. Should the Contractor propose any item on his shop drawings, or incorporate an item into the work, and that item should subsequently prove to be defective or otherwise unsatisfactory, (regardless of the Engineer's preliminary review), the Contractor shall, at his own expense, replace the item with another item that will perform satisfactorily.

14. Review of first submittal and one resubmittal will be performed by the Engineer at no cost to the Contractor. Subsequent submittals will be reviewed by the Engineer; however, the Engineer will document the work-hours and other expenses required for such review(s) and the Contractor shall reimburse the Owner for the charges of the Engineer with a deduction from the Contractor's monthly pay estimate.

C. SPECIFIC SUBMITTAL PROCEDURES

1. Submittals shall be transmitted with a letter of transmittal or coversheet signed and dated by the Contractor. The Contractor shall submit six (6) copies of the submittals (8.5-inch by 11-inch, 11-inch by 17-inch, or full-size drawings). The Engineer shall retain three (3) copies and return three (3) to the Contractor upon review.

2. The Contractor may submit an electronic submittal plan to the Engineer for their approval.

   a. If authorized, an electronic submittal form will be provided.

   b. For large shop drawing files greater than 5MB, submittals should be made to an FTP site or Dropbox.

c. Review comments and resubmittals are to be provided electronically, after which a minimum of three hard copies of the final and approved shop drawings are submitted for distribution. Distribution would be to the Engineer, RPR, and Owner.

d. Submittals shall be an electronic file in Adobe Acrobat Portable Document File (PDF) format created directly to PDF (preferred) or via scans of the hard copy. Scans must be legible.

e. Electronic files that contain more than 10 pages in PDF format shall contain internal bookmarks linked from an index page to major sections of the document.

f. General submittal information shall be added to each PDF file, including project, subject, submittal number, supplier, and keywords.

g. PDF files shall be set up to print legibly at 8.5-inch by 11-inch, 11-inch by 17-inch, or 22-inch by 34-inch. No other paper sizes will be accepted.

h. New electronic files shall be submitted for each resubmittal, i.e., resubmit entire submittal when individual pages or portions thereof are modified.

3. Combine submittals specified in each Specification section into a single package. Partial packages will not be reviewed until all submittals required for the section have been received. These shop drawings shall be accurate, distinct, and complete, and shall contain all required information, including satisfactory identification of items, units, and assemblies in relation to the Contract Drawings and Specifications.

4. Transmit each submittal with an Engineer accepted form.

5. Sequentially number the transmittal forms. Resubmittals to have original number with an alphabetic suffix.

6. Identify project, Contractor, subcontractor or supplier; pertinent Drawing sheet and detail number(s), and Specification section number, as appropriate.

7. Apply Contractor's stamp, signed or initialed certifying that review, verification of products required, field dimensions, adjacent construction work, and coordination of information is in accordance with the requirements of the work and Contract Documents.

8. Schedule submittals to expedite the project, and deliver to Morrison-Maierle, 2880 Technology Blvd. W., Bozeman, Montana 59718. Coordinate submission of related items.

9. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of the completed work.

10. Provide space for Contractor and Engineer review stamps.

11. Revise and resubmit submittals as required, identify all changes made since previous submittal.

12. Distribute copies of reviewed submittals to concerned parties. Instruct parties to promptly report any inability to comply with provisions.

13. Submittals will be acted upon by Engineer and transmitted to Contractor not later than 20 regular working days after receipt by Engineer. Shop drawings shall be submitted in sufficient time to allow the Engineer not less than 20 regular working days for examining the shop drawings.

1.03 CONSTRUCTION PROGRESS SCHEDULES

A. Submit initial progress schedule in duplicate within 15 days after date of Owner's Notice of Award for the Engineer's review.

B. Submit revised schedules with each Application for Payment, identifying changes since previous version.

C. Submit a chart with separate line for each major section of work or operation, identifying first work day of each week.

D. Show complete sequence of construction by activity, identifying work of separate stages and other logically grouped activities. Indicate the early and late start, early and late finish, float dates, and duration.

E. Indicate estimated percentage of completion for each item of work at each submission.

F. Indicate submittal dates required for shop drawings, product data, samples, and product delivery dates.

1.04 PROPOSED PRODUCTS LIST

A. Within 15 days after date of Owners Notice of Award, submit complete list of major products proposed for use, with name of manufacturer, trade name, and model number of each product.

B. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

C. Should the Contractor elect to substitute a proposed equivalent material to an "or approved equal" specification, the Contractor shall submit to the Engineer adequate documentation allowing the Engineer to determine the equivalency of the material.

1.05 SHOP DRAWINGS

A. General:

1. The Contractor shall submit shop drawings, equipment and materials data as required in the Technical Provisions of these specifications concerning the specific item as soon as practical. The Contractor may proceed, only at his own risk, with manufacture or installation of any equipment or work covered by said drawings, etc. until they are approved, and no claim, by the Contractor, for extension of the contract time will be granted by reason of his failure in this respect.

2. Shop drawings, as defined herein, consist of all drawings, diagrams, illustrations, schedules, and other data which are specifically prepared by or for Contractor to illustrate some portion of the work; and all illustrations, brochures, standard schedules, performance charts, instructions, diagrams, and other information prepared by a manufacturer and submitted by Contractor to illustrate material or equipment for distinct portions of the work.

3. Submittal of incomplete or unchecked shop drawings will not be acceptable. Shop drawing submittals, which do not clearly show Contractor's review stamp or specific written indication of Contractor review, will be returned to Contractor for resubmission.

4. Submittal of shop drawings not required under these Contract Documents and not shown on the Submittal Register will be returned to the Contractor unreviewed and unstamped by the Engineer.

B. Stamp of Approval: All drawings, equipment, materials, and other submitted data shall be carefully reviewed by an authorized representative of the Contractor prior to submission to the Engineer. Each submittal shall be dated, signed, and certified by the Contractor, as being correct and in strict

conformance with the Contract Documents. No consideration for review by the Engineer of any Contractor submittals will be made for any items which have not been so certified by the Contractor. All noncertified submittals will be returned to the Contractor without action taken by the Engineer, and any delays caused thereby shall be the total responsibility of the Contractor.

C. Shop Drawing Contents:

1. Shop drawings referred to herein shall include shop drawings and other submittals for both shop and field-fabricated items. The Contractor shall submit, as applicable, the following for all prefabricated or manufactured structural, mechanical, electrical, plumbing, process systems, and equipment:

a. Shop drawings or equipment drawings, including dimensions, size and location of connections to other work, and weight of equipment.

b. Catalog information and cuts.

c. Installation or placing drawings for equipment, drives, and bases.

d. Supporting calculations for equipment and associated supports specified to be designed by equipment manufacturers or suppliers.

e. Wiring and control diagrams of systems and equipment.

f. Complete manufacturer's specifications, including materials description and paint system.

g. List of special motor features being provided (i.e. space heater, altitude corrections, thermal protectors, etc.).

h. Performance data and pump curves.

i. Complete motor rating for all motors 15 horse-power and larger, including motor no-load, starting, and full-load current at rated voltage; full-load speed and current at 110 percent voltage; motor efficiency and power factor at 1/2, 3/4, and full-load at rated voltage.

j. Suggested spare parts list with current price information.

k. List of special tools required for checking, testing, parts replacement, and maintenance (special tools are those which

have been specially designed or adapted for use on parts of the equipment, and which are not customarily and routinely carried by maintenance mechanics).

l. List of special tools furnished with the equipment.

m. List of materials and supplies required for the equipment prior to, and during startup.

n. List of materials and supplies furnished with the equipment.

o. Samples of finish colors for selection.

p. Special handling instructions.

q. Requirements for storage and protection prior to installation.

r. Requirements for routine maintenance required prior to startup.

s. List of all requested exceptions to the Contract Documents.

D. Interfacing Work: Where called for in the Specifications, and as determined necessary by Engineer to provide proper correlation with other work, complete interface information shall be submitted. This interface information shall be accurate and contain all information necessary to allow for manufacturing and construction of the interfacing or connection work.

1.06 SAMPLES AND TEST SPECIMENS

A. Where required in the Specifications and as determined necessary by Engineer, submit test specimens or samples of materials, appliances, and fittings to be used or offered for use in connection with the work. Include information as to their sources, prepay cartage charges, and submit such quantities and sizes for proper examination and tests to establish the quality or equality thereof, as applicable.

B. Submit samples and test specimens in ample time to enable Engineer to make tests or examinations necessary, without delay to the work.

C. Submit additional samples as required by Engineer to ensure equality with the original approved sample and/or for determination of Specification compliance.

D. Laboratory tests and examinations that Owner elects to make in its own laboratory will be made at Owner’s cost except that if a sample of any material or equipment proposed for use by Contractor fails to meet the Specifications, Contractor shall bear cost of testing subsequent samples.

E. Test required by the specifications to be performed by an independent laboratory shall be made by a laboratory licensed or certified in accordance with state statutes.

F. Samples and laboratory services shall be at the expense of Contractor and included in the prices bid for the associated work.

G. Approved sample items (fixtures, hardware, etc) may be incorporated into the work upon approval and when no longer needed by Engineer for reference.

1.07 QUALITY CONTROL SUBMITTALS

A. Manufacturers' Certification of Proper Installation: Where manufacturer's certification is required in the Specifications, the manufacturer shall provide certification stating the following:

1. The product or system has been installed in accordance with the manufacturers' recommendations.

2. The product or system has been inspected by a manufacturer's authorized representative.

3. Applicable safety equipment has been properly installed.

4. Proper electrical and mechanical connections have been made.

5. The product or system has been serviced with the proper lubricants.

6. Proper adjustments have been made and the product or system is ready for functional testing, startup, and operation.

B. Certification of Compliance:

1. Where specified, furnish certification of compliance for products specified to a recognized standard or code prior to the use of such products in the work.

a. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by a certification of compliance.

b. Certifications shall be signed by the manufacturer of the product; state that the components involved comply in all respects with the requirements of the Specifications.

c. Furnish certification of compliance with each lot delivered to the jobsite and clearly identify the lot so certified.

2. Products used on the basis of a certification of compliance may be sampled and tested at any time. The fact that a product is used on the basis of a certification of compliance shall not relieve Contractor of responsibility for incorporating products in the work which conforms to requirements of the Contract Documents. Products not conforming to such requirements will be subject to rejection whether in-place or not.

3. Engineer reserves the right to refuse permission for use of products on the basis of a lack of a certification of compliance.

C. Functional Test Certification: Where a certification of functional testing is specified for certain facilities or equipment, Contractor (as applicable to the facilities or equipment furnished) shall state in writing that:

1. Necessary hydraulic structures, piping systems, valves, and similar facilities have been successfully tested.

2. Necessary equipment systems and subsystems have been checked for proper installation, started, and successfully tested to indicate they are operational.

3. Adjustments and calibrations have been made.

4. The systems and subsystems are capable of performing their intended functions.

5. The facilities are ready for performance testing, or for startup and intended operation, as applicable.

6. The manufacturer has reviewed and acknowledged this certification. Where several manufacturers have furnished equipment in a system, obtain each manufacturer's review and acknowledgment of its respective equipment as part of a functional test for the overall system.

D. Performance Test Reports: Prepare and submit performance test reports where specified for equipment and systems.

1.08 MANUFACTURER'S INSTRUCTIONS

A. When specified in individual specification Sections, submit manufacturers' printed instructions for delivery, storage, assembly, installation, adjusting, and finishing, in quantities specified for product data.

B. Identify conflicts between manufacturers' instructions and Contract Documents.

1.09 MANUFACTURER'S CERTIFICATES

A. When specified in individual specification Sections, submit manufacturers' certificate to the Engineer for review.

B. Indicate that the material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

C. Certificates may be recent or previous test results on the material or product, but must be acceptable to Engineer.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION 01300

PART 1 GENERAL

1.01 DESCRIPTION: This section includes furnishing and installing geotextiles for Storage Pond #2, including geotextile for underdrain collection sumps under the pond.

1.02 RELATED SECTIONS

Section 02130	Geocomposites
Section 02220	General Excavation
Section 02224	Storage Pond Excavation and Backfill

1.03 OTHER SPECIFICATIONS: Geotextile shall comply with the latest revision of the Geosynthetic Research Institute's GT12 specification, hereinafter referred to as "GRI-GT12." A copy is included in Appendix B.

1.04 SUBMITTALS

A. Submit samples, product specifications and a complete description of geotextile fabrics, sewing method and thread product proposed for use to the Engineer at least 14 days prior to ordering the materials.

B. At least 14 days prior to delivery, provide written instructions for storage, handling, installation and seaming of proposed geotextiles.

C. Manufacturing Quality Control: Submit manufacturer's quality control certificates for manufacturer's testing of geotextile materials. Perform testing in compliance with specified product requirements. Provide certified test results for each lot and each shift production of geotextile with certification. The certificates shall include:

1. Roll numbers and identification;
2. Sampling procedures;
3. Results of individual quality control tests, including a description of the test methods used;
4. Certification that all geotextiles are UV-resistant in accordance with ASTM D 4355.

1.05 DELIVERY, LABELING, STORAGE AND HANDLING

A. For shipping, storage and handling, follow the manufacturer's written instructions and GRI-GT12.

B. Furnish geotextile in relatively impermeable and opaque protective coverings. Immediately restore any damaged protective covering.

C. Label each roll with product identification including manufacturer's name, product identification, lot number, roll number and roll dimensions.

D. Ship geotextiles in an enclosed trailer.

E. Protect geotextile from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Ultraviolet light exposure shall not exceed a total of two weeks, including exposure of installed geotextile prior to sideslope cover placement and exposure of uninstalled rolls.

PART 2 PRODUCTS

2.01 GEOTEXTILE CUSHION

A. Geotextile cushion shall be a non-woven, chemical-resistant, continuous or staple filament, needle-punched polypropylene or needle-punched polyester material meeting the following minimum average roll values:

Property	ASTM Test Method	Min. Requirements:	
		Liner Cushion	Geocell Cushion
Fabric Weight	D-5261	12.0 oz/yd^2	8.0 oz/yd^2
Grab Tensile Strength	D-4632	300 lbs.	205 lbs.
Grab Tensile Elongation	D-4632	50%	50%
Trapezoid Tear Strength	D-4533	115 lbs.	85 lbs.
Puncture (Pin) Strength	D-4833	140 lbs.	120 lbs.
UV Resistance (500 hrs.)	D-4355	70% strength	70% strength

Note : Test frequencies shall be in accordance with ASTM D-4354. Provide certification for compliance with UV testing requirements.

B. Geotextile cushion shall comply with GRI-GT12, where applicable.

2.02 GEOTEXTILE FILTER

A. Geotextile filter shall be a non-woven, chemical-resistant, needle-punched or spun bond polypropylene or polyester material meeting the following minimum average roll values:

Property	Test Method	Min. Requirements
Fabric Weight	ASTM D-5261	10 oz/yd^2
Grab Tensile Strength	ASTM D-4632	135 lbs
Trapezoid Tear Strength	ASTM D-4533	57 lbs
Puncture Resistance	ASMT D-4833	90 lbs

Permittivity	ASMT D-4491	1.4 sec[1]
Apparent Opening Size	ASMT D-4751	> #70 sieve
UV Resistance (500 hrs)	ASTM D-4355	70% strength

Note: Test frequencies shall be in accordance with ASTM D-4354. Provide certification for compliance with UV testing requirements.

B. Geotextile filter shall comply with GRl-GT12.

2.03 SEWING THREAD: Thread for sewing together geotextile panels shall be a polymeric thread with chemical resistance properties equal to or exceeding those of the geotextile.

2.04 CONFORMANCE TESTING

A. Upon delivery to the site, the Engineer will collect samples of geotextile for conformance testing. Sample frequency will be a minimum of one test per 50,000 square feet of geotextile delivered to the site.

B. The Contractor shall cut samples off the rolls selected by the Engineer. Samples shall be 3 feet long by the roll width.

C. The Contractor retains all ownership and responsibility for the geotextile until final acceptance by the Engineer and the Owner. The geotextile will be accepted by the Owner when:

1. The installations and all specified documentation is complete.
2. Verification of the adequacy of all seams and repairs, including all associated conformance testing, is complete.
3. Written certification documents have been received by the Owner.
4. Conformance test results meet project specifications.

PART 3 EXECUTION

3.01 PREPARATION

A. The geotextile installer shall verify in writing to the Engineer that the surface on which the geotextile will be installed is acceptable.

B. Before placing the geotextile, the underlying construction must meet the requirements of Sections 02220 (General Excavation) and 02224 (Storage Pond Excavation and Backfill).

C. Inspect the prepared subgrade. Before the geotextile can be placed, the surface must be free of irregularities, protrusions including any stones exceeding 1/2-inch in size, loose soil and abrupt changes in grade, and shall meet the warranty requirements of the geomembrane manufacturer.

D. Any ruts in the subgrade caused by equipment must be regraded and compacted to meet the requirements of Section 02224 (Storage Pond Excavation and Backfill) prior to geotextile placement.

E To avoid sharp bends in geomembrane at anchor trench or any other trench locations, round leading edge of trench excavations before placing geotextile.

3.02 HANDLING AND PLACEMENT

A. Ensure that geotextiles are not damaged during handling and placement. Comply with all manufacturer's recommendations.

B. Keep the geotextile sheet in sufficient tension to mm1m1ze folds and wrinkles. Remove folds and wrinkles by hand as required.

C. Weigh down geotextile with sand bags or equivalent as ballast during placement, and leave in place until geotextile is covered with specified cover materials indicated on the Drawings.

D. Immediately repair any damaged geotextile fabric as required in paragraph 3.04 below.

3.03 SEAMS AND OVERLAP

A. Geotextile Cushion Seams: Seam geotextile by overlapping 18 inches or by continuously sewing in accordance with the following requirements:

1. For all types of seams, do not seam horizontally on slopes greater than 10H:1V (i.e., seam up and down, not across slopes). Horizontal seaming does not include butt seams made in accordance with the manufacturer's recommendations pertaining to butt seams on steep slopes.
2. Sewed Seams: Overlap geotextile a minimum of 4 inches before sewing. Sew with a 401 2-thread chain stitch or equivalent. Ensure that no soil materials are present within the seams. Seams shall have a minimum strength equal to 75 percent of the geotextile strength as measured in a wide-strip tensile test.
3. Overlapped Seams: Overlap geotextile a minimum of 18 inches.
4. Heat Seams: With prior approval of the Engineer, heat seaming with hot air may be performed, provided that the seaming meets the requirements of this section and the manufacturer's recommendations.

B. Geotextile Filter Seams: Overlap geotextile by a minimum of 18 inches. Ensure that no soil materials are present within the seams.

3.4 REPAIR: Immediately repair any and all holes and tears found in the installed geotextile. Before repairing, remove any soil or other material which may have penetrated the torn geotextile. Perform repairs in accordance with the following:

A. Repair on Slopes > 10 Percent: Sew a patch of the same material, double-seamed into place with seams at least % inch apart and no closer than 4 inches from any edge of the installed geotextile or the patch. Sew as specified in paragraph 3.04(A) above. Should any tear exceed 10 percent of the width of the roll, remove and replace the roll.

B. Repair on Slopes < 10 Percent: Repair holes and tears in geotextile by overlapping a patch of the same material a minimum of 24 inches in all directions and sewing in place.

PART 4 MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02110

PART 1 GENERAL

1.01 DESCRIPTION: This section includes furnishing and installing 60-mil coextruded, double-side textured and non-textured polyethylene geomembrane in Storage Pond #2.

1.02 RELATED SECTIONS

Section 02110	Geotextiles Geocomposites
Section 02130	Storage Pond Excavation and Backfill Aggregate
Section 02224	Materials
Section 02231	

1.03 OTHER SPECIFICATIONS: Geomembrane shall comply with the latest revisions of the Geosynthetic Research institute's standard specifications GM13 (regarding product testing and warranty) and GM17 (regarding seam strength and testing), which are included in appendix B. Hereinafter, these specifications will be referred to as "GRI-GM13" and "GRI-GM17."

1.04 SUBMITTALS

A. Resin Data: Submit the following items to the Engineer at least 14 days prior to receiving materials at the site:

1. Statement of production date or dates.
2. Certification stating that the resin meets the project requirements.
3. Certification stating that all resin is from the same manufacturer.
4. Copies of quality control certificates issued by the manufacturer.
5. Test reports from the manufacturer.

B. Geomembrane Roll Data: Submit the following items to the Engineer at least 14 days prior to receiving materials at the site:

1. Statement of production date or dates.
2. Laboratory test results and certification stating that the geomembrane meets the project requirements.
3. Certification stating that all geomembrane rolls are furnished by one supplier, and that all rolls are manufactured from one resin type obtained from one resin supplier.
4. Copies of quality control certificates issued by the manufacturer.
5. Test reports from the manufacturer.

6. Typical results of complete notched constant tensile load test, performed in accordance with Geosynthetic Research Institute test method GM-5, for specified resin and sheet thickness.
7. Certification stating that no reclaimed polymer is added to the resin.
8. Statement listing percentages of processing aids, anti-oxidants and other additives other than carbon black added to or in the resin.
9. Geomembrane delivery, storage and handling instructions.
10. Sample warranties for review.

C. Extrudate Beads and/or Rods: Submit the following items to the Engineer at least 14 days prior to receiving materials at the site:

1. Statement of production date or dates.
2. Laboratory certification stating that the extrudate meets the project requirements.
3. Certification stating that all extrudate is manufactured by one manufacturer, and that all resin comes from one supplier.
4. Copies of quality control certificates issued by the manufacturer.
5. Test reports from the manufacturer.
6. Certification stating that the extrudate beads or rod resin is the same type, is from the same manufacturer and compatible with the resin used to manufacture the geomembrane supplied for the project.

D. Equipment: Submit installation equipment list including the type of seaming apparatus proposed for use on this project.

E. Schedules and Drawings: Submit the following items to the Engineer at least 14 days prior to beginning geomembrane installation:

1. Installation schedule including planned hours worked per day, per week and per shift. Indicate all weather delay built into the schedule.
2. Installation layout drawings showing the panel layout indicating textured and non-textured panels, both fabricated (if applicable) and field seams, and details not conforming to the Contract Drawings. Upon acceptance, these drawings shall be used for installation of the geomembrane.

F. Qualifications: Submit the following items to the Engineer at least 14 days prior to beginning geomembrane installation:

1. Name of manufacturer, name of installer
2. Resumes of installation supervisor and field engineer to be assigned to the project.

3. Resumes of master seamer and of all installation seamers and other personnel that will perform field seaming operations.

G. Field Quality Control Documents: Submit quality control documentation prepared during installation. Prior to each day's installation, submit daily subgrade acceptance certificates signed by the installation supervisor and applicable to the area to be covered that day. Document actual coverage area and location daily.

H. Documentation of Completion: Submit the following upon completion of the installation:

1. Certificate stating that the geomembrane has been installed in accordance with the Contract Documents.
2. Warranties obtained from the manufacturer/fabricator and the installation warranty.
3. Record drawings showing as-constructed location of panels, seams, repairs, patches and destructive test samples, including measurements.
4. Copies of seam test results and statistical analysis of each seam welder's performance.

1.05 QUALIFICATIONS

A. Manufacturer Qualifications: The following companies are pre-qualified to manufacture and supply geomembrane rolls, fabrications and extrudate beads and rods for the project, provided that they fully meet all the requirements of the Contract Documents:

1. GSE Lining Technology, Inc.
19103 Gundle Road
Houston, TX 77073 Phone: (800) 435-2008

2. Poly-Flex, Inc.
2000 W. Marshall Drive
Grand Prairie, TX 75051 Phone: (888) 765-9359

B. Fabricator/Installer Qualifications: The following companies are pre-qualified to fabricate and install the project's geomembrane materials, provided that they fully meet all the requirements of the Contract Documents:

1. Northwest Linings and Geotextile Products, Inc.
21000 71h Avenue South,
Kent, WA 98032 Phone: (253) 872-0244

2. Colorado Lining International, Inc.
1062 Singing Hills Road
Parker, CO 80138 Phone: (303) 841-2022

C. Substitute or alternate manufacturers/fabricators/installers shall meet the requirements of paragraph 1.06 of Section 01400 (Quality Control).

D. Installer: The installer must have successfully installed a minimum of 10,000,000 square feet of welded polyethylene geomembrane. Include documented references.

E. Master Welder: the master welder must have completed a minimum of 5,000,000 square feet of polyethylene geomembrane seaming work using the type of seaming apparatus proposed for use on this project.

F. Other Seamers: All seamers with the exception of the master welder (Item C above) must have completed a minimum of 1,000,000 square feet of polyethylene geomembrane seaming work using the type of seaming apparatus proposed for use on this project.

1.06 DELIVERY, LABELING, STORAGE AND HANDLING

A. Deliver materials to the site only after the Engineer accepts the required geomembrane submittals.

B. Follow manufacturer's written instructions for shipping, storage and handling.

C. Each roll shall be labeled with product identification including manufacturer's name, product identification, lot number, roll number and roll dimensions.

D. Upon delivery, separate damaged rolls from undamaged rolls and store at locations designated by the Owner until the extent of the damage can be assessed by the Engineer.

E. Store geomembrane rolls at a location approved by the Owner. Store on prepared surface (not on wooden pallets). Stack geomembrane no more than 3 rolls high.

F. Protect geomembrane rolls from puncture, mud, dirt, grease, water, moisture, mechanical abrasions, excessive heat or other damage.

G. Use appropriate handling equipment to load, move and deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading, and spreader and roll bars for deployment.

H. Dragging panels on ground surface will not be permitted.

I. Do not fold geomembrane material; folded material will be rejected.

1.07 WARRANTI ES

A. Provide manufacturer's warranty for geomembrane material in compliance with the requirements of the Contract Documents. Provide a minimum 5-year pro rata warranty for the material against deterioration due to exposure to the elements, either exposed or buried. The warranty for material must cover costs of material removal, replacement and installation, including that of cover materials on the geomembrane.

B. Provide an installation warranty for geomembrane material in compliance with the requirements of the Contract Documents. Provide a minimum 1-year non-pro rata warranty for the installation against any defects.

PART 2 PRODUCTS

2.01 MANUFACTURERS: The companies listed in Part 1.05(A) above are pre-qualified to manufacture and supply the geomembrane materials specified on this project, provided that they fully meet all the requirements of the Contract Documents.

2.02 POLYETHYLENE GEOMEMBRANE RESIN

A. Polyethylene Resin shall be high density polyethylene (HOPE) and very low density polyethylene (VLDPE) resin, new, first quality, compounded, manufactured specifically for producing geomembrane.

B. Specific gravity of the resin without additives shall be from 0.89 to 0.915 for VLDPE and 0.935 to 0.942 for HOPE measured in accordance with ASTM D-792, method A, or with ASTM D 1505.

C. Do not mix resin types during manufacturing. Do not use recycled materials or seconds in manufacturing.

2.03 SMOOTH HOPE GEOMEMBRANE

B. Smooth HOPE geomembrane shall comply with GRI-GM13.Provide finished product free of blemishes, holes, pin holes, bubbles, blisters, excessive gels, undispersed resins and/or carbon black, contamination by foreign matter and nicks or cuts on edges.

C. Additives shall meet the following requirements:

1. Identify percentages of processing aids, anti-oxidants, UV inhibitors such as carbon black, and other additives.
2. Additives other than carbon black or pigment shall not exceed a combined maximum total of 1 percent by weight of finished geomembrane.
3. The total of all additives including UV inhibitors shall not exceed

3.5 percent by weight of finished geomembrane.

4. All additives for UV protection, thermal stability, color or processing agents must not "bloom" to the surface over time or inhibit welding.

2.04 TEXTURED HOPE GEOMEMBRANE

A. Textured HOPE geomembrane shall comply with GRI-GM13.

B. Textured HOPE geomembrane shall be textured on both sides and produced by the same manufacturer as the smooth geomembrane specified above.

C. Provide finished product free of blemishes, holes, pin holes, bubbles, blisters, excessive gels, undispersed resins and/or carbon black, contamination by foreign matter and nicks or cuts on edges.

D. Additives shall meet the same requirements as specified above for smooth geomembrane.

2.05 HOPE SEAM WELDING EQUIPMENT

A. Extrusion Welder: Extrusion welders shall be equipped with gauges showing temperatures in extruder apparatus and at nozzle. Temperature at the nozzle may be measured by external temperature gauges.

B. Hot Wedge Welder: Automated variable-speed vehicular mounted devices equipped with devices adjusting and giving temperatures at wedge. Pressure controlled by spring, pneumatic or other system that allows for variations in sheet thickness. Rigid frame, fixed-position equipment is not acceptable. Equipment must be able to use rubber nip rollers if needed in hot weather.

PART 3 EXECUTION

3.01 PREPARATION

A. The geomembrane installer shall verify in writing to the Engineer that the surface on which the geomembrane will be installed is acceptable.

B. Round edges of anchor trenches and cushion with additional geotextile as necessary. Repair damage to subgrade before deploying geomembrane.

C. Trial Seam Welds: Perform trial seam welds on geomembrane samples to verify the effectiveness of the proposed welding equipment and seaming methods under current field conditions, as follows:

1. No seaming equipment or welder shall be permitted to perform production welds until equipment and welders have successfully completed trial welds.

2. Perform a minimum of two trial welds per day with one prior to the start of work and one at mid-shift, and a minimum of one trial weld per welder per shift. Perform additional test welds when directed by the Engineer.
3. Trial welds shall be continuous welds made from samples at least 2 feet long by 12 inches wide with the seam centered lengthwise.Make trial welds in contact with the subgrade, in the same surroundings and environmental conditions as the production welds.
4. Cut test strips from opposite ends of the trial weld and test properties in accordance with GRI-GM17.
5. A trial weld sample is considered passing when both specimens pass peel and shear tests. If a trial weld fails more than once, do not use welding apparatus and welder until deficiencies or conditions are corrected and two consecutive successful trial welds are completed.

3.02 DEPLOYMENT

A. Give careful consideration to the timing and temperature during deployment. The Contractor should strive to perform deployment, welding and covering within as narrow a temperature range as practical, and avoid these activities during peak hot or cold conditions.

B. During deployment, clearly label each geomembrane panel in the field consistent with the panel identification on the Contractor's submitted panel layout drawing. Overlap panels a minimum of 3 inches for extrusion welding and 4 inches for hot wedge welding.

C. Deploy no more panels in one shift than can be welded or secured in the same day. Do not deploy in the presence of excessive moisture or high winds. Place non-damaging ballast, such as sand bags or tires, on geomembrane to prevent uplift from the wind.

D. Do not wear damaging shoes or engage in activities that could damage the geomembrane.

E. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for repair.

F. Install material to account for shrinkage and contraction while avoiding excessive wrinkles. Remove, replace and repair heavily wrinkled or folded material as specified herein.

G. For exposed geomembrane in pond bottom, provide excess material in every panel such that geomembrane will remain stress-free at minus 60° F.

3.03 SEAM LAYOUT

A. Orient seams parallel to line of maximum slope (i.e., down not across slope). Keep horizontal seams (i.e., those across slope or along the elevation contours) at least 6 feet from the toe or top of slopes.

B. Use seam numbering system consistent with panel numbering system.

C. Shingle panels on all slopes and grades so that upgradient panel is on top.

3.04 GENERAL WELDING PROCEDURES

A. Weld only when ambient temperature as measured 6 inches above the geomembrane is between 40° F (5° C) and 104° F (40° C).

B. Do not weld when moisture from precipitation, dew or other sources is present. Geomembrane must be dry and free of all moisture before welding takes place.

C. Clean surface of any grease, moisture, dust, debris or other foreign material. Protect against moisture buildup between panels.

D. Every 2 hours, log:

1. Temperature directly on the geomembrane surface being welded.
2. Extrusion Welding Equipment: Log extrudate temperatures in barrel and at nozzle.
3. Hot Wedge Welding Equipment: Log operating temperature, any pressure adjustments made, and speed in feet per minute.

E. Extrusion Welding Procedures:

1. When tack-welding adjacent panels together, use procedures that do not damage geomembrane.
2. Purge welding apparatus of heat-degraded extrudate before beginning welding.
3. Bevel top edges of geomembrane a minimum of 45 degrees through the full thickness of geomembrane before welding.
4. Clean seam welding surfaces of oxidation by disc grinder or equivalent not more than 30 minutes before welding. Grind across, not parallel to, welds. Do not remove more than 4 mils of material when grinding. Change grinding discs frequently. Do not use clogged discs.
5. Cover entire width of grind area with extrudate. When re-starting welding, grind ends of all welds that are more than 5 minutes old.

F. Hot Wedge Welding Procedures:

G.

1. Bevel edges of top and bottom panels on cross seams.
2. Extrusion weld a patch over all seam intersections as described in Section 3.06 below.

3.05 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. The manufacturer, fabricator and installer of geomembrane materials shall participate in and conform with all terms and requirements specified in the Contract Documents including this section.

B. Conformance Testing of Geomembrane Materials:

1. Sample at a rate of one per batch or one per 50,000 square feet of material, whichever results in the greatest number of samples.
2. Obtain samples 3 feet long, across the entire width of the roll excluding the first 3 feet of the roll. Mark machine direction on the samples with an arrow.
3. Test samples for conformance with design specifications and guaranteed properties, including density, thickness, tensile strength, carbon black content and dispersion and additional tests at the discretion of the Engineer. Tests procedures shall meet the requirements specified herein.

C. Non-Destructive Field Seam Testing: Test all field seams over their full length using vacuum, air pressure or spark testing equipment, or other approved methods as specified below. Perform testing as the seaming progresses.

1. Air Pressure Testing: For hot wedge weld seams or other seams producing a double seam with an enclosed channel, use air pressure to test the seam. Use an air pump which can generate and sustain a pressure of at least 30 psi and which has a pressure gauge with an accuracy of plus or minus 1 psi. Test as follows:

   a. Seal both ends of the seam to be tested.
   b. Insert needle into air space between welds at one end of seam being tested.
   c. Pump to 30 psi, close valve and monitor pressure drop for 5 minutes.
   d. If pressure loss exceeds 2 psi, locate faulty area and repair in accordance with Section 3.06 below.
   e. Puncture opposite end of seam being tested to release air. If blockage is present, locate blockage and test seam on both sides of blockage.
   f. Seal penetration holes by extrusion welding.

2. Vacuum Testing: For seams that cannot be tested by positive air pressure, use vacuum (negative pressure) to test the seam. Use a vacuum box with a rigid housing, transparent viewing window, soft

neoprene gasket attached to the bottom, port hole or valve assembly. Connect the vacuum box to an air pump which can generate, control and measure a negative pressure of 5 psi to an accuracy of plus or minus 0.5 psi., and test as follows:

a. Apply a soapy solution to the entire weld area.
b. Place the vacuum box over the soapy, ensuring a leak-tight seal can be created.

c. Turn on the vacuum pump to generate a vacuum of 5 psi gauge, and verify adequate seal to sustain pressure.
d. Examine the seal through the viewing window for the presence of soap bubbles for a period of not less than 10 seconds. All areas where soap bubbles appear shall be marked and repaired as specified in Section 3.06 below.

3. Spark Testing: For penetrations or other difficult areas not accessible for air pressure testing or vacuum testing, spark test as follows:

a. Use 24-gauge or larger, uncoated solid copper wire and a low-amperage electric detector, 20,000 to 35,000 volts, with brush-type electrode capable of causing a visible arc up to % inch from the copper wire.
b. Place the copper wire within Y.. inch of the edge of the extrusion seam or clamp seal.
c. Pass the electrode over the seam and observe for spark.
d. If a spark is detected, mark the area and repair as specified in Section 3.06 below.

D. Destructive Field Seam Testing: Collect destructive test samples at a minimum frequency of one test location per 500 feet of seam length, at locations determined by the Engineer. Installer will not be notified in advance as to destructive test sample locations. The Engineer may increase or decrease test frequency based upon analysis of previous test results. Collect samples and test as follows:

1. Cut 12-inch-wide by 44-inch-long sample with the seam centered lengthwise. Immediately repair all holes in the geomembrane resulting from destructive test sample collection, as specified in Section 3.06 below.
2. Distribute the sample by cutting off 12 inches for the installer, 12 inches for storage and 18 inches for the testing laboratory, and two 1-inch strips for field testing (shear and peel tests).
3. Perform shear and peel tests in accordance with paragraph 3.01.C above.

E. Laboratory Testing: Test at least five specimens for shear strength, peel strength and other properties in accordance with GRI-GM17. Four of the five specimens must pass both tests. The fifth specimen must meet or exceed

80 percent of the given values for a passing test or the entire sample set will be considered as failing.

F. Failed Welds: For any destructive test failure, reconstruct the seam between the two adjacent passing test locations. Additional destructive testing may be used to bracket the failed seam to a smaller length, at the sole expense of the Contractor.

G. Acceptable Welded Seams: Acceptable welded seams are bracketed by two locations from which samples have passed field and laboratory destructive testing.

3.6 REPAIR PROCEDURES

A. Removal, repair and replacement shall be performed at the Contractor's expense. Repair procedures, materials and techniques must be approved by the Engineer prior to performing the work.

B. Spot-welding or Seaming: Repair pin holes, tears under 2 inches long or other minor, localized flaws by spot-welding or seaming.

C. Patching: Repair holes over 3/8-inch in diameter, tears over 2 inches long, and undispersed or defective raw materials by patching. Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of the material to be patched and the patches to a radius of at least 3 inches. The minimum patch size shall be 8 inches in diameter.

D. Cut geomembrane out from under large patches before re-seaming.

E. Number and log each patch repair, and test as required.

3.7 ACCEPTANCE

A. The Contractor retains all ownership and responsibility for the geomembrane until acceptance by the Owner.

B. The Owner will accept the geomembrane installation when the installation has been fully completed and the Owner has received and accepted the following documentation:

1. All required documentation from the manufacturer, fabricator and installer.
2. Test reports verifying completion of all field seams and repairs, including associated testing, in accordance with this section.
3. Written documents certifying that the geomembrane was installed and tested in accordance with these specifications.
4. Record (as-constructed) drawings, to include an accurate, detailed panel layout identifying all seam and penetration locations.

3.8 COMPENSATION FOR EXCESSIVE SEAM FAILURES: Excluding one destructive test failure, the Owner will deduct $2,000 from the final payment to the Contractor for each test failure in excess of 2 percent of the total number of destructive weld tests performed.

3.9 FINAL LEAK TESTING

A. The effluent storage pond shall be tested for water tightness after installation of the liner and certification by the Fabricator. Leak testing shall occur when ambient temperatures are high enough to prevent freezing of the pond contents during the testing period.

B. The pond shall be filled to the maximum water surface elevation (8203.00) with water provided by the Owner and from a source and by a method accepted by the Engineer. Continued filling of the pond by the Owner is expected during test. Metered water quantity and pond surface area shall be taken into account for pond level. The water shall be allowed to stand in the basins for no less than two (2) weeks. Water level may be read by surveyed elevations with an accuracy of 0.01 feet. Once a measurement location and benchmark is chosen, all readings must occur at the same locations. Measurements shall occur on days without wind effects.

C. The pond shall be considered watertight if leakage is less than 6-inches per year (0.23 inches in 14 days) in the pond after the effects of evaporation and precipitation plus filling volume by the Owner are considered. In the event of a failed test, the pond shall be drained, patched, and retested before final acceptance. Final acceptance will be in the form of the Engineer certification to MDEQ.

D. Evaporation and Precipitation: Provide a standard evaporation pan as described in the National Weather Service Instruction 10-1302, accessible at http://www.nws.noaa.gov/directives/sym/pd01013002curr.pdf. Refer to the document for measurement procedures and coordinate with the Engineer.

E. Any other proposed method for leak testing must be approved by the Engineer and MDEQ. The Contractor and Owner shall develop and execute a plan for accurately measuring and documenting leakage and submit to the Engineer for approval at least 21 days prior to the start of leak testing.

F. Leak testing does not relieve the Contractor from performing the testing of joints described in this specification.

PART 4 MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02120

PART 1 GENERAL

1.01 DESCRIPTION: This section includes furnishing and installing the geosynthetic-soil composite material for the underdrain collection sumps under the Storage Pond, and the geocell-type cellular confinement system for topsoil placement along the top perimeter of the Storage Pond.

1.02 RELATED SECTIONS

Section 02110	Geotextile
Section 02220	General Excavation
Section 02224	Storage Pond Excavation and Backfill

1.03 SUBMITTALS

A. Submit samples, product specifications and a complete description of geocomposite fabrics, sewing method and thread product proposed for use to the Engineer at least 14 days prior to ordering the materials.

B. At least 14 days prior to delivery, provide written instructions for storage, handling, installation and seaming of proposed geocomposites.

C. Manufacturing Quality Control: Submit manufacturer's quality control certificates for manufacturer's testing of geocomposite materials. Perform testing in compliance with specified product requirements. Provide certified test results for each lot and each shift production of geocomposite with certification. The certificates shall include:

1. Roll numbers and identification;
2. Sampling procedures;
3. Results of individual quality control tests, including a description of the test methods used.

1.04 DELIVERY, LABELING, STORAGE AND HANDLING

A. For shipping, storage and handling, follow the manufacturer's written instructions.

B. Furnish geocomposites in relatively impermeable and opaque protective coverings. Immediately restore any damaged protective covering.

C. Label each roll with product identification including manufacturer's name, product identification, lot number, roll number and roll dimensions.

D. Ship geocomposites in an enclosed trailer.

E. Protect geocomposites from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

PART 2 PRODUCTS

2.01 GEOSYNTHETIC- SOIL COMPOSITE

A. Geosynthetic-Soil Composite Liner (geosynthetic clay liner, or GCL) shall be a non-reinforced geo-synthetic clay liner comprised of natural sodium bentonite encapsulated between two lightweight, non-woven geotextiles

B. GCL shall meet or exceed the following minimum average roll values:

Property	ASTM Test Method	Minimum Requirements
Geotextile:		
Fabric Weight	D-5261	3.0 oz/yd^2
Grab Tensile Strength	D-4632	60 lbs.
Grab Tensile Elongation	D-4632	40% - 75%
Puncture (Pin) Strength	D-4833	30 lbs.
Color	N/A	Black
UV Resistance (500 hrs.)	D-4355	70% strength
Bentonite:		
Swell Index	D-5890	24 ml/2g min.
Fluid Loss	D-5891	18 mL max.
Finished Geocomposite:		
Bentonite Mass [1]	D-5993	0.75 lb/sq. ft.
Grab Tensile Strength [2]	D-4632	100 lbs.
Hydraulic Conductivity [4]	D-5887	5 x 10^{-9} cm/sec max.
Index Flux [4]	D-5887	1 x 10^{-8} m^3/m^2/sec max.
Hydrated Internal Shear Strength [5]	D-5321	50 psf (typical)

NOTES:
1. Bentonite mass/area reported at 0% moisture content.
2. Measured at maximum peak, in the weakest principal direction.
3. Modified to use a 4-inch-wide grip. The maximum peak of five specimens averaged.
4. De-aired tap water at 5 psi maximum effective confining stress and 2 psi head.
5. Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf normal stress.

C. Acceptable Product: Claymax 200R as supplied by Northwest Linings and

Geotextile Products, Inc., or Engineer-approved equal

D. Installer Qualifications: The GCL Installer must either have installed at least 1 million square feet of GCL, **or** must provide to the Engineer satisfactory evidence, through similar experience in the installation of other types of geosynthetics, that the GCL will be installed in a competent, professional manner.

E. Accessory Bentonite: The granular bentonite sealing clay used for overlap seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer. Seaming shall be conducted in accordance with the manufacturer's guidelines.

2.02 GEOTEXTILE-GEONET COMPOSITE

A. Geotextile-Geonet Composite shall be a three-dimensional, high-density polypropylene (HOPE) geonet sandwiched between two geotextile layers thermally bonded to the geonet. The HOPE geonet shall consist of parallel, extruded HOPE strands thermally bonded into a diamond-shaped material, designed to transmit large volumes of liquid.

B. The Geotextile-Geonet Composite shall meet or exceed the following minimum average roll values:

Property	Test Method	Minimum Requirements
Geotextile:		
Fabric Weight	ASTM D-5261	6.0 oz/yd^2
Grab Tensile Strength	ASTM D-4632	160 lbs.
Puncture (Pin) Strength	ASTM D-4833	90 lbs.
Mullen Burst	ASTM D-3786	350 psi
Geonet:		
Thickness	ASTM D-5199	200 mil
Mass	ASTM D-5261	0.162 lb/ff
Density	ASTM D-1505	0.940 g ee
Tensile Strength	ASTM D-1682 or D-5035	45 lb/in
Carbon Black Content	ASTM D-1603	2%
Maximum Opening Size		5/8" (long axis)
Transmissivity [1]	ASTM D-4716	4.8 gal/min/ft
Finished Geocomposite:		
Transmissivity [1]	ASTM D-4716	0.48 gal/min/ft
Peel Adhesion [2]	ASTM D-413 or F-904	1 lb/in

NOTES:
1. Transmissivity tested between metal plates, hydraulic gradient (i) = 1.0, normal pressure = 15,000 lb/ft^2
2. Peak load on 2" wide specimen.

C. Acceptable Product: Tendrain Geocomposite as supplied by Colorado Lining International, or Engineer-approved equal.

2.03 SEWING THREAD: Thread for sewing together geocomposite panels shall be a polymeric thread with chemical resistance properties equal to or exceeding those of the geotextile fabric.

2.04 CONFORMANCE TESTING

A. Upon delivery to the site, the Engineer shall collect samples of geocomposites for conformance testing. Sample frequency will be a minimum of one test per 100,000 square feet of geocomposite delivered to the site.

B. The Contractor shall cut samples off the rolls selected by the Engineer. Samples shall be 3 feet long by the roll width.

2.05 GEOCELLS

A. Geocells shall be lightweight, flexible, expandable, high-density polyethylene (HDPE) mats meeting the following minimum requirements:

Property	Value	Test Method
Expanded Dimensions	8' x 20' x 8" deep	
Cell Area	70 sq. in. (nominal)	
Color	Black	
Tensile Peel Strength (seams)	640 lbs.	(see note)
Polyethylene Thickness	50 mils, ± 5%	ASTM D5199
Carbon Black Content	2% - 3%	ASTM D1603
Density	0.94 g/cm^3	ASTM D1505
Environmental Stress Crack Resistance	4,000 hrs.	ASTM D1693

NOTE: Peel strength per US Army Corps of Engineers Technical Report GL 86 19, Appendix A

B. Seam Hang Strength: A 4 inch wide weld joint shall support a load of 160 lbs. for a minimum of 30 days while undergoing temperature change from 74˚F to 130˚F on a 1 hour cycle.

C. Connections: Geocells shall be physically connected along adjacent edges using hog rings or staples as recommended by the geocell manufacturer.

D. Anchoring System: Geocells shall be anchored to the top of the slope using high strength tendons running through holes drilled in the geocells, with a minimum of four tendons evenly spaced across the 8 foot wide geocell. The tendons shall be secured at the lower end using a continuous batten strip, and at the top end with a continuous dead man anchor as shown on the Drawings

and as recommended by the geocell manufacturer. The top end anchor shall be compacted in the bottom of the geomembrane anchor trench, or in a separate trench at the same depth.

E. Acceptable Product: Terracell 140, as manufactured by Webtec, Inc., or Engineer approved equal.

PART 3 EXECUTION

3.01 PREPARATION

A. The geocomposite installer shall verify in writing to the Engineer that the surface on which the geocomposite will be installed is acceptable.

B. Before placing the geocomposites , the underlying construction must meet the requirements of Sections 02220 (General Excavation) and 02224 (Storage Pond Excavation and Backfill).

C. Before the Geosynthetic-Soil Composite can be placed, the surface must be free of irregularities, protrusions including any stones exceeding 1-inch in size, loose soil, and abrupt changes in grade.

D. Before the Geotextile-Geonet Composite can be placed, the surface shall meet the warranty requirements of the geomembrane manufacturer.

3.02 HANDLING AND PLACEMENT

A. Ensure that geocomposites are not damaged during handling and placement. Comply with all manufacturer's recommendations.

B. Keep the geocomposite sheet in sufficient tension to minimize folds and wrinkles. Remove folds and wrinkles by hand as required.

C. Weigh down geocomposite with sand bags or equivalent as ballast during placement, and leave in place until geocomposite is covered with specified cover materials indicated on the Drawings.

D. Immediately repair any damaged geocomposite as required in paragraph 3.04 below.

3.03 STORAGE AND PLACEMENT OF GEOSNTHETIC SOIL COMPOSITE (GCL)

A. Unloading: Unloading, on-site handling and storage of the GCL are the responsibility of the Contractor. The party responsible for unloading the GCL should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment

B. Storage: Rolls should be stacked no higher than four rolls, in a level, dry and well drained area. All stored GCL materials and the accessory bentonite shall be covered with a plastic sheet or tarpaulin. The integrity and legibility of the labels shall be preserved during storage.

C. Installation: Install GCL as recommended by the manufacturer and in accordance with the manufacturer's guidelines, and as follows:

1. The specified GCL is intended for placement on slopes less than 10 percent and has limited durability. Minimize dragging and shifting of unrolled GCL. GCL should be maneuvered into place and unrolled at its intended location, with minor shifting into final position. A temporary geosynthetic subgrade covering commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement.

2. Panels shall be unrolled parallel to the slope direction and shingled down the slope with the upgradient panel placed over the downgradient panel. Side overlap (machine direction) shall be a minimum of 6 inches, and end overlap shall be a minimum of 24 inches.

3. All GCL panels shall lie flat on the underlying surface, with no wrinkles or folds.

4. Installation equipment shall not travel directly on the GCL. If rutting or other damage occurs in the subgrade during installation, the subgrade must be restored to its originally accepted condition before placement continues.

5. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material. The GCL supplier shall be consulted for specific guidance if premature hydration occurs.

6. Toe Drain Collection Trench and Underdrain Collection Sump: The GCL along the south edge of the pond bottom shall be placed in a toe drain collection trench and underdrain collection sump as specified and as shown on the Drawings. Edges of the trench and sump areas shall be rounded so as to eliminate any sharp corners, and loose soil shall be removed. The GCL shall extend above the elevation of the GCL adjacent to the trench and sump the specified minimum vertical distance. Apply a continuous bead of granular sodium bentonite to all seams within the trench and sump, at a rate of ½ lb. per square foot of seam area.

D. Seams: Construct GCL seams by overlapping their adjacent edges. Ensure that the overlap zone is not contaminated with loose soil or other debris. Use supplemental bentonite on seams in accordance with the GCL manufacturer's recommendations

E. Pipe Penetrations: Cut a cross in GCL just large enough to accommodate the pipe's outside diameter. Pack supplemental bentonite into the voids behind the GCL and clamp the GCL to the pipe, as recommended by the GCL manufacturer.

F. Placement of Cover Materials: Use low ground pressure construction

equipment to minimize stresses on the GCL. Maintain a minimum thickness of 12 inches of cover between the equipment tires/tracks and the GCL at all times during the covering process. Maintain a minimum thickness of 24 inches of cover on frequently trafficked areas or roadways.

3.04 REPAIR: Immediately repair any and all holes and tears found in the installed geocomposite. Before repairing, remove any soil or other material which may have penetrated the torn geocomposite. Perform repairs in accordance with the following:

A. Repair on Slopes > 10 Percent: Sew a patch of the same material, double-seamed into place with seams at least % inch apart and no closer than 4 inches from any edge of the installed geotextile or the patch. Sew as specified in paragraph 3.04(A) above. Should any tear exceed 10 percent of the width of the roll, remove and replace the roll.

B. Repair on Slopes < 10 Percent: Repair holes and tears in geocomposites by overlapping a patch of the same material a minimum of 24 inches in all directions and sewing in place.

3.05 GEOCELLS

A. Before placing the geocells, install a non-woven cushion geotextile as shown on the Drawings.

B. Install geocells as shown on the Drawings and as recommended by the manufacturer.

C. Orientation and Connections: Each geocell panel shall be oriented lengthwise down the slope in a continuous 20-foot panel length. Panels shall be connected edge-to-edge at each cell to form a continuous, flexible mat, using hog rings or staples as recommended by the geocell manufacturer.

D. Anchoring System: Install a minimum of four tendons evenly spaced across each 8-foot-wide geocell panel. Tendons shall be run down the slope through holes drilled through the center of the 8-inch deep geocells. The tendons shall be secured at the lower end using large washers or batten strips and at the top end with a continuous dead man anchor, as shown on the Drawings and as recommended by the geocell manufacturer. Compact the dead man anchor trench as specified for the pond liner anchor trench.

E. Filling: No earthmoving equipment shall be driven on the geocells. Fill geocells with topsoil starting at the downslope edge, using a slip sheet and hand work to evenly fill the geocells and minimize spillage below the geocells. As work progresses up the slope, a backhoe may be used as long as it is not driven beyond the “top of pond slope” as identified on the Drawings. Overfill to about 1-2 inches above the top of the geocells, to allow for reduction in volume as the topsoil consolidates and is compacted. Lightly compact the topsoil by tamping, and seed over the topsoil.

PART 4 MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02130

PART 1: GENERAL

1.01 DESCRIPTION

A. General: This section covers excavation, haul and disposal of excess material, subgrade preparation, and compaction to finished subgrade for construction of Storage Pond #2, roads, retaining walls and other non-structural items. Additional specifications specific to Storage Pond #2 are included in Section 02224 (Storage Pond Excavation and Backfill).

B. Structures: Excavation and backfill for tanks, pump stations, booster stations and other structures is not included in this section; refer to Section 02222 (Excavation and Backfill for Structures).

C. Pipelines: Refer to Section 02221 (Trench Excavation and Backfill for Pipelines and Appurtenant Structures) of the Standard Specifications for excavation and backfill specifications for utility pipelines. In addition, the following requirements apply:

1. Detectable warning tape and locate wires are required as shown on the Drawings.
2. Typical trench sections are as shown on the Drawings.

1.02 RELATED SECTIONS:

Section 02101	Clearing and Grubbing
Section 02222	Excavation and Backfill for Structures
Section 02223	Rock Excavation and Blasting
Section 02224	Storage Pond Excavation and Backfill

1.03 OTHER SPECIFICATIONS: General Excavation is also subject to the requirements of Section 02230 (Street Excavation, Backfill and Compaction) of the Standard Specifications.

1.04 DENSITY CONTROL AND MATERIALS TESTING

A. In-place field density tests and laboratory testing of borrow materials shall be tested for quality assurance by the Engineer in accordance with the Standard Specifications.

B. During the course of the work, testing will be required to identify materials, to determine compaction characteristics, to determine moisture content, and to determine in-place fill densities. These tests shall be performed by the Contractor and will be used to verify that the fills conform to these specifications.

C. Quality Assurance: Under-compacted soil placed by the Contractor shall, at the expense of the Contractor, be corrected by additional compaction effort or excavation, replacement, and re-compaction. Any costs incurred by the Owner or the Engineer as a result of the under-compaction and replacement of under-compacted materials, such as additional professional engineering services, materials testing or construction inspection services, shall be the responsibility of the Contractor.

1.05 MATERIALS SUBMITTALS: Submit to the Engineer results of gradation tests for backfill materials. Submit to the Engineer samples of soils and/or aggregates for laboratory moisture-density relationship testing by the Engineer.

PART 2: PRODUCTS

2.01 GENERAL EARTHFILL

A. All general earthfill materials shall be approved for suitability by the Engineer prior to placement. Regardless of source, General Earthfill shall be free of detrimental quantities of organic material, such as vegetation, roots or peat, and shall be free of roots, organic matter, trash, debris, frozen material, wood, rocks larger than 6 inches in average dimension and other unsuitable materials. Root mats or other organic layers greater than 4 inches thick and woody debris greater than 2 inches in diameter shall be removed and disposed of. General earthfill, regardless of source, shall meet the following gradation requirements:

Sieve Opening	% Passing (by weight)
6 Inch	100
3 Inch	70-85
No. 4	25-60
No. 200	12 (Max.)

B. SOURCES

1. Undisturbed Native Material: Undisturbed native material is located outside the limits of the cut and fill slopes of existing on-site roads.
2. Existing Road Bed Material: Existing road bed material is located within the limits of the cut and fill slopes of existing on-site roads. Many of the existing roads were originally constructed as logging roads and may contain significant amounts of roots, woody debris or other unsuitable materials. Existing road bed material that is excavated may be used as embankment fill, provided that organic matter or other objectionable materials observed within the fill are

separated from the remaining fill to the extent practicable, removed and disposed of as directed by the Engineer and as specified herein.

3. Imported Backfill: If additional General Earthfill is required, obtain Imported Backfill from borrow areas to be determined by the Owner and the Engineer.

2.02 COMPACTION EQUIPMENT

A. Hand compaction equipment shall be required within 5 feet of culverts, utilities or other structures. Hand-operated equipment shall be capable of achieving the specified densities.

B. Compaction equipment shall be of suitable type and adequate to obtain the densities specified, and shall provide satisfactory breakdown of materials to form a dense fill.

C. Compaction equipment shall be operated in strict accordance with the manufacturer's instructions and recommendations. Equipment shall be maintained in such condition that it will deliver the manufacturer's rated compactive effort. If inadequate densities are obtained, larger and/or different types of additional equipment shall be provided by the Contractor.

2.03 MOISTURE CONTROL EQUIPMENT: Equipment for applying water shall be of a type and quality adequate for the work, shall not leak, and shall be equipped with a distributor bar or other approved device to assure uniform application. Equipment for mixing and drying out material shall consist of blades, discs, or other approved equipment.

PART 3: EXECUTION

3.01 PREPARATION

A. Construction Staking: The Engineer will provide construction staking as specified in Section 01050 (Field Engineering).

B. Clearing and Grubbing: Perform clearing and grubbing, to include topsoil salvage, as specified in Section 02101 (Clearing and Grubbing).

3.02 EXCAVATION

A. Excavation shall be performed to the lines, grades, and elevations as specified herein and as shown on the Drawings. The Engineer reserves the right to make minor adjustments or revisions in lines or grades.

B. All excavation, including but not limited to excavation of gravel, frost, hard soils, boulders, hard soils and solid rock, shall be performed by the Contractor without extra compensation. Where solid rock is encountered, the Contractor shall perform the work as specified in Section 02223 (Rock Excavation and Blasting).

C. The method of excavation used is optional; however, no equipment shall be operated within 5 feet of existing utilities, structures or newly completed construction, or within 3 feet vertically of existing buried utilities. Excavation that cannot be accomplished without endangering present or new structures shall be done with hand tools.

D. Excavation made outside the specified grade limits is not measured for payment. Restore over-excavated areas as directed by the Engineer. Correct subgrade disturbance by removing the disturbed soil and replacing and compacting to reach at least 95% of the maximum laboratory dry density determined by AASHTO T99 or ASTM D698. Correct subgrade disturbance before placing overlying fill materials. Disturbed soils may be replaced with imported material approved by the Engineer and compacted to 95% of maximum laboratory dry density determined by AASHTO T99 or ASTM D698.

E. Maintain the subgrade to drain at all times. Construct side ditches or gutters from cuts to embankments to prevent erosion damage to embankments. Construct and maintain temporary drainage facilities until permanent drainage facilities are completed.

F. All material encountered of whatever nature shall be removed and used in embankment or disposed of as specified in this section. The presence of rock or frozen material shall not constitute a claim by the Contractor for performance of extra work.

G. Storage Pond Excavation: Excavation of the storage pond shall be staged to provide use of the underdrain outlet pipe as soon as practicable, and to minimize infiltration of surface runoff. Refer to Section 02224 (Storage Pond Excavation and Backfill) for additional requirements.

H. Explosives: Upon prior approval and coordination with the Owner and the Engineer, controlled blasting shall be permitted for the excavation of less-fractured or more intact zones of rock. The blasting shall be performed in accordance with section 02223 (Rock Excavation and Blasting).

3.03 SUBEXCAVATION/REPLACEMENT BELOW SUBGRADE

A. Subexcavation consists of removing and disposing of unsuitable material from below planned subgrade elevation in cut sections or from below the natural groundline in embankment sections. All subexcavation must be authorized by the Engineer.

B. Assure the Engineer has measured the area where unstable materials have been removed before backfilling. Do not backfill any area where unstable foundation soils have been excavated until the Engineer has surveyed or measured the subexcavation and authorized the backfill placement. Backfill placed without approval may be ordered removed and replaced at the Contractor's expense.

C. Unauthorized Subexcavation: Unauthorized subexcavation shall be corrected at the sole expense of the Contractor. Unauthorized subexcavation made by the Contractor beyond the specified line and grade shall be corrected by placing fill material and compacting to 95 percent of maximum density at optimum moisture as determined by ASTM D698, in accordance with the Standard Specifications. Additional costs incurred by the Owner or the Engineer as a result of the unauthorized subexcavation, such as additional materials, professional engineering or construction inspection services, shall be fully reimbursed by the Contractor.

D. Excavation of earth beyond the specified lines and grades shall be corrected by filling the resulting voids with approved compacted earth fill, except that if the earth is to become the subgrade for riprap, rock fill, sand or gravel bedding or drainfill, the voids may be filled with material conforming to the specifications for the riprap, rock fill, bedding or drainfill.

3.04 DISPOSAL OF EXCESS EXCAVATED MATERIAL

A. Dispose of debris and unused, excess excavated materials to Owner and Engineer approved sites, in accordance with all applicable state and local regulations.

B. Provide seeding, compaction and other erosion protection of disposal site as directed by the Engineer and in accordance with all applicable permits and regulations.

C. Disposal of Excess Material from Storage Pond Excavation: Refer to Section 02224 (Storage Pond Excavation and Backfill).

3.05 FINISHED SUBGRADE COMPACTION AND FINAL PREPARATION

A. General: Once excavation is complete, the finished subgrade, including subexcavations and all remaining portions of existing road surfaces, shall be compacted to not less than 95 percent of maximum ASTM D698 dry density. Maintain material at optimum moisture content, plus or minus 2 percentage points. After subgrade compaction and prior to placing fill, scarify the compacted surfaces. Do not begin fill placement until the subgrade construction and compaction have been approved by the Engineer. Do not place fill over frozen subgrade.

B. Storage Pond: Prepare finished pond subgrade as specified in Section 02224 (Storage Pond Excavation and Backfill).

3.06 EMBANKMENT PLACEMENT AND COMPACTION:

A. Embankment fill shall be placed to the grades and elevations shown on the Drawings.

B. Storage Pond: Place fill as specified in Section 02224 (Storage Pond Excavation and Backfill).

C. Road Embankments: Place and compact in uniform lifts not exceeding 8 inches in loose thickness as specified in the Standard Specifications, Section 02230 (Street Excavation, Backfill and Compaction).

3.07 TOLERANCES

A. Storage Pond(s): All materials shall be placed to a grade tolerance of plus or minus 1/2" except where dimensions or grades are shown or specified as a maximum or minimum. All grading shall be performed to maintain slopes and drainage as shown. Final subgrade must be approved by the Engineer and the Geomembrane installer before the work is considered complete. The Contractor shall maintain the excavation in a smooth state with no sharp edges or sudden changes.

B. Finished Subgrade of Roadways: In placing the final lift of embankment fill, assure the finished surface does not deviate not more than 0.4 foot (3 cm) at any point from the staked elevation; and that the sum of the deviations from true grade of any two points less than 30 feet (9 m) apart does not exceed 0.4 foot (3 cm). Do not place any surface course until the subgrade has been checked and approved by the Engineer.

3.08 FINAL PREPARATION

A. Final Compaction: Compact the final lift in accordance with Section 02230 (Street Excavation, Backfill, and Compaction) of the Standard Specifications. Proof roll the subgrade surface for observation by the Engineer. Compact all soft, yielding or otherwise unstable areas to provide adequate support of construction equipment as determined by the Engineer.

B. Side Slope Finishing: Prior to placing additional fill materials over finished embankment slopes, finish the slopes as follows:

a. Round top edges of fill slopes.
b. Spread stockpiled topsoil evenly over the side slopes.
c. "Track-walk" side slopes and prepare for seeding.

3.09 DUST CONTROL: Furnish dust control meeting the requirements of Section 01500 (Construction Facilities and Temporary Controls).

PART 4: MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02220

PART 1: GENERAL

1.01 DESCRIPTION: This section covers excavation, foundation preparations, and backfill for tanks, pump stations, booster stations and other structures included in this project.

1.02 RELATED SECTIONS

Section 01560	Environmental Quality Control
Section 02101	Clearing and Grubbing
Section 02905	Finish Grading, Seeding, and Landscaping

1.03 CLASSIFICATION OF EXCAVATED MATERIAL: Unclassified Excavation: Materials encountered during the construction of the work regardless of their nature or the manner in which they are removed, will be considered unclassified excavation.

1.04 DEFINITIONS

A. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either the as-compacted field dry density or the maximum dry density, as determined by the Engineer.

B. Optimum Moisture Content: Determined by the ASTM standard specified to determine the maximum dry density for relative compaction. Field moisture content shall be determined on the basis of the fraction passing the 3/4 inch sieve.

C. Relative Density: As defined by ASTM D4253 and D4254.

D. Prepared Ground Surface: The ground surface after clearing, grubbing, stripping, excavation, and scarification and/or compaction.

E. Completed Course: A course or layer that is ready for the next layer or next phase of work.

F. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.

Well-graded is used to define a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

G. Influence Area: The area within planes sloped downward and outward at an angle of 60 degrees from the horizontal from (a) 1 foot outside the outermost edge at the base of foundations or slabs; or (b) 1 foot outside the outermost edge at the surface of roadways or shoulder; or (c) 0.5 foot outside the exterior edge at the spring line of pipes and culverts.

H. Borrow: Material imported from borrow areas off the immediate project site.

I. Backfill Material: Imported material described in Part 2 below.

J. Imported Material: Material obtained by the Contractor from sources off the immediate project site.

K. Structural Fill: Fill material as required under structures, paving, etc.

L. Embankment: The fill material required to raise the existing grade in areas other than under structures.

M. Unsuitable Materials: Unsuitable materials shall consist of debris, rubble, trash, organics, and other deleterious materials as determined by the Engineer. Unsuitable materials shall include previously placed, non-engineered fills that were not placed in 6-inch thick lifts and not compacted to the densities specified herein.

1.05 SUBMITTALS

A. Submittals shall be made in accordance with the General Conditions, Section 01300, SUBMITTALS in Division 1, GENERAL REQUIREMENTS, and the requirements of this section.

B. The Contractor shall submit plans indicating dewatering (if needed) and shoring or excavation sloping systems. The submittals shall include information on scheduling and sequencing of construction and protection of existing structures and utilities. Design shall address the sequence of excavation and placement of lateral support elements. Drawings shall show the locations of all system elements in plan and section.

C. Review by the Engineer of submittals by the Contractor shall not in any way be considered to relieve the Contractor from full responsibility for errors

therein or form the entire responsibility for complete and adequate design and performance of dewatering and shoring or excavation sloping systems. The Contractor shall be solely responsible for proper design, installation, operation, and maintenance, and any failure of any component of the dewatering and shoring or excavation sloping systems.

1.06 IMPORTED MATERIAL ACCEPTANCE

A. All imported materials specified in this section are subject to the following requirements:

1. All tests necessary for the Contractor to locate an acceptable source of imported material shall be made by the Contractor. Certification that the material conforms to the Specification requirements along with copies of the test results from a qualified commercial testing laboratory shall be submitted to the Engineer for approval at least 10 days before the material is required for use. All material samples shall be furnished by the Contractor at the Contractor's sole expense. Samples shall be representative and be clearly marked to show the source or the material and the intended use on the project. Sampling of the material source shall be done by the Contractor in accordance with ASTM D75. Notify the Engineer at least 24 hours prior to sampling. The Engineer may, at the Engineer's option, observe sampling procedures. Tentative acceptance of the material source shall be based on an inspection of the source by the Engineer and/or the certified test results submitted by the Contractor to the Engineer and/or the certified test results submitted by the Contractor to the Engineer, at the Engineer's discretion. No imported materials shall be delivered to the site until the proposed source and materials tests have been tentatively acceptance in writing by the Engineer. Final acceptance will be based on tests made on samples of material taken from the completed and compacted course. All testing for final acceptance shall be performed by the Contractor.

2. Gradation tests by the Contractor shall be made on samples taken at the place of production prior to shipment. Samples of the finished product for gradation testing shall be taken from each 500 tons of prepared materials or more often as determined by the Engineer, if variation in gradation is occurring, or if the material appears to depart from the Specifications. Test results shall be forwarded to the Engineer within 48 hours after sampling.

3. If tests conducted by the Contractor or the Engineer indicate that the

material does not meet Specification requirements, material placement will be terminated until corrective measures are taken. Material that does not conform to the Specification requirements and is placed in the work shall be removed and replaced at the Contractor's sole expense. Sampling and testing performed by the Contractor shall be done at the Contractor's sole expense.

1.07 SHORING, SHEETING, BRACING, AND SLOPING: Install and maintain shoring, sheeting, bracing, and sloping necessary to support the side of the excavation, to keep and to prevent any movement which may damage adjacent pavements, utilities, or structures, damage or delay the work, or endanger life and health. Install and maintain shoring, sheeting, bracing, and sloping as required by OSHA and other applicable governmental regulations and agencies.

1.08 EXCAVATION SAFETY: The Contractor is solely responsible for making all excavations in a safe manner. Provide appropriate measures to retain excavation sideslopes and prevent rock falls to ensure that persons working in or near the excavation are protected. Any necessary trench excavation permits shall be the responsibility of the Contractor.

1.09 CODES, ORDINANCES, AND STATUTES: Contractors shall familiarize themselves with, and comply with, all applicable codes, ordinances statutes, and bear sole responsibility for the penalties imposed for non-compliance.

1.10 TOLERANCES: All materials shall be constructed within a tolerance of 0.1 foot except where dimensions or grades are shown or specified as a minimum. All grading shall be performed to maintain slopes and drainage as shown. No reverse slopes will be permitted.

1.11 QUALITY ASSURANCE

A. The Contractor shall perform earthwork operations in compliance with these specifications and within the applicable requirements of governing authorities having jurisdiction.

B. Over-excavation made by the Contractor in the earth or rock beyond the specified line and grade shall be corrected, at the expense of the Contractor, by filling with structural fill and compacting to 98 percent of maximum density at optimum moisture as determined by ASTM D698. Any other costs incurred by the Owner, or the Engineer as a result of the over-excavation, such as professional engineering or construction inspection services or additional materials, shall be the responsibility of the Contractor. If the over-excavation is directed by the Engineer, the excavation will be paid at a price

negotiated with the Contractor through a change order to the lines and grades specified by the Engineer.

C. Under-compacted soil placed by the Contractor shall, at the expense of the Contractor, be corrected by additional compaction effort or excavation, replacement, and compaction. Any costs incurred by the Owner or the Engineer as a result of the under-compaction, such as additional professional engineering services, materials testing or construction inspection services, shall be the responsibility of the Contractor.

D. Field density testing will be the responsibility of the Owner, as specified in Sections 01400 (Contractor Quality Control and Owner Quality Assurance).

E. Bracing And Shoring: Safe temporary cut slopes are the responsibility of the Contractor who shall meet all appropriate OSHA regulations including, but not limited to: "Constructions Standards for Excavations" (29 CFR Part 1926.650-.652) Subpart P, effective on the date of the bid opening.

PART 2: PRODUCTS

2.01 EQUIPMENT: The Contractor may use any type of earthmoving and compacting equipment he may choose; except only hand compaction equipment will be utilized within 5 feet of structure walls and provided the equipment is in satisfactory condition and of such capacity as to fulfill the requirements of this section.

2.02 SUITABILITY: All material to be used in backfill or embankment shall be approved for suitability by the Engineer. Material to be used shall be free of detrimental qualities of organic material, such as vegetation, roots or peat. Rocks larger than 3 inches in average dimension shall not be used in backfill and structural embankment.

2.03 MATERIAL

A. Imported Gravel Backfill/Structural Fill: Where detailed on the Drawings or where required to supplement available native backfill quantities, gravel backfill shall be provided that is reasonably clean (less than 20 percent passing the 200 sieve) naturally occurring or produced aggregate, crushed rock, or gravel graded from 3-inch maximum, with 100 percent passing the 1½" inch sieve. Fill shall be free from clay balls and organic material and shall be well graded from coarse to fine, containing sufficient finer material for proper compaction.

B. Native Backfill: Excavated gravel and on-site processed rock free from roots, organic matter, trash, debris and other deleterious material. Material shall be processed to be well graded from coarse to fine. On-site clay materials may not be used. Maximum size aggregate shall be 3 inches and not more than 20 percent shall pass the No. 200 sieve. Provide imported gravel backfill/structural fill, if required to accomplish the work.

2.04 WATER FOR COMPACTION: The Contractor shall furnish water as required.

2.05 COMPACTION EQUIPMENT

A. Compaction equipment shall be of suitable type and adequate to obtain the densities specified, and shall provide satisfactory breakdown of materials to form a dense fill.

B. Compaction equipment shall be operated in strict accordance with the manufacturer's instructions and recommendations. Equipment shall be maintained in such condition that it will deliver the manufacturer's rated compactive effort. If inadequate densities are obtained, larger and/or different types of additional equipment shall be provided by the Contractor. Hand-operated equipment shall be capable of achieving the specified densities.

2.06 MOISTURE CONTROL EQUIPMENT: Equipment for applying water shall be of a type and quality adequate for the work, shall not leak, and shall be equipped with a distributor bar or other approved device to assure uniform application. Equipment for mixing and drying out material shall consist of blades, discs, or other approved equipment.

PART 3 EXECUTION

3.01 EXCAVATION

A. General: Dewater the ground as hereinafter specified (if necessary), prior to starting excavation. Excavation shall be performed to the lines, grade, and elevations shown on the Drawings. The Engineer reserves the right to make minor adjustments or revisions in lines or grades. Perform all excavation regardless of the type, nature, or condition of the material encountered. The method of excavation used is optional; however, no equipment shall be operated within 5 feet of existing structures or newly completed construction. Excavation that cannot be accomplished without endangering present or new structures shall be done with hand tools. The Contractor is responsible for

field staking the earthwork. No excavation shall be started until the staking is complete. Should the Contractor excavate below the designated lines through fault or negligence, the Contractor shall replace such unauthorized over-excavation with approved materials in an approved manner at his own expense.

B. Classification: All excavation shall be considered unclassified. All material encountered of whatever nature shall be removed and used in embankment or disposed of as specified in this section. The presence of rock or frozen material shall not constitute a claim by the Contractor for extra work.

C. Limits Of Excavation: Excavation shall extend a sufficient distance from walls and footings to allow for placing and removal and inspection of forms, except where the Contractor is authorized to place concrete directly against excavated surfaces. Undercutting will not be permitted. Where suitable bearing is not encountered at the detailed elevation, the Engineer may direct that additional depth as required be excavated. Such authorized over-excavation shall be compensated for on a supplemental agreement or work order basis, if not specifically provided for in the Bid Form. Unauthorized over-excavation by the Contractor shall be corrected by the Contractor using approved materials as specified herein before at no cost to the Owner. Over-excavation below slabs shall be replaced with imported structural fill materials, thoroughly compacted to not less than ninety-eight percent (98%) of maximum density, (ASTM D698), to the subgrade elevation.

D. Protection Of Excavation: All necessary bailing, drainage, sheeting, and construction of cribs and cofferdams shall be included as part of the excavation. Excavations over four feet in depth shall be shored, sheeted and braced as may be necessary for the protection of the work and the safety of the personnel, or sloped to the angle of repose of the material when saturated per OSHA standards. Where concrete is to be placed on excavated surface, care shall be taken not to disturb the bottom of the excavation. Final removal of material to grade shall be made just before the concrete is poured. When excavation is at the required depth, any water, if present, shall be pumped out for cleaning and foundation bed inspection.

E. Dewatering Of Excavation:

1. Provide and operate equipment to keep all excavations and trenches free of water. Remove all water during periods when concrete is being deposited, when pipe is being laid, during the placing of backfill, and at such other times as required for efficient and safe execution of the work. Avoid settlement or damage to adjacent property. Dispose

of water in a manner that will not damage adjacent property. When dewatering open excavations, dewater from outside the structural limits and from a point below the bottom of the excavation when possible. Design dewatering system to prevent removal of fines from existing ground.

2. Adjacent areas shall be graded so that surface drainage is away from excavations. Any water accumulating within the excavation shall be promptly. Pumping from the interior of any foundation enclosed shall be done so the possibility of any portion of the concrete materials being carried away is eliminated. No pumping will be allowed during the placing of concrete and for 24 hours thereafter, unless it is done from a suitable slump separated from the concrete work by a water tight wall.

3. Positive dewatering systems shall be furnished and installed as necessary to maintain all excavations and trenches free of water at all times until the structure or facility is completely constructed, so that full dead load is applied, and backfill is in place. If necessary, such systems shall remove ground water from outside the limits of the excavation, and shall maintain the water level sufficiently far below the base of the excavations to prevent buoyancy conditions or softening of the base. The Contractor shall prevent water from seeping through the excavated side slopes. Provisions shall be made fro removal of storm runoff and all other water that may enter the excavations. Open-sump pumping from the interior of excavations will be permitted only to dispose of surface runoff, and shall not be used as the primary means of dewatering.

F. Structure Shoring:

1. Where necessary due to the site limitations, the Contractor shall shore the excavation for various structures. It shall be the Contractor's responsibility to provide and maintain a reasonable and safe excavation for all phases of construction. In no case shall any excavation be made in such a manner so as to endanger or damage adjacent facilities or property adjacent to the site.

2. The Contractor shall design, install and maintain all shoring. The type of shoring shall be the Contractor's option. The shoring shall be designed and maintained so as to prevent any movement of soil that may cause damage to the adjacent facilities and property, damage or delay the work, or endanger life and health.

3. Shoring shall be designed and constructed to withstand soil and hydrostatic loadings, and appropriate equipment and surcharge loadings. Tie-backs and bracing shall be installed where required to prevent movement. Design of shoring shall incorporate the Contractor's sequence of excavation and placement of lateral support elements. The Contractor shall repair, at his own expense, all damage resulting from failure to provide adequate support.

4. Shoring shall be removed in a manner that avoids damage to new or existing facilities or adjacent property. All voids left be removal of shoring shall be immediately filed.

G. Approval Of Excavation By Engineer: Prior to the placing of concrete for footings, walls, or slabs the completed excavation shall be inspected and approved by the Engineer. No footing or slab shall be placed until after the Engineer has approved the depth of the excavation and the character of the foundation material. Provide imported structural fill below all footings and slabs at bottom of excavations as indicated in the drawings.

3.02 SUBGRADE PREPARATION: Preparation of the foundation subgrade should be observed by the Geotechnical Engineer to ascertain conditions consistent with the analysis used and the recommendations made. Where suitable bearing material is not encountered at the footing elevation, the Geotechnical Engineer may require sub-excavation and additional imported structural fill. Such authorized action shall be compensated for on a negotiated, supplemental agreement.

3.03 BACKFILLING

A. General: Backfilling shall be performed where indicated to the grades and elevations shown on the Drawings. No backfilling shall be commenced without the approval of the Engineer. Prior to backfilling, all concrete forms shall be removed and the excavation cleaned of all trash and debris. Any paint, waterproofing or coating which has been applied to below grade surfaces shall be completely dried or cured. Backfill around concrete structures only after the concrete has reached the specified compressive strength indicated in Section 03300, CONCRETE. Backfill water-holding structures only after satisfactory leakage tests have been conducted as specified in Section 03300, CONCRETE. All material used for backfill shall be of a quality acceptable to the Engineer and shall be free of large and frozen lumps, wood, and other extraneous materials. On-site clay soils shall not be used for backfill around structures. No placement of fill or backfill shall be conducted over frozen subgrade.

B. Compaction: Backfill materials shall be placed in continuous horizontal layers not to exceed 8-inches in thickness. Each layer shall be compacted to 95 percent of maximum density at optimum moisture as determined by ASTM D698. Where backfill is placed on both sides of a wall or column, both sides shall be backfilled in such a manner so that the difference in compacted grade does not exceed 18 inches at any time. Care shall be taken when compacting around structure footings, slabs, and walls to prevent damage to the structure.

C. Watering: Water may be added only to bring the backfill material to the specified moisture content range (plus or minus from optimum) for compaction. Jetting or ponding of the backfill material will not be permitted.

D. Imported Structural Fill: Where called for on the Drawings or as otherwise directed by the Engineer, provide hereinbefore specified imported structural fill for foundation backfill. Place fill material in maximum 8-inch thick lifts and compact to each lift to not less than 98 percent of maximum ASTM D698 dry density at optimum moisture content, plus or minus 2 percentage points.

E. Native Backfill Around Structures: Place hereinbefore specified Native material in all areas not designated to be structural fill. Deposit material in horizontal lifts of maximum 8-inch uncompacted depth and compact each lift to not less than 95 percent of maximum ASTM D698 dry density. Maintain material at optimum moisture content, plus or minus 2 percentage points. Place backfill material free of roots, organic matter, trash, and rocks larger than 3-inch diameter. Stop backfill at specified grade. Make allowance for topsoil where required.

F. Any subsequent damage to slabs, piping, concrete structures, facilities, or other structures caused by settlement of fill material shall be corrected and repaired by the Contractor at the Contractor's sole expense.

3.04 MOISTURE CONTROL

A. During all compacting operations, maintain at each lift of fill optimum practicable moisture content. Maintain moisture content uniform throughout the lift. Insofar as practicable, add water to the material at the site of excavation. Supplement, if required, by sprinkling the fill. At the time of compaction, the water content of the material shall be at optimum moisture content, plus or minus 2 percentage points.

B. Do not attempt to compact fill material that contains excessive moisture.

Aerate material by blading, discing, harrowing, or other methods, to hasten the drying process.

3.05 FIELD DENSITY AND MOISTURE TESTS: The Contractor will determine in-place density and moisture content by any one or combination of the following methods: ASTM D2922, D1556, D2216, D3017, or other methods selected by the Engineer. Backfill test areas at Contractor's sole expense. The frequency and location of testing shall be determined by the Engineer and as defined in Section 01400, QUALITY CONTROL. The Engineer may require the Contractor to test any lift of fill at any time, location, or elevation. No areas will be accepted that have compacted densities less than specified hereinbefore.

3.06 WEATHER CONDITIONS: Earthwork operation shall be suspended at any time when satisfactory results cannot be obtained on account of rain, freezing weather, or other unsatisfactory field conditions.

3.07 DRAINAGE: During earthwork operations the grade shall be maintained in such a condition that it will be well drained at all times. If necessary, temporary drains or diversion ditches shall be installed in intercept or divert surface water which could affect the work.

3.08 CLEANUP

A. All unsuitable material, waste sheeting or forming, and debris shall be removed from the site and disposed of in approved areas as directed by local regulatory agencies or the Owner. The area shall be graded to required elevations and all rocks and boulders bladed into a furrow and removed for disposal. Topsoil stripped during clearing and stockpiled shall be spread in such a manner as to restore the area surface to its original condition.

B. All native excess soil materials not required for backfilling around new structures or filling in existing structures to be abandoned may be disposed of on-site. Materials shall be clean without any debris or contaminants. On-site disposal area shall be coordinated with the Owner. Disposal area must be shaped and graded as directed by the Owner and Engineer to leave the site with a neat appearance.

END OF SECTION 02222

PART 1 GENERAL

1.01 DESCRIPTION: This section includes work related to excavation of boulders, fractured and un-fractured rock, and hard soils that cannot be broken up and excavated by standard construction methods. Methods of excavation may include the use of rock saws, pneumatic or hydro-hammers, and blasting with explosives.

1.02 DEFINITIONS

A. Solid Rock: Solid rock shall be defined as rock and hard soils which require one of the following methods of removal:

1. Use of a rock saw to create a slot.
2. Chipping with a pneumatic or hydro-hammer to create a channel through the rock.
3. Blasting.

B. Blasting: Work required to quarry rock for crushing, or to loosen, shatter or otherwise break rock that is deemed by the Engineer as not capable of being excavated by standard construction methods (such as using a Caterpillar Model 245 excavator with rock teeth), or not capable of being broken by standard construction methods (such as using a Caterpillar Model D-9L dozer with a single ripper).

1.03 LEGAL REQUIREMENTS FOR BLASTING:

A. Comply with all local, state and federal laws, codes and regulations applicable to the storage, transport, handling and use of explosives. If there are discrepancies between these specifications and the applicable laws, codes and regulations, the laws, codes and regulations shall govern.

B. Obtain written permission from authorities having jurisdiction, and provide copies of such written permission to the Owner and Engineer, before bringing explosives to the site or using explosives on the site.

1.04 SUBMITTALS

A. Blasting: Submit the following in accordance with the requirements of Section 01300 (Submittals). The Engineer must receive and approve all submittals prior to starting the work.

1. A copy of the blaster's license, a statement of the blaster's blasting competence, and proof of insurance covering liability for blaster's performance of blasting operations.
2. A safety plan indicating methods to be employed to protect persons in and around the work area, and to prevent damage to buildings, utilities both above and below ground, and other property.
3. A security plan for receiving, handling, transporting and storing explosives that complies with all local, state and federal regulations.
4. A drilling plan indicating drill type, size, methods, locations and depths of holes, and requirements for pre-splitting.
5. A blasting plan indicating type of explosives, loading and firing sequence, and test blast plan if required.
6. As the blasting is performed, keep records of each blast including location, depth, quantity and type of explosive, and other relevant data. Submit all such blasting records to the Engineer.

1.05 QUALITY ASSURANCE: Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the type of blasting required for the work and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

PART 2 PRODUCTS

2.01 EXPLOSIVES: The types of explosives, detonators and other materials used shall be determined by the Blasting Contractor. The Blasting Contractor shall meet all applicable regulations.

PART 3 EXECUTION

3.01 GENERAL

A. Excavation of solid rock and/or blasting, defined in Part 1.02 above, must be authorized by the Engineer before performing the work.

B. The Contractor shall decide the construction method to be used in performing work in solid rock.

3.02 GENERAL BACKFILL: No jagged or sharp rock shall be used in any backfill. Rocks encountered during pre-rip, which can be removed by trenching equipment and pieces of solid rock which have been removed by chipping with a pneumatic or

hydro-hammer, shall be removed from the running line and hauled away at the Contractor's expense. The Contractor will be responsible for obtaining a site for disposal.

3.03 BLASTING

A. **No blasting shall be permitted without prior approval of the Engineer.** Submit the required items as specified in Part 1.04 above.

B. The blasting shall be a controlled program designed by a blast specialist with demonstrable experience who is also retained to monitor the field work and vibrations.

C. Grass, brush and combustible debris shall be cleared and kept at least 50 feet away from the explosives storage area. No smoking or ignition source of any kind is allowed within 50 feet of the explosives storage area.

D. Store no more than a 1-day supply of explosives on site. Clearly mark all storage places "Dangerous - Explosives."

E. Clear blast area of unauthorized personnel and unnecessary equipment before explosives are brought on site. Mark roadways with appropriate caution signs.

F. Electric Detonators: When electric detonators are used, provide special signs or signals at all access points, including a warning to turn off radio transmitters. Prevent accidental detonation by static electricity or other sources of extraneous electricity.

G. Provide a positive warning system to give adequate warning in every direction immediately prior to firing the explosives. Guard all access points to the blast area to halt personnel and vehicles a safe distance from the blast. Maintain intercommunication between guards and persons firing the blast, assuring the blast area is clear prior to firing.

H. Do not damage adjacent structures, property, or site improvements or weaken the bearing capacity of rock subgrade when using explosives. Monitor and maintain ground vibrations, and retain the services of a qualified Geotechnical Engineer as required.

I. When blasting rock in trenches, cover the blasting area with earth backfill or approved blasting mats.

J. Loading of explosives into drill holes shall not begin until all drilling is completed and all security and safety measures are in place.

PART 4 MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02223

PART 1 GENERAL

1.01 DESCRIPTION: This section covers excavation of Storage Pond #2, placement of the secondary liner and drainage layer under the pond, and sideslope cover materials over the geomembrane and geotextile materials. This section also covers miscellaneous items within and around the pond, as shown on the Drawings. Geotextile and geomembrane is specified in Sections 02110 (Geotextile) and 02111 (Geomembrane); the aeration unit and cables are specified in Section 11300 (Aeration Unit and Cables).

1.02 RELATED SECTIONS
Section 02110 Geotextile
Section 02120 Geomembrane
Section 02130 Geocomposites
Section 02220 General Excavation
Section 02232 Aggregate Materials
Section 02480 Finish Grading, Seeding and Landscaping

1.03 GEOTECHNICAL REPORTS

A. Storage Pond: For geotechnical information on the Storage Pond, refer to the *Geotechnical Investigation Report for Effluent Pond #2,* dated August 9, 2002, by NTL Engineering and Geoscience, Inc. Copies are available from the Engineer.

B. Storage Pond Outlet: For geotechnical information related to the Storage Pond's gravity and underdrain outlet lines, refer to the *Geotechnical Report, Pond 2 Outlet Alignment,* dated December 19, 2002, by NTL Engineering and Geoscience, Inc. Copies are available from the Engineer.

C. Storage Pond Outlet: For geotechnical information related to the Storage Pond's gravity and underdrain outlet lines, refer to the *Yellowstone Club Emergency Response Geotechnical Services and Slope Assessment-Treated Effluent Pond #2 letter,* dated March 11, 2016, by Terracon. Copies are available from the Engineer.

PART 2 PRODUCTS

2.01 EXCAVATION: Refer to Section 02220 (General Excavation) for subexcavation backfill material specifications.

2.02 SECONDARY LINER MATERIALS

A. Type 8 Fill and Type D Fill: Refer to Section 02231 (Aggregate Materials).

B. .Geosynthetic Clay Liner: Refer to Section 02130 (Geocomposites).

2.03 DRAINAGE LAYER AND GEOMEMBRANE MATERIALS

A. Type A Fill and Type C Fill: Refer to Section 02231 (Aggregate Materials and Gabion Retaining Walls).

B. Geotextile: Refer to Section 02110 (Geotextile).

C. Geomembrane: Refer to Section 02120 (Geomembrane).

D. Geosynthetic-Soil Composite: Refer to Section 02130 (Geocomposites) for material specifications of the Geosynthetic-Soil Composite to be used in the Underdrain Collection Sumps.

2.04 SIDESLOPE COVER MATERIALS:

A. Geotextile: Refer to Section 02110 (Geotextile).

B. Geocells: Refer to Section 02130 (Geocomposites).

C. Topsoil and Seeding: Refer to Section 02905 (Finish Grading, Seeding and Landscaping).

D. Erosion Control Blankets: The erosion control blanket for the Storage Pond's sideslope cover (above the geocells, as shown on the Drawings) shall be a biodegradable mat of a uniform thickness, made of a uniform mixture of 70 percent straw and 70 percent coconut fiber stitched between two synthetic fiber nets having a maximum mesh size of 1 inch x 1 inch. The top synthetic fiber net shall be UV-stabilized, and the bottom net shall be photo-degradable. Minimum weight of the blanket shall be 9.5 ounces per square yard. Use North American Green product No. SC 150 or Engineer-approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. Pond construction shall be scheduled and sequenced to:

1. Minimize potential erosion damage to prepared subgrade from storm runoff or snowmelt.
2. Minimize exposure of the geotextile to ultraviolet degradation.
3. Protect successive lifts of backfill material from mixing, and from erosion damage.

3.02 EXCAVATION

A. General: Storage pond excavation shall be performed in accordance with Section 02220 (General Excavation), as modified in this Section.

B. Aggregate Production and Disposal of Excess Material: The storage pond excavation is considered a potential source for production of the specified aggregate and soil materials required for other parts of the work on this and other projects within the Yellowstone Mountain Club development. However, all excavated material not used within the development shall be disposed of by placing the material on the Anticipated Disposal Site as specified, or alternate site(s) as directed by the Owner. No additional pond excavation is expected in 2016.

C. Anticipated Disposal Site: The anticipated disposal site is the future ski run located between Third Yellow Mule Creek and the West Golf Course Road, as shown on Sheet G-1 of the Drawings. Soil placement procedures within this area, including grading, compaction and limits of fill, will be determined by the Engineer following wetlands delineation work and geotechnical investigations of the disposal area that will be completed over the late spring and early summer months. In order to avoid existing wetland areas and geotechnically unstable areas, it is expected that fill placement will be in several separate locations interspersed throughout the identified disposal area. No additional pond excavation is expected in 2016.

D. Excavate inlet pipe trenches and install piping as specified and as shown on the Drawings.

E. Groundwater Seeps: Significant groundwater seeps may be exposed during pond excavation. If the Contractor identifies any groundwater seeps, the Engineer shall be notified immediately and excavation in the area continued as directed by the Engineer. Upon inspection of the area, the Engineer may require the Contractor to install additional underdrain collection trenches and piping to collect and route flows to the primary collection trench shown on the Drawings. Terracon inspection will be required during excavation of the pond outlet area to determine adequate soils conditions for work continuance.

F. Tolerances: Excavate to the lines and grades shown on the Drawings, to within plus or minus 3 inches. Occasional protrusions or variations are acceptable, but on average the bottom of the excavation shall match the design elevations. Protrusions of hard rock or other material shall not exceed 6 inches above the design elevation at the point of the protrusion. Any such protrusions shall be removed.

G. Protection: Protect the excavation from storm runoff and snowmelt. Divert runoff from upstream areas and construct additional, temporary runoff

diversion ditches as necessary to minimize erosion damage. To minimize runoff accumulations in the excavation, stage the excavation such that the underdrain outlet line may be installed as shown on the Drawings as soon as practicable.

3.03 FINISHED SUBGRADE COMPACTION AND FINAL PREPARATION

A. Compaction: Once excavation is complete, the finished subgrade, including subexcavations and all remaining portions of existing road surfaces, shall be compacted to not less than 95 percent of maximum ASTM D698 dry density. Maintain material at optimum moisture content, plus or minus 2 percentage points. Do not scarify the subgrade surface after compaction. Do not begin fill placement until the subgrade construction and compaction have been approved by the Engineer. Do not place fill over frozen subgrade.

B. The finished subgrade surface must be free of irregularities, rock, cobbles and protrusions including any stones exceeding 1-inch in size, loose soil and abrupt changes in grade, and shall meet the warranty requirements of the geomembrane manufacturer. Refer to Sections 02110 (Geotextile) and 02120 (Geomembrane) for additional requirements.

C. Tolerance: Grade the finished subgrade surface to the lines and grades shown on the Drawings to a tolerance of plus or minus 0.50 feet. Remove all large or angular rocks protruding more than 0.50 feet above the surrounding soil surface. Correct localized slope irregularities as directed by the Engineer and the geomembrane installer.

D. Areas Excavated by Blasting: Blast rock in accordance with Section 02223 (Rock Excavation and Blasting), such that no rock protrudes above the design finished subgrade. Place and compact leveling course of General Earthfill as specified above and in Section 02220 (General Excavation) to the finished subgrade elevation.

3.04 SECONDARY LINER PLACEMENT

A. Place Type B Fill on prepared subgrade surface under the pond bottom on the finished, prepared subgrade as shown on the Drawings, and compact as specified for finished subgrade compaction. Use Type B Fill as a leveling course to cover all protrusions with a minimum 6 inch compacted thickness, while maintaining a nominal compacted thickness of 12 inches.

B. Place Type D Fill over Type B Fill as shown on the Drawings. Compact as specified for finished subgrade compaction, and prepare the surface for placement of the geosynthetic-soil composite as specified in Section 02130 (Geocomposites).

C. Around the pond perimeter where the geosynthetic-soil composite will be in direct contact with the subgrade, prepare subgrade by removing irregularities, protrusions, loose rock and soil.

D. Place geosynthetic-soil composite, as specified in Section 02130 (Geocomposites).

3.05 DRAINAGE LAYER PLACEMENT

A. Underdrain Collection Trenches: Construct the Primary Collection Trench and the Toe Drain Collection Trench, and connect these to the Underdrain Outfall Line, as specified and as shown on the Drawings. If significant groundwater seeps exist in the pond excavation as determined by the Engineer (refer to 3.02 above), construct additional collection trenches or sumps, and connect these to the Underdrain Outfall Line with solid 8" SDR-9 HOPE pipe.

B. Place Type B Fill on prepared subgrade surface as shown on the Drawings, and compact as specified for finished subgrade compaction. Use Type B Fill as a leveling course to cover all protrusions with a minimum 6 inch compacted thickness, while maintaining a nominal compacted thickness of 12 inches.

C. Place Type A Fill over Type B Fill as shown on the Drawings.

D. Preparation for Geotextile/Geomembrane Placement:

1. Compact Type A Fill with a vibrating roller or a steel wheel roller weighing not less than 50 pounds per linear inch of drum width. Compact to a stable condition as approved by the geotechnical engineer, with 95 percent of the ASTM 0698 maximum dry density as the target such that the shear strength and permeability requirements for Type A Fill are met. Areas not accessible to the roller shall be compacted using Engineer-approved mechanical or hand tampers.
2. Before the geotextile and geomembrane can be placed, the Type A Fill surface must be free of irregularities, protrusions including any stones exceeding ¾-inch in size, loose soil and abrupt changes in grade, and shall meet the warranty requirements of the geomembrane manufacturer. Refer to Sections 02110 (Geotextile) and 02120 (Geomembrane) for additional requirements.

E. Tolerances: Place Type B Fill to a minimum compacted thickness of 1.0 feet, and place Type A Fill to a minimum compacted thickness of 0.5 feet. Layer thicknesses below the minimum specified shall be

corrected by placing additional fill materials.

F. Place additional fill materials to correct localized slope irregularities as directed by the Engineer and the geomembrane manufacturer. Additional fill materials as described in this paragraph shall be produced and placed at the sole expense of the Contractor.

G. Protection: Protect finished drainage layer from erosion or other damage until the geotextile is installed. Prevent runoff from eroding the finished drainage layer. Any damage to the finished drainage layer shall be corrected by the Contractor in accordance with these specifications at no additional cost to the Owner.

3.06 GEOTEXTILE AND GEOMEMBRANE PLACEMENT: Refer to Section 02110 (Geotextile) and Section 02120 (Geomembrane).

3.07 SIDESLOPE COVER PLACEMENT

A. Protection: When placing materials over the installed geomembrane and underlying geotextile, ensure the following:

1. Place successive layers of cover materials over the installed geomembrane in such a way as to reduce stresses on the geomembrane. Push out or remove all wrinkles as specified in Section 02120 (Geomembrane).
2. Prevent slippage and excessive tensile stresses in the geomembrane. Install material stress-free with no bridging before it is covered.
3. Place and compact cover materials using the equipment and methods as recommended by the geomembrane installer, and as required to protect the geomembrane.

B. Place sideslope cover materials on the installed and tested geomembrane liner as specified and as shown on the Drawings.

C. Ballast: Place sandbags, or other permanent ballast material approved by the geomembrane (liner) installer and the Engineer, to hold the liner in place prior to the pond being filled. Ballast shall be placed on the installed liner along the toe of the pond slope and over the pond bottom at the spacing and density recommended by the geomembrane installer to protect the liner from lifting due to high winds and pressure differential for a period of one year minimum. Ballast placement shall proceed along with liner installation to protect finished work. Ballast shall remain in place permanently.

D. Cellular Confinement System (Geocells): Place geotextile in accordance with Section 02110 (Geotextile). Place and fill geocells in accordance with Section 02130 (Geocomposites).

E. Transition Slope (Top of Pond Slope to Road G): Place geotextile and erosion control blanket at the top of the geocell cover materials as specified and as shown on the Drawings. Then place the topsoil, seed the topsoil as specified in Section 02905, wrap the erosion control blanket over the topsoil and anchor it at the edge of Road B. Overlap, anchor and staple the erosion control blanket as recommended by the manufacturer.

PART 4 MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02224

PART 1 GENERAL

1.1 DESCRIPTION: This section covers aggregate materials to be used on the project including pipe bedding, structural road fill, foundation/drainage layers for structures and lined ponds, cover materials for lined ponds, riprap and other materials as specified or as shown on the Drawings. This section also covers the installation of gabion retaining walls.

1.2 OTHER SPECIFICATIONS: All provisions in Section 02232 of the Standard Specifications shall apply unless stated otherwise in this section.

PART 2 PRODUCTS

2.1 SUB BASE COURSE

A. Sub Base Course for roads and parking areas shall conform to the following gradation requirements:

Screen/Sieve Size:	Percent Passing:
6"	100
3"	70 - 100
No. 4	25 – 60
No. 10	20 – 55
No. 200	12 max.

B. For the material passing the No. 40 sieve, the maximum liquid limit shall be 25, and the maximum plasticity index shall be 6.

2.2 CRUSHED BASE COURSE

A. Crushed Base Course for roads and parking areas shall conform to the following gradation requirements:

Screen/Sieve Size:	Percent Passing:
1"	100
No. 4	40 – 70
No. 10	25 – 50
No. 200	5 - 10

B. For the material passing the No. 40 sieve, the maximum liquid limit shall be 35, and the maximum plasticity index may vary from 3 to 10.

C. Dust Ratio: For the material passing the No. 200 sieve shall not be

greater than two-thirds (2/3) of that portion passing the No. 40 sieve.

2.3 PIPE BEDDING: Pipe bedding for all non-slotted pipe shall be a clean sand/gravel mixture consisting of a crushed, processed, or a naturally occurring product free from organic matter and conforming to the requirements of Section 02221 of the Standard Specifications.

2.4 SLOTIED DRAIN PIPE BEDDING: Pipe bedding for slotted drain pipe shall be a clean sand/gravel mixture consisting of a crushed, processed, or a naturally occurring product free from organic matter and conforming to the following gradation requirements:

Screen/Sieve Size:	Percent Passing:
3/4"	100
3/8"	70 - 100
No. 4	55 – 100
No. 10	35 – 95
No. 20	20 – 80
No. 40	10 – 55
No. 100	0 – 10
No. 200	0 – 3

2.5 RIPRAP

A. Furnish stone that is hard, durable, angular in shape, resistant to weathering and water action, free from overburden and loose soils, shale, structural defects, and organic material. Each stone must have its greatest dimension not greater than 3 times its least dimension. Do not use rounded stone or boulders from a streambed source as rip rap. Do not use shale or stone with shale seams.

B. Riprap material shall conform to the following specifications:

1. Absorption per AASHTO T 85 shall be 4.2% maximum
2. Coarse Durability Index per AASHTO T 210 shall be 52% minimum.
3. Riprap shall conform to the following gradation requirements:

Percent of Rock by Mass (lbs.)	Mass (lbs.)	Approximate Max. Dimension (in.)
20	20 to 30	6 to 8
30	10 to 20	5 to 6
40	1 to 10	2 to 5
10	0 to 1	0 to 2

2.6 TYPE A FILL

A. Type A Fill shall be a clean sand/gravel mixture consisting of a crushed, processed, or a naturally occurring material free from organic matter. The Type A material shall be moderately well-graded to well-graded, and shall conform to the following gradation requirements:

Screen/Sieve Size:	Percent Passing:
3/8"	100
No. 200	5 max.

B. Type A Fill shall meet the following additional requirements. Tests shall be performed at a dry density corresponding to 95 percent of the maximum dry density per ASTM 0698:

1. Compacted Hydraulic Conductivity shall be greater than 1x10-2 cm/sec. Measurement shall be per ASTM 02434.
2. Residual Internal Friction Angle (Shear Strength) shall be greater than or equal to 36 degrees. Measurement shall be per ASTM 05321.

2.7 TYPE B FILL

A. Type B Fill shall be a clean sand/gravel mixture consisting of a crushed, processed, or a naturally occurring material free from organic matter. Type B Fill shall be moderately well-graded to well-graded, and shall conform to the following gradation requirements:

Screen/Sieve Size:	Percent Passing:
1¾"	100
No. 200	5 max.

B. Type B Fill shall meet the following additional requirements. Tests shall be performed at a dry density corresponding to 95 percent of the maximum dry density per ASTM 0698, or 65 percent relative density in accordance with ASTM 04253 and 04254.

1. Compacted Hydraulic Conductivity shall be greater than 1x10-2 cm/sec. (not required under secondary liner). Measurement shall be per ASTM 02434.
2. Residual Internal Friction Angle (Shear Strength) shall be greater than or equal to 36 degrees. Measurement shall per ASTM 05321.

2.8 TYPE C FILL

A. Type C Fill shall be a clean sand/gravel mixture consisting of an angular, crushed, processed material free from organic matter. Type C Fill shall be moderately well-graded to well-graded, and shall conform to the following gradation requirements:

Screen/Sieve Size:	Percent Passing:
3"	100
1"	40 - 70
No. 200	5 max.

2.9 TYPE D FILL

A. Type D Fill shall be a clean sand/gravel mixture consisting of a crushed, processed, or a naturally occurring material free from organic matter. Type D Fill shall be moderately well-graded to well-graded, and shall conform to the following gradation requirements:

Screen/Sieve Size:	Percent Passing:
3/4"	100
No. 40	10 – 60
No. 200	10 max.

PART 3 EXECUTION

(Not Used)

PART 4 MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02231

PART 1 GENERAL

1.01 DESCRIPTION: This section covers construction of the Effluent Line force main, District force main, miscellaneous pipeline accessories including flow meters and vaults, and the Storage Pond's Gravity Outlet Line and Underdrain Outlet Line. Refer to the Standard Specifications for other pipelines, and for additional requirements for the above-described pipelines.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish force main pipe and fittings as specified herein, and meeting the materials and testing requirements of Section 02610A (Water Main Materials) and Section 02610 B (Sanitary Sewer Main Materials) of the Standard Specifications . HDPE pipe shall meet the requirements specified herein. Pipe strength and/or dimensional (SDR) classifications are shown on the Drawings.

B. Furnish a manufacturer's certification attesting that the pipe and fittings furnished meet the applicable specifications.

C. References made to ASTM, ANSI or AASHTO designation are the latest revision at the time of call for bids. Assure that all pipe is clearly marked with type, class and/or thickness as applicable. Assure lettering is legible and permanent under normal conditions of handling and storage.

D. Furnish the joint type, class, thickness designation, castings, lining, marking, testing, etc. as specified.

2.02 HIGH DENSITY POLYETHYLENE (HDPE) PIPE - SOLID WALL

A. All pipe sizes shown on the Drawings and specified in this Section reference nominal diameter, unless otherwise indicated on the Drawings or in this Section. The pipe shall have a nominal Iron Pipe Size (IPS) outside diameter unless otherwise specified. Pipe shall meet the dimensions and tolerances specified in AWWA C906.

B. Resin for pipe and fittings shall be extra high molecular weight, high density ethylene/hexene copolymer PE 3408 polyethylene resin, listed by both N.S.F. and P.P.I. and manufactured in accordance with ASTM D-3350 and ASTM F-714. Pipe and fittings shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification and from the same raw material supplier. The pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions or other deleterious defects.

C. Pipe sizing and workmanship shall be in accordance with ASTM F-714

and ASTM D-3035, and shall conform to the following minimum requirements:

Property	ASTM Test Method	Minimum Requirements
Material Classification	D-1248	Type Ill, Class C, Cat. 5, Grade P34
Cell Classification	D-3350	Grade PE34 (345434C)
Density	D-1505	0.955 g/cm^3
Melt Index	D-1238	< 0.14 gm/10 min
Flexural Modulus	D-790	133,000 psi
Tensile Strength (yield)	D-638	3,200 psi
Environmental Stress Crack Resistance, F_0 , Cond. C	D-1639	>10,000
Environmental Stress Crack Resistance, Compressed Ring	F-1248	>10,000 hrs
Hydrostatic Design Basis	D-2837	1,600 psi @ 73.4°F
UV Stabilizer, Carbon Black	D-1603	2%
Elastic Modulus	D-638	110,000 psi
Brittleness Temperature	D-746	< -180° F
Vicat Softening Temperature	D-1525	+255° F
Hardness, Shore "D"	D-2240	64

D. Pipe Markings: Provide pipe with the following information continuously marked on the pipe or spaced at intervals not exceeding 5 feet:

1. Name and/or trademark of the manufacturer
2. Nominal pipe size
3. PE3408
4. Standard Dimension Ratio (SDR) value
5. Production code for date and place of manufacture

E. Pressure Class: Pipe shall meet the following pressure classes:

1. SDR-17 Pipe: 100 psi
2. SDR-9 Pipe: 200 psi

The above values indicate working pressures and shall include allowances for occasional positive pressure transients not exceeding two times the nominal pressure class and recurring pressure surges not exceeding 1% times the nominal pressure class

2.03 HIGH DENSITY POLYETHYLENE (HOPE) PIPE - PROFILE WALL

A. Slotted HDPE Drain Pipe:

1. Slotted HDPE Drain shall be corrugated, double-wall high-density Polyethylene (HDPE) with slots or circular perforations uniformly spaced along the length and circumference of the pipe.

2. Acceptable Product: N-12 polyethylene corrugated pipe with an integrally formed smooth interior as manufactured by Advanced Darinage Systems, Inc. (ADS) for leachate collection, or Engineer-approved equal.

3. Perforations shall be configured to match the Standard Pipe Perforations for Single Wall Pipe as specified by ADS. All drill hole or sawed slot filings and waste shall be removed from the interior of the pipe prior to installation.

4. All perforated pipe lengths shall be visually inspected by the Engineer prior to installation.

2.04 PIPE FITTINGS

A. Fittings for HDPE Pipe:

1. Fusion-Weld Fittings: Fusion-weld HDPE pipe fittings shall be standard commercial products manufactured by injection molding or by extrusion and machining, or shall be fabricated from AWWA C906 pipe conforming to this specification. All fusion-weld fittings shall be manufactured by the pipe manufacturer from the same approved resin type, grade and cell classification as the pipe used on the project. All fittings shall be pressure tested by the pipe/fitting manufacturer in accordance with AWWA C906.

2. Connections to Other Pipe Materials: For connections from HDPE to other pipe materials such as C900 PVC, use restrained joint type Ductile Iron fittings made specifically for connecting the dissimilar materials being joined.

B. Fittings for Ductile Iron Pipe:

1. Use mechanical joint, ductile iron fittings for all ductile iron pipelines.

2. Where joint restraints are required, use Mega-Lug joint restraints or Engineer-approved equal.

C. Joints and Fittings for PVC Pipe:

1. Use mechanical joint, ductile iron fittings for all C900 PVC pipelines.

2. Where joint restraints are required, use Mega-Lug joint restraints or Engineer-approved equal.

3. Use solvent weld joints and fittings for all Schedule 40 PVC pipelines.

D. Pipe to Manhole Connections: Use "Z-lock" connectors, as manufactured by A-Lok Products Inc. and distributed by Anderson Precast, or Engineer-approved equal.

2.05 FLOW METER VAULT ON GRAVITY OUTLET LINE

A Vault: The flow meter vault shall be a concrete vault meeting the general requirements specified in Section 02740 (Sewage Treatment Systems) for concrete tanks.

B. Flow Control Valve: The flow control valve shall be able to provide a constant flow rate of 2,500 gpm, and shall be adjustable to within ±200 gpm of the design flow. The valve housing and other metal components exposed to wastewater shall be stainless steel. The valve shall be connected to the pipeline with flange-by-flange joints. The valve shall have strainer on pilot assembly. The valve shall be an 8-inch Cla-Val Model 640-01, or Engineer-approved equal.

C. Flow Meter: The flow meter shall be a direct magnetic drive propeller meter with an accuracy of ±2 percent (±50 gpm) of the 2,500 gpm design flow, and shall be able to withstand a maximum pressure of 150 psi. The flow meter shall be equipped with a sealed direct reading register and a low flow indicator. The flow meter shall be connected to the pipeline with flange-by-flange joints. The flow meter shall be an 8" Sensus Model 101 flow meter, or Engineer-approved equal.

2.06 SEPTIC TANK ON IRRIGATION BACKWASH SYSTEM

A. General: The Septic Tank for the irrigation backwash system shall be a 1,000-gallon concrete tank meeting the general requirements specified in Section 02740 (Sewage Treatment Systems) for concrete tanks.

B. Acceptable Product: Pre-cast 1,000-gallon single-compartment concrete septic tank as supplied by Anderson Pre-cast & Supply, Inc., or Engineer-

approved equal.

C. The septic tank shall be vented to atmospheric pressure.

D. Effluent Filter: Orenco Systems®, Inc. Biotube® Effluent Filter or Engineer-approved equal, installed as shown on the Drawings and as specified. The filter shall have a minimum effective screen area of no less than 16.8 square feet. The Biotube® Effluent Filter shall consist of a 4-inch diameter PVC vault with eight (8) 1-3/8 inch diameter holes evenly spaced around the perimeter, located appropriately to allow for maximum sludge and scum accumulation before requiring pumping (approximately 70% of minimum liquid level). Inside the PVC housing shall be the Biotube® assembly consisting of 1/8-inch mesh polypropylene tubes.

E. Pipe And Related Items: Z-lok connectors shall be used on wall pipe entry/exit points.

F. Pumps: Pumps shall be Orenco Systems Inc. Model #P500712, ¾-horsepower 3-phase high head effluent pumps. Individual pumps shall deliver 255 gpm against a TOH of approximately 74.1 feet. One pair of pumps shall be installed within the dosing chamber, as shown on the Drawings. Pumps shall be corrosion resistant, UL Listed, and meet the requirements of electric code Class 1, Division 2. Each pair of pumps shall be enclosed in an Orenco Pump Vault, model number X521296-3636. Pump vault shall contain an effluent filter that meets the requirements of circular DEQ-4, Chapter 7. Pumps shall alternate with each dose. Discharge piping shall meet the pump manufacturer's recommendations as to size and type. Pumps shall be installed so that removal and installation can be performed from ground level. Electrical controls are specified in Section 16445 (Radio Telemetry [SCADA] System).

PART 3 EXECUTION

3.01 PIPE TRENCH EXCAVATION AND BACKFILL: Perform pipe trench excavation and backfill in accordance with the Standard Specifications, Section 02221 (Trench Excavation and Backfill for Pipelines and Appurtenant Structures).

3.02 PIPE INSTALLATION

A. Perform pipe installation in accordance with of the Standard Specifications Section 02713 (Water Mains).

B. Install joint restraints at all pipe joints and fittings between the limits specified on the Drawings and as directed by the Engineer.

C. HDPE Pipe: HDPE pipe shall be installed as recommended by the pipe manufacturer. Pipe may be curved to the minimum radius recommended by

the manufacturer.

3.03 HDPE PIPE JOINTS

A. All HDPE pipe shall be joined into continuous lengths on the job site by the heat fusion method. Joining shall be performed in strict accordance with the manufacturer's recommendations, using equipment that meets all conditions recommended by the pipe manufacturer.

B. Preparation: Any amount of dirt, oil, moisture, airborne dust or debris on the heater plate, pipe ends, facer, or anything else that contacts the fusion surface can cause improper fusion. Ensure that all equipment and pipe ends are clean.

C. The installer shall visually inspect pipe joining and make adjustments to the heating cycle to account for ambient temperature, wind, humidity and other factors. Uniform heating around the pipe, uniform bead "roll back," acceptable bead thickness, and maintaining adequate contact pressure during cooling are required for each joint.

D. Qualifications: Personnel performing heat fusion must have successfully installed a minimum of 10,000 feet of HDPE pipe. Submit documented references.

3.04 TESTING

A. General: The Contractor shall conduct pressure and leakage tests concurrently on all newly installed pipelines in accordance with MPW Standard Specification Section 02660, WATER DISTRIBUTION.

PART 4: MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02723

PART 1: GENERAL

1.01 DESCRIPTION: The work of this section consists of installing new fences and gates at the locations shown on the Drawings and/or as marked, directed or staked by the Engineer.

1.02 OTHER DRAWINGS: The following Standard Drawings from the *Montana Department of Transportation Detailed Drawings*, August 1999 edition, are included in Appendix A and are incorporated by reference:

607-00 Farm Fence
607-10 Fencing Details
607-15 Fencing Details
607-20 Farm Entrance gates
607-25 Chain Link Fence

1.03 OTHER SPECIFICATIONS: Comply with Sections 607 and 712 of the *Standard Specifications for Road and Bridge Construction*, 1999 edition, Montana Department of Transportation.

PART 2: PRODUCTS

2.01 POND PERIMETER FENCE

A. Fence: The Pond Perimeter Fence identified on the Drawings shall be 72 ~~48~~-inch-high combination woven wire and barbed wire fence, 32" WW-2 BW, Type F2-32WW, as shown on the Standard Drawings in Appendix A.

B. Gates: All gates on the Pond Perimeter Fence shall be 72 ~~48~~-inch-high, 16-foot-wide Metal Farm Entrance Gate, Type G-3, as shown on the Standard Drawings in Appendix A.

2.02 CHAIN LINK FENCE: The Chain Link Fence identified on the Drawings shall be constructed of the materials shown on Standard Drawing 607-25, to the height shown on the drawings.

PART 3: EXECUTION

3.01 GENERAL: Construct all fences and gates in accordance with the standard drawings and specifications specified herein.

PART 4: MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02820

PART 1 GENERAL

1.01 DESCRIPTION: This section specifies finish grading and reseeding of all areas cleared or otherwise disturbed during construction, and any incidental work which can reasonably be inferred as necessary to provide established vegetation which is substantially free of noxious weeds or other undesirable species.

1.02 CONTRACTOR'S AND OWNER'S RESPONSIBILITES:

A. Contractor's Responsibilities:

1. The Contractor shall stockpile topsoil from clearing and grubbing operations, prepare the subgrade, spread the stockpiled topsoil and construct and maintain surface runoff diversions and controls to reduce erosion potential throughout the period of vegetation establishment.
2. The Contractor shall coordinate with the Owner to schedule the Owner's seeding operations.
3. After the Owner has seeded the prepared areas in cooperation with the Contractor and in accordance with these specifications, the Contractor shall accomplish other work as necessary to initiate germination and promote successful growth of the vegetation, and shall provide and maintain erosion and sediment control measures as required by the applicable regulations and permits

B. Owner's Responsibilities:

1. The Owner may, at the Owner's option, supply additional topsoil; any additional Owner-supplied topsoil may be hauled and placed by the owner, or by the Contractor at a unit price to be negotiated at a later date.
2. The Owner may, at the Owner's option, incorporate soil amendments and fertilizer to the topsoil stockpiled by the Contractor and/or any additional Owner-supplied topsoil; incorporation of soil amendments and/or fertilizer may be done by the Owner, or by the Contractor at a unit price to be negotiated at a later date.
3. Once the surfaces to be seeded are prepared by the Contractor as specified above, the Owner will seed the areas as specified herein.

PART 2 PRODUCTS

2.01 TOPSOIL

A. Topsoil shall be natural surface soil capable of producing satisfactory agricultural crops and shall be free of matter that may be harmful to plant growth or a hindrance to grading, seeding, and maintenance. Topsoil shall be obtained from the Contractor's onsite stockpiles, specified in Section 02101 (Clearing And Grubbing). Topsoil supplies may be supplemented by Owner-provided topsoil, at the Owner's option.

B. Topsoil, both stockpiled and imported, shall meet, or shall be improved to meet, the following mechanical requirements by adding sand and/or peat or manure and incorporating into the topsoil:

Component:	Maximum Percentage:
Sand	65 percent
Silt	50 percent
Clay	25 percent

2.02 TEXTURAL SOIL AMENDMENTS: Textural Soil Amendments shall meet the following specifications:

A. Peat: A natural residue formed by decomposition of reeds, sedges, or mosses from fresh-water site, free from lumps, roots, and stones, absorbing at least four times its dry weight of water, organic matter not less than 90 percent on a dry weight basis. The maximum moisture content at time of delivery shall be 65 percent by weight.

B. Manure: Well rotted, unleached stable or cattle manure, reasonably free from weed seed and refuse, containing no chemicals or materials harmful to plant life; not less than 4 months nor more than 2 years old. Sawdust or shavings shall not exceed 50 percent content.

C. Sand: Clean, coarse, well-graded material meeting all of the requirements of ASTM C 33 for fine aggregate.

2.03 FERTILIZER: Fertilizer shall be 18-46-0 dry standard commercial product conforming to Montana Fertilizer Law. Each brand and grade must be registered with the State Department of Agriculture. Each bag shall clearly show the net

weight of contents, name and address of manufacturer, the brand, grade, and the guaranteed analysis of the contents showing the minimum percentages of total nitrogen available, phosphoric acid and water soluble potash, in that order.

2.04 SEED

A. Seed shall be labeled in accordance with U.S.D.A. Rules and Regulations under the Federal Seed Act in effect on date of seed purchase. Seed which has become wet, moldy or otherwise damaged in transit or in storage will not be acceptable. Seed shall contain not less than eighty-five percent pure live seed and not more than 0.5 percent weed seed.

B. Testing: All seed shall be tested within twelve months prior to the planting date. All testing shall be performed by a State Seed Lab, Commercial Seed Testing Lab, or a registered member of the Society of Commercial Seed Analysts (Registered Seed Technologist). The Contractor shall furnish the Engineer with a certified test report prior to the start of seed operations. Seed not planted within the 12-month period shall be retested for dormant seed, hard seed and germination and a new certified test report furnished to the Engineer. Testing shall be the responsibility of the Contractor.

C. Labeling: Before seed is placed, the Engineer shall verify that each bag of seed delivered to the project bears a tag which shows the following information:

1. Name and address of supplier.
2. County and project number for which seed is to be used.
3. Supplier's lot number for each kind of seed.
4. Origin (where grown) for each kind of seed.
5. Purity and germination for each kind of seed.
6. Pounds of bulk seed of each kind of seed in bag.
7. Pounds of pure live seed (PLS) in each bag.
8. Dormant Seed and Hard Seed.

D. Seed Mix: The seed mixture shall be a dense nesting cover (DNC) mix of field grasses composed of the varieties described below, mixed to produce the proportions of established vegetation (% of Blend) specified below. The minimum rates of pure live seed (PLS) per acre specified below apply to broadcast-seeded or hydroseeded areas. Seed drilled by mechanical seeding equipment may be applied at half the rates specified below.

Seed Variety:	Lbs. of Pure Live Seed (PLS) per acre:
Bluebunch Wheatgrass	4.0
Western Yarrow	0.3
Crested Wheatgrass	4.0
Mountain Brome Grass	10.0
Slender Wheatgrass	2.0
TOTAL MIX	20.3

2.05 MULCH: Grass hay or straw mulching material shall be substantially free of noxious weed seeds and objectionable foreign matter. The mulch shall have been baled dry, in bales of approximately equal weight and shall be relatively dry when applied. Materials having characteristics making them unsuitable for the purpose intended will be rejected. Bromegrass is not an acceptable mulch.

PART 3 EXECUTION

3.01 GENERAL: Topsoil unnecessarily removed shall be replaced and seeded as specified herein at the Contractor's expense.

3.02 PREPARATION

A. Preparation of Subgrade: Place topsoil and prepare surface for seeding as specified in the Standard Specifications. For a more natural finished appearance, the Contractor shall round the upper and lower edges of all cut and fill slopes at subgrade before placing topsoil.

B. Spreading of Topsoil: Spread topsoil and textural soil amendments over the prepared rough grade using a rubber-tired tractor with grader blade or equivalent not weighing more than 32 tons. Spread topsoil evenly over disturbed areas.

C. Fertilizing: Fertilizer shall be applied not more than 48 hours prior to seeding. Apply commercial fertilizer at the rate of 40 pounds per 1,000 square feet distributing uniformly with a mechanical spreader, or as

recommended by local nurseries based on soil test data. Fertilizer shall be applied by one of the following methods:

1. With a fertilizer attachment on the drill, which will place the fertilizer in a band on or near the drill row behind the openers during the drilling operations (preferred method).
2. By drilling in with an approved drill prior to seeding.
3. By spreading the fertilizer uniformly over the areas to be seeded prior to or during seedbed preparation (before final pass). This method will not be acceptable when seedbed preparation is not required.

3.03 SEEDING

A. Time of Seeding: Seeding shall be done at times of the year when climatic conditions including temperature and soil moisture are conducive to growth. These periods occur in the spring of the year after the frost leaves the ground and until June 30th; and in the period of approximately September 1 through October 15th. These periods vary depending on the climatic conditions and are subject to final approval by the Engineer.

B. Inoculating Seed: Inoculant shall be stored as recommended by manufacturer and shall not be used later than the date indicated on the container or as otherwise specified. Inoculation of legumes shall be done within 48 hours before seeding.

C. Method of Seeding: The seed shall be drilled by mechanical seeding equipment approved by the Engineer. Areas that are too steep to drill shall be broadcast seeded with a mechanical seeder, or hydroseeded. Other methods of seeding may be used at the discretion of the Contractor on his own responsibility to establish smooth, uniformly grassed areas.

D. Application Rates: The seed shall be applied at the rates specified in Part 2 above.

E. Seed Cover: After application, the seed shall be covered with 0.5 to 0.75 inches of soil. The seed may be covered by dragging or by other appropriate mechanical means.

F. Maintenance: Any portion of the ground surface on which the expected stand of seed has not produced within the first year shall be restored to a satisfactory condition and reseeded with the same seed and procedures as

originally specified. Begin maintenance immediately after each portion of lawn and grass is planted and continue for 8 weeks after all lawn planting is completed. Water to keep surface soil moist. Repair washed out areas by filling with topsoil, liming, fertilizing, and seeding. Replace mulch on banks when washed or blown away. Weed by local spot application of selective herbicide only after first planting season when grass is established.

3.04 MULCHING AND MATTING

A. Matting: Erosion control blankets shall be placed as shown on the Erosion Control Plan and as specified in Section 02270. All seeded areas not receiving erosion control blankets shall be mulched.

B. Mulch Placement: The grass hay or straw mulch shall be placed within 48 hours after the seeding has been completed. Mulching operations shall not be performed during periods of high winds which preclude the proper placing of the mulch, or when wind velocity causes appreciable displacement before it can be anchored by the mulch tiller. The placing of mulch shall begin on the windward side of the areas to be covered. The mulch shall be machine blown to uniformly distribute mulch over the seeded areas. The machine shall blow or eject mulch with a constant air stream that controls the amount of mulch. The machine shall cause a minimum of cutting or breakage of the mulch. Mulch containing excessive moisture which prevents uniform feeding through the machine shall not be used. Mulch shall be placed uniformly over the seeded areas at the specified rates. Approximately 10 percent of the soil surface shall be visible through the mulch blanket prior to mulch tiller (punching) operation. Excessive cover which will smother seedlings shall be avoided.

C. Mulch Punching: Immediately following placement, the mulch shall be punched into the soil by a mulch tiller consisting of a series of dull, flat disks with notched or cut-out edges. The disks shall be approximately 20 inches in diameter, 3 inch thick, spaced approximately 8 inches apart and fitted with scrapers. The working width of the tiller shall not exceed six feet per member, but may be operated in gangs of not over three members. The tiller shall be operated on contour, except that on slopes 3:1 or steeper diagonal operation will be permitted. Tiller members shall be ballasted, to push mulch into the soil approximately three inches with ends exposed above the soil surface. The mulch tiller shall follow as closely as possible behind the mulcher. More than one pass of the mulch tiller may be required to assure adequate anchoring.

3.05 ASSESSMENT OF VEGETATION

A. A satisfactory stand is defined as a section of grass that has:

1. No bare spots larger than 3 square feet;
2. Not more than 10 percent of total area with bare spots larger than 1 square foot; and
3. Not more than 15 percent of total area with bare spots larger than 6 inches square.

B. Eight weeks after the start of maintenance on the last section of completed grass, the Engineer will assess whether a satisfactory stand of grass has been produced. If a satisfactory stand of grass, as determined by the Engineer, has not been established at the end of the 8-week maintenance period, the Engineer will make recommendations to the Owner regarding renovation and reseeding of the unsatisfactory portions thereof. If a satisfactory stand of grass does not exist in all areas after the next growing season, a complete replanting meeting all of the requirements specified herein should be completed during the fall planting season.

PART 4 MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 02905

PART 1 GENERAL

1.01 WORK INCLUDED

A. This item of work includes the formwork and shoring for cast-in-place concrete and the installation into formwork of items such as anchor bolts, pipe and pipe fittings, and other items to be embedded in concrete (but not including reinforcing steel - see Section 03200, CONCRETE REINFORCEMENT).

1.02 RELATED WORK

A. Submittals: Section 01300.

B. Quality Control: Section 01400.

C. Construction Joints: Section 03251.

D. Concrete: Section 03300.

E. Miscellaneous Metal Items and Fabrication: Section 05500.

1.03 QUALITY ASSURANCE

A. Codes and Standards:

1. The Contractor shall design, construct, erect, maintain, and remove forms and related structures for cast-in-place concrete work in compliance with the American Concrete Institute Standard ACI 347, "Recommended Practice for Concrete Formwork."

2. ACI 117, “Specifications for Tolerances for Concrete.”

3. ACI 318, “Building Code Requirements for Structural Concrete.”

4. ACI 301, “Specifications for Structural Concrete.”

B. Allowable Tolerances:

1. The Contractor shall construct formwork to provide complete finished cast-in-place concrete work within tolerances in accordance with ACI 117.

2. Before concrete placement, the Contractor must check the lines and levels of erected formwork. The Contractor shall make corrections and adjustments to ensure proper size and locations of concrete members and stability of forming systems.

3. During concrete placement, the Contractor must check formwork and related supports to ensure that forms are not displaced and that completed work will be within the specified tolerances.

1.04 SUBMITTALS

A. Samples: Prior to start of work, submit one sample each as follows:

1. Form ties.

2. Form release agent.

3. Form facing materials.

1.05 SEQUENCING AND SCHEDULING

A. Schedule work for embedded, buried, or other items of work that affects form layout before completing concrete formwork.

PART 2 PRODUCTS

2.01 FORMS FOR EXPOSED FINISH CONCRETE

A. Unless otherwise shown, the Contractor shall construct formwork for exposed concrete surfaces with plywood, plywood-faced metal frames, steel or other panel-type materials, in new and undamaged condition, to provide continuous, straight and smooth as-cast surfaces. The Contractor shall furnish the forms in the largest practicable sizes to minimize the number of joints and to conform to the joint system shown on the construction documents. The Contractor shall provide form material with sufficient thickness to withstand the pressure of the newly placed concrete without bow or deflection.

2.02 FORM TIES

A. The Contractor shall provide factory-fabricated, adjustable-length, removable or snap-off metal form ties with conical or spherical type inserts, designed to prevent form deflection and to prevent spalling concrete surfaces upon removal. Do not use wire ties.

B. The Contractor shall provide ties so that portion remaining within the concrete after removal of exterior parts is at least 1 ½ inches from the outer concrete surface except as otherwise specified. Form ties shall be provided which will not leave a hole larger than 1-inch diameter in the concrete surface. The holes shall be filled with non-shrink grout as per Section 03300, CONCRETE.

C. Form ties and wire ties fabricated on the project site are not acceptable. Do not use wire ties of any kind. Ties shall withstand form pressures and limit

form deflection to specified tolerances. Flat bar ties for panel forms shall have plastic or rubber inserts with minimum 1-inch depth and sufficient dimensions to permit proper patching of tie hole.

D. Water Stop Ties:

1. Provide for water-holding structures or dry structures with access such as basements, pipe galleries, etc., that are below finish grade.

2. Ties shall have either an integral steel water stop 0.103-inch thick and 0.625-inch in diameter tightly and continuously welded to tie, or neoprene water stop 3/16-inch thick and 15/16-inch in diameter whose center hole is ½ diameter of snap tie, or a molded plastic water stop of comparable size.

3. Flat snap ties meeting these Specifications may be provided.

4. In all cases, the water stop shall be considerably larger in area than tie cross-sectional area, oriented perpendicular to tie and symmetrical about center of tie.

5. Construct ties to provide positive means of preventing rotation or disturbance of center portion of tie during removal of ends and prevent water leaking along tie.

2.03 FORM COATING

A. The Contractor shall provide commercial formulation form-coating compounds that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, or impede the wetting of surfaces to be cured with water or curing compounds.

1. Formulate form reuse agent with rust inhibitor for steel form facing materials.

B. Form coating (non-staining form oil) shall be equal to:

1. Nox-Crete Company, Omaha, Nebraska.

2. "Form-Guard", W.R. Grace and Company, Cambridge, Massachusetts.

3. "Rheofinish 211", Master Builders, Inc.

4. "Formcel", Lambert Corporation, Houston, Texas.

2.04 DESIGN OF FORMWORK

A. The design of forms, shores, and bracing is the responsibility of the Contractor.

B. The Contractor shall design, erect, support, brace, and maintain formwork so that it will safely support vertical and lateral loads that might be applied, until such loads can be supported by the concrete structure. Formwork shall be constructed so that concrete members and structures are of correct size, shape, alignment, elevation, and position.

C. The Contractor shall provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof. Trussed supports shall be provided when adequate foundations for shores and struts cannot be secured.

D. The Contractor shall support form facing materials by structural members spaced sufficiently close to minimize deflection. Forms placed in successive units for continuous surfaces shall be fitted to accurate alignment, free from irregularities, and within allowable tolerances.

E. Design joints in forms to remain watertight and withstand placing pressures without bulging outward or creating surface patters. Do not use formwork that leaks mortar.

F. Where poor formwork is used and finish obtained is less than specified, upgrade finish to an acceptable finish at no additional cost to the Owner.

G. Panel Deflections: Limit as required to achieve construction tolerances specified herein.

H. For circular structures, forms shall conform to circular shape of structure. Straight panels may be substituted for circular forms if they do not exceed 2 feet in width and in addition to the requirement each panel does not provide an angular deflection more than 3 ½ degrees per joint, and do not conflict otherwise with these Specifications and/or Drawings.

I. Design shall account for tolerances, form ties, finishes, architectural features, rebar supports, construction joint locations, and other nonstructural formwork requirements specified.

J. Design formwork strong enough to hold high liquid heads without form distortion and to meet tolerances as specified herein. Coordinate form design with admixture company information and concrete slump.

K. Structurally design forms, falsework, shoring, and other structural formwork and meet applicable safety regulations, current OSHA regulations, and other applicable codes. Where noted or where formwork is of a critical nature (in

terms of size, complexity, etc.), a licensed engineer shall prepare formwork, falsework, and shoring designs to meet these Specifications and to meet all federal and state requirements.

L. Meet applicable portions of ACI 347, ACI 318 current edition, and these Specifications.

2.05 REINFORCING SPACERS AND REBAR SUPPORTS

A. Walls:

1. Provide positive spacers or chairs specifically designed for wall forms to hold forms and reinforcing at correct dimensions and clearances.

2. Remove spacer or chair if not designed to remain in place as concrete is placed, consolidated, and proper support and spacing is achieved.

B. Columns:

1. Provide a positive spacer between column reinforcing and column forms to ensure adequate cover.

2. Remove spacer as concrete is place, consolidated, and proper support and spacing is achieved.

3. Provide concrete blocks of same strength and density as column concrete for permanent spacers and rebar supports designed to be left in place. Color shall match concrete.

PART 3 EXECUTION

3.01 FORM CONSTRUCTION

A. General: The Contractor shall construct forms complying with ACI Standards 301, 318, and 347, to the exact sizes, shapes, lines, and dimensions shown, and as required to obtain accurate alignment, location, grades, level and plumb work in finish structures. All necessary detail work, construction aids, and embedded items shall be provided as required.

B. Design, erect, shore, brace and maintain formwork in accordance with ACI 301 to support vertical, lateral, static, and dynamic loads and construction loads that might be applied until concrete structure can support such loads.

C. The Contractor shall fabricate forms for easy removal without hammering or prying against concrete surfaces. Crush plates or wrecking plates shall be provided where stripping may damage cast concrete surfaces. Kerf wood inserts shall be provided for forming key-ways, reglets, recesses, chamfers and the like, to prevent swelling and assure ease of removal.

D. Forms for Exposed Concrete:

1. Construct formwork so concrete members and structures are of the size, shape, alignment, elevation, and position indicated, all within tolerance limits of ACI 117.

2. Limit concrete surface irregularities designated by ACI 347 as Abrupt or Gradual as follows: Class B, ¼-inch.

3. The Contractor shall drill forms to suit the ties used and to prevent leakage of concrete mortar around the tie holes. The Contractor shall not splinter forms by driving ties through improperly prepared holes.

4. The Contractor shall not use metal cover slates for patching holes or defects in forms.

5. The Contractor shall provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections shall be provided.

6. The Contractor shall use extra studs, walers, and bracing to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Narrow strips of form material which will allow the forms to bow shall not be used.

7. The Contractor shall assemble forms so that they may be readily removed without damage to exposed concrete surfaces.

8. The Contractor shall place carefully and accurately all bracing to prevent sagging or misalignment.

9. All forms shall be new or in good condition free from holes, indentations, or irregular surfaces.

10. The exposed concrete joints shall be formed with special care to assure proper alignment and uniform cross section.

11. The Contractor shall form molding shapes, recesses and projections with smooth-finish materials, and install these in the forms with sealed joints to prevent displacement.

E. Cleaning and Tightening:

1. The Contractor shall thoroughly clean forms and adjacent surfaces to receive concrete. All chips, wood sawdust, dirt, or other debris shall be removed just before concrete is to be placed. All forms shall be

retightened immediately after concrete placement as required to eliminate leaks.

3.02 FORM COATINGS

A. The Contractor shall coat the contact surfaces of forms with form-coating compound before steel reinforcement is placed. No form coating shall be allowed on steel reinforcement or on previously cast concrete sections which abut the new concrete pour.

B. The Contractor shall thin form-coating compounds only with the thinning agent of type and in amount and under the conditions recommended by the coating compound manufacturer. Excess form-coating material shall not be allowed to accumulate in the forms or to come into contact with concrete surfaces against which fresh concrete will be placed. All form coatings shall be applied in compliance with the manufacturer's instructions.

C. Steel forms shall be coated with a non-staining, rust-preventative form oil or otherwise to protect against rusting. Rust-stained steel formwork will not be accepted. Coat contact surfaces of forms with a light uniform film (a coverage rate of 1,200 square feet per gallon or higher) of the surface consolidation agent. Apply to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust. Do not get surface consolidation agent on concrete surfaces or reinforcing steel against which fresh concrete will be placed.

3.03 INSTALLATION OF EMBEDDED ITEMS

A. General: Set and build into the work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of the items to be attached thereto. Securely anchor embedded items to prevent displacement during placement of concrete.

B. Edge Forms and Screed Strips for Slabs:

1. The edge forms or bulkheads and intermediate screed strips for slabs shall be set to obtain the required elevations and contours in the finished slab surface. The Contractor shall provide and secure units to support the types of screeds required.

3.04 BEVELED EDGES (CHAMFER)

A. Form 3/4-inch bevels at concrete edges, unless otherwise shown.

B. Where beveled edges on existing adjacent structures are other than 3/4 inch, obtain Engineer's approval of size prior to placement of bevel form strip.

3.05 REMOVAL OF FORMS

A. General: Formwork not supporting concrete, such as sides of walls, and similar parts of the work, may be removed after cumulatively curing at not less than 50 degrees Fahrenheit for 24 hours after placing concrete, provided; (1) concrete strength is sufficient to withstand damage by form removal operation and the forces acting on it, and (2) that curing and protection operations are maintained.

B. Formwork supporting the weight of concrete, such as slabs and other structural elements, may not be removed until the concrete has achieved the following:

1. At least 70 percent of 28-day design compressive strength.

2. Determine compressive strength of in-place concrete by testing representative field-or laboratory-cured test specimens according to ACI 301.

3. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

C. Contractor shall assume responsibility for damage resulting from improper and premature removal of forms.

D. Satisfy applicable OSHA requirements with regard to safety of personnel and property.

E. Do not remove supports and reshore prior to obtaining adequate field cured cylinder results.

3.06 SHORES AND RESHORES

A. Comply with ACI 318, ACI 301, and recommendations in ACI 347R for design, installation, and removal of shoring and reshoring.

3.07 CONCRETE FINISHES

A. As specified in Section 03300, CONCRETE.

3.08 BACKFILL AGAINST WALLS

A. Do not backfill against walls until concrete has obtained compressive strength equal to specified 28-day compressive strength and all permanent supporting structure is in place.

B. Place backfill simultaneously on both sides of wall where required to prevent differential pressures.

3.09 FIELD TESTS

A. Wall Finish Tolerances: Test for compliance with tolerances as specified.

B. Slab Finish Tolerances and Slope Tolerances:

1. Floor flatness measurements will be made the day after floor is finished and before shoring is removed, to eliminate effect of shrinkage, curling, and deflection.

2. Support 10-foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.

3. Compliance with designated limits in four of five consecutive measurements is satisfactory unless obvious faults are observed.

4. A check for adequate slope and drainage will also be made to confirm compliance with these Specifications.

C. Finish Tolerance Failures: Repair or replace concrete as specified in Section 03300, CONCRETE.

3.10 RE-USE OF FORMS

A. All forms to be re-used in following work shall be clean and surfaces repaired to the satisfaction of the Engineer. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable. The Contractor shall apply new form-coating compound material to concrete contact surfaces as specified for new formwork.

B. When forms are extended for successive concrete placement, the Contractor shall thoroughly clean all surfaces, remove fins and laitance, and tighten forms to close all joints. All joints shall be secured and tightened to avoid offsets.

END OF SECTION 03100

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section includes the fabrication and placement of steel reinforcement for cast-in-place concrete structures, including bars, ties, supports, and welded wire fabric.

1.02 RELATED SECTIONS

A. Submittals: Section 01300.

B. Construction Joints: Section 03251.

C. Cast-in-Place Concrete: Section 03300.

D. Epoxy Anchoring of Concrete Reinforcing: Section 05500.

1.03 QUALITY ASSURANCE

A. Codes and Standards: The Contractor shall comply with all requirements of the following codes and standards (most recent edition), except as modified herein:

1. American Welding Society, AWS D12.1 "Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction."

2. Concrete Reinforcing Steel Institute, "Manual of Standard Practice."

3. American Concrete Institute, ACI 318 "Building Code Requirements for Reinforced Concrete."

4. American Concrete Institute, ACI 301 “Specifications for Structural Concrete.”

5. American Concrete Institute, ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structure."

1.04 SUBMITTALS

A. Manufacturer's Data:

1. The Contractor shall submit the Manufacturer's specifications and installation instructions for all proprietary materials and reinforcement accessories.

a. Mechanical Threaded Connections and Metal Sleeve Connectors: Furnish current International Code Conference (ICC) Research Report or equivalent code agency report listing

findings to include acceptance, special inspection requirements, and restrictions.

B. Shop Drawings:

1. The Contractor shall submit shop drawings for the fabrication, bending, and placement of concrete reinforcement. All work shall comply with the ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures." Submittals shall show bar schedules, stirrup and tie spacing, diagrams of bent bars, arrangements and assemblies. Indicate required lap lengths and construction joints. Provide submittal of proposed joint locations that differ from those shown on the Drawings for approval by the Engineer prior to submittal of reinforcing steel shop drawings.

2. The Contractor shall submit certification of grade, chemical analysis and tensile properties of the steel furnished.

3. Also see Section 01300, SUBMITTALS.

1.05 DELIVERY, HANDLING, AND STORAGE

A. All steel reinforcement delivered to the project site shall be bundled, tagged, and marked. Metal tags shall be used indicating the bar size, lengths, and other information corresponding to markings shown on placement diagrams in accordance with ACI 315.

B. The Contractor shall store concrete reinforcement materials at the site in a manner that will prevent damage and accumulation of dirt or excessive rust. Store to prevent contact with the ground. Protect all reinforcement from any contact with oil, grease, or petroleum based products of any kind.

PART 2 PRODUCTS

2.01 REINFORCING STEEL GRADE

A. Unless otherwise called for on the Drawings, all reinforcing steel for this project shall conform to ASTM A615 Grade 60. Reinforcing which is welded shall conform to ASTM A706.

2.02 ACCESSORIES

A. Chairs and spacers shall be metal stock, designed for the purpose intended.

B. All accessories shall comply with CRSI "Recommended Practice for Placing Bar Supports, Specifications and Nomenclature."

C. The Contractor shall provide stainless steel accessories for sight-exposed concrete (exterior) and at surfaces exposed to moisture (such as water holding basins, etc.).

D. Slabs on grade where the base material will not support chairs, shall use supports with sand plates or horizontal runners to properly locate steel reinforcing in the slab.

E. Wire-bar type supports shall complying with CRSI recommendations. Wood, brick, or other materials will not be accepted.

F. Tie wire shall be 16-gauge, black, soft-annealed wire. Tie wire shall not be closer than 1-inch from surface of wall or slab after tying in place.

2.03 WELDED WIRE FABRIC

A. Welded-wire fabric shall be electrically welded, 65,000 psi yield strength minimum, and shall conform to ASTM A185 or A 497 (AASHTO M55) and ACI 318, latest edition.

2.04 SPLICES AND MECHANICAL CONNECTIONS

A. Metal Sleeve: If used for splice, provide with cast filler metal, capable of developing in tension or compression 125 percent of specified yield strength of the bar, as manufactured by:

1. Erico Products, Inc., Cleveland, OH, Cadweld C-Series.

2. Or equal.

B. Mechanical Threaded Connections (Rebar Couplers): Metal coupling sleeve with internal threads which engage threaded ends of bars to be spliced, and develops in tension or compression 125 percent of the specified yield strength of the bar, as manufactured by:

1. Erico Products, Inc., Cleveland, OH, Lenton Reinforcing Steel Couplers.

2. Richmond Screw Anchor Co., Inc., Fort Worth, TX, Richmond DB-SAE Dowel Bar Splicers.

PART 3 EXECUTION

3.01 FABRICATION

A. General: The Contractor shall fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with CRSI "Manual of Standard Practice" and ACI 301. In case of fabricating

errors, the heating, rebending or straightening of reinforcement will not be permitted.

3.02 GENERAL

A. Meet requirements in the manual titled, "Placing Reinforcing Bars", published by Concrete Reinforcing Steel Institute (CRSI).

B. Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil and other foreign substance. When steel reinforcement has detrimental rust, loose scale and dust which is easily removable, it shall be cleaned by a satisfactory method, if approved.

C. All bars shall be bent cold, unless otherwise permitted. No bars partially embedded in concrete shall be field bent except as shown on the Drawings or otherwise permitted.

D. Details of concrete reinforcement and accessories not covered herein or on the Drawings shall be in accordance with ACI 315.

E. Notify Engineer when reinforcing is ready for inspection and allow sufficient time for this inspection prior to close-up of the forming system or placing concrete.

3.03 INSTALLATION

A. The Contractor shall clean reinforcement to remove all loose rust and mill scale, earth, ice, oil or grease, and other materials which reduce or destroy the bond between the concrete and reinforcing steel.

B. The Contractor shall position, support, and secure all reinforcement to prevent displacement by formwork, construction loadings, or concrete placement operations. Steel reinforcing shall be located and supported by metal chairs, runners, bolsters, spacers and hangers, as required. The reinforcement shall be placed to obtain the coverage for concrete protection noted on the Drawings. Where the coverage is not shown, the reinforcement shall be placed to obtain at least the minimum coverage specified hereinafter. The Contractor shall arrange, space, and securely tie bars and bar supports together with 16-gauge wire to hold reinforcement accurately and solidly in position during concrete placement operations. Wire ties shall be set so that the twisted ends are directed away from the exposed concrete surfaces. All reinforcement will be tied and secured in the correct position in the forms before placing concrete. Do not stab reinforcing into fresh placed concrete.

C. The Contractor shall provide a sufficient number of supports of adequate strength to carry the reinforcement. Reinforcing bars shall not be placed more than 2 inches beyond the last leg of any continuous bar support.

Supports shall not be used as bases for runways for concrete conveying equipment and similar construction loads.

D. Supports or spacers of pebbles, pieces of broken stone, concrete rubble, broken brick or building blocks, metal pipe or wooden blocks will not be permitted.

E. Splices:

1. Standard reinforcement splices shall be done by lapping the ends, placing the bars in contact, and tightly wiring the splice together. The requirements of ACI 318 for minimum lap of spliced bars shall be provided. Use lap splices unless otherwise shown on the Drawings or permitted in writing by the Engineer. Stagger splices in adjacent bars.

2. No field welding or tacking of reinforcement will be permitted.

3. Vertical bars in columns shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all column dowels.

F. Unless otherwise shown on the detail Drawings, the Contractor shall provide cover as shown in the General Structural Notes in the Drawings.

G. The Contractor shall provide extra reinforcing at all openings in structural walls as shown on the Drawings.

H. The Contractor shall notify the Engineer when reinforcing is in place so that an inspection of reinforcement placement can be made prior to the close-up of formwork or the placement of concrete.

I. Conform to ACI 301 for all placing tolerances.

J. Bars may be moved to avoid interference with other reinforcing steel, conduits, or embedded items. If moved more than one bar diameter or the stipulated tolerance, the Contractor shall consult with the Engineer to determine final placement.

K. At construction joints and before constructing concrete form work for next stage of construction, the Contractor shall clean all dowels, reinforcing bars and concrete surfaces. All loose material and foreign objects shall be cleaned out of forming before placement of concrete.

L. Placing Welded Wire Fabric:

1. Extend fabric to within 2-inches of edges of slab, and slab control joints and lap splices at least 1 ½ courses of fabric or minimum 8-inches.

2. Tie laps and splices securely at ends and at least every 24-inches with 16-gauge black annealed steel wire.

3. Place welded wire fabric on #4 continuous bars at 4-foot 0-inches supported at proper distance above bottom of slab. All slab reinforcing is to be discontinuous at slab control joints.

4. Meet current ACI 318 and current Manual of Standard Practice, Welded Wire Fabric, by the Wire Reinforcement Institute regarding placement, bends, laps, and other requirements.

5. All welded wire fabric shall be provided in flat sheets. Rolled fabric will not be permitted.

M. Field Bending:

1. Straightening and Rebending: Do not straighten or rebend metal reinforcement. Field bending of reinforcing steel bars is not permitted.

2. Unless permitted by Engineer, do not cut reinforcing bars in the field.

3.04 MECHANICAL SPLICES AND CONNECTIONS

A. Install as required by manufacturer with threads tightened as required by referenced ICC Report.

B. Carefully inspect each splice and verify that each component meets manufacturer's and ICC requirements.

C. Maintain minimum edge distance and concrete cover.

END OF SECTION 03200

PART 1 GENERAL

1.01 WORK INCLUDED

A. Work necessary to furnish and install, complete, the expansion, construction, and control joints including premolded fillers.

1.02 RELATED WORK SPECIFIED UNDER OTHER SECTIONS

A. Submittals: Section 01300.

B. Quality Control: Section 01400.

C. Reinforcing Steel: Section 03200.

D. Concrete: Section 03300.

1.03 SUBMITTALS

A. Product Data: Furnish for the following:

1. Joint fillers for horizontal and sloped joints.

2. Preformed control joints.

3. Water stop.

4. Sealants.

B. Shop Drawings: Furnish information listed below:

1. Plastic Type Water Stops: Details of construction joint types; show in sufficient detail water stop support used in both concrete pours to demonstrate water stop will remain secure until complete encasement.

2. Construction and Control Joints: Layout and location indicating type to be used.

C. Quality Control submittals: Furnish the following documents:

1. Water stop manufacturer's written instructions for product shipment, storage, handling, installation and repair.

2. Joint Filler and Primer: Manufacturer's written instructions for product shipment, storage, handling, application, and repair.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Prepare and protect materials for shipment in accordance with manufacturer's recommendations.

B. Acceptance at Site: Verify that plastic water stops delivered meet the cross-section dimensions shown on the Drawings and manufacturer's reviewed product data prior to unloading and storage at the site.

C. Protect hydrophilic waterstop from premature exposure to moisture which may cause premature swelling of waterstop. Store waterstops under tarps to protect from oil, dirt, and sunlight.

PART 2 PRODUCTS

2.01 PLASTIC WATER STOP

A. Extruded from an elastomeric plastic compound of which the basic resin shall be polyvinyl chloride (PVC). Reclaimed PVC in the compound is not acceptable.

B. Factory fabricate corners, intersections, and directional changes. Splice to maintain continuity at all fabricated joints.

C. Specific Gravity: Approximately 1.37.

D. Shore Durometer Type A Hardness: 65 to 80.

E. Performance Requirements: Corps of Engineers' Specification CRD-D-572.

F. Type: Center bulb with a number of parallel ribs or protrusions on each side of strip center.

1. Corrugated or tapered type water stops are not acceptable.

G. Size: Four-inch with 3/16-inch web, 6-inch or 9-inch with 3/8-inch web, as shown. Only use 4-inch size where specifically shown on the Drawings.

H. Thickness: Constant from bulb edge to the outside stop edge.

I. Minimum Weight per Foot of Water Stop:

1. 0.90 pounds for 3/16-inch by 4 inch.

2. 1.60 pounds for 3/8-inch by 6-inch.

3. 2.45 pounds for 3/8-inch by 9-inch.

J. Provide at all construction, expansion and control joints indicated on the Drawings.

K. Manufacturers and Catalog Numbers:

1. Vulcan Metal Products, Inc., Construction Materials Division, Birmingham, AL; Catalog No. 3/81-15M: Type 8067 (4-inch by 3/16-inch), Type 8069 (6-inch by 3/8-inch), and Type 8070 (9-inch by 3/8 inch).

2. Vinylex Corp., Knoxville, TN; Catalog No. 03250/ VIN (1987): No. RB6-38H (6-inch by 3/8-inch) and No. RB9-38H (9-inch by 3/8 inch).

3. Greenstreak Plastic Products, St. Louis, MO; Catalog No. 03250/GRD (1987): Style 732 (6-inch by 3/8-inch) and Style 735 (9-inch by 3/8-inch).

4. A.C. Horn, Inc., Beltsville, MD; Catalog No. CSP-162 (1987): Type 3 (4-inch by 3/16-inch), Type 9 (6-inch by 3/8-inch) and Type 10 (3/8-inch by 9-inch).

2.02 HYDROPHILIC WATERSTOP

A. Provide strip applied waterstop comprised of bentonite clay and butyl rubber where specifically shown on the Drawings, or where otherwise approved by the Engineer. Hydrophilic waterstop shall be Greenstreak Hydrotite, or equal.

B. Performance requirements shall be as follows:

Property	**Test Method**	**Required Limits**
Specific Gravity	ASTM D71	1.2 min, 1.35 max
Penetration	ASTM D217 @ 77 Degrees F	50 min, 120 max at 150 GTL 80 min at 300 GTL
Penetration after 21 day aging	ASTM D217 @ 130 Degrees F	75 @ 300 GTL
Expansion Characteristics		200% min after 21 days
Application Temperature Range		5º to 125º F
Service Range Temperature		-40º to 212º F

C. Accessories shall be provided as follows:

1. Provide manufacturer's recommended primer adhesive to secure waterstop to concrete, or other specific surfaces as required.

2. Provide concrete nails as required to secure waterstop in vertical applications to concrete surfaces.

2.03 BOND BREAKER TAPE FOR EXPANSION JOINT

A. Adhesive-backed glazed butyl or polyethylene tape which will adhere to the premolded joint material or concrete surface.

B. Width: Same as the joint.

C. Location: As shown.

2.04 BOND BREAKER

A. Provide either bond breaker tape as hereinbefore specified or a bond prevention material, nonstaining type, as specified in Section 03300, CONCRETE, except where a tape is specifically called for.

2.05 PREMOLDED JOINT FILLER (PJF)

A. Bituminous Type: ASTM D994 or D1751.

B. Sponge Rubber: Neoprene, closed-cell, expanded; ASTM D1056, Type RE-45-E1, with a compression deflection, 25 percent deflection (limits), 119 to 168 kPa (17 to 24 psi) minimum.

C. Closed-Cell Neoprene: ASTM D1752, Type I; as manufactured by W.R. Meadows, Inc., Elgin, IL; or equal.

2.06 PREFORMED CONTROL JOINT

A. One-piece, flexible, polyvinyl chloride joint former; Kold-Seal Zip-Per Strip KSF-150-50-50, manufactured by Vinylex Corp., Knoxville, TN; or equal.

B. One-piece steel strip with preformed groove; Kold Keyed Retained Kap, manufactured by Burke Concrete Accessories, Inc., San Mateo, CA; or equal.

C. Provide in full-length unspliced pieces, where possible.

D. Provide only where specifically permitted by Drawings.

2.07 SURFACE RETARDER

A. Retardant for exposing aggregates for nonformed surfaces in construction joints shall be Sika Rugasol-S, Horn Aggretex-H, Burke Company True Etch Surface Retarder, or equal. Retarder shall be applied in accordance with manufacturer's instructions sufficient to assure a minimum penetration of ¼-inch.

2.08 ACCESSORIES

A. Joint Sealant: Joint sealant shall be as specified in Section 07900, CAULKING AND SEALANTS. The type used shall be specifically intended for exterior, submerged control joint applications. A non-sag joint sealant shall be used for vertical joints and self-leveling for horizontal joints.

B. Nonshrink Grout:

1. As specified in Section 03300, CONCRETE.

2. Compatible with joint sealant.

C. Roofing Felt: 30-pound asphalt-saturated; ASTM D226, Type II; or a tar-saturated roofing felt of equal quality.

D. Reinforcing Steel: As specified in Section 03200, CONCRETE REINFORCEMENT.

E. Nails: Provide for securing bituminous type premolded joint filler.

PART 3 EXECUTION

3.01 GENERAL JOINT CONSTRUCTION

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Concrete in each unit of construction shall be placed continuously. Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by the Engineer.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.

2. Construction joints shall be formed as specified. A rough surface of exposed concrete aggregates with a minimum amplitude of +1/4-inch shall be produced using a surface retardant at construction joints,

including joints between slab and topping concrete. The limit of the treated surfaces shall be 1-inch away from the joint edges. Within 24 hours after placing, retarded surface mortar shall be removed either by high pressure water jetting or stiff brushing or combination of both so as to expose coarse aggregates. A rough surface of exposed aggregate may also be produced by sandblasting, followed by high pressure water jetting.

3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.

4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.

5. Walls exceeding 50 feet in length shall be cast in panels not to exceed 30 feet in length. Where the number of panels is three or more, the panels shall be cast in an alternating pattern, unless 5 days have elapsed between casting of adjoining panels.

6. Contractor shall submit a slab pour plan to the Engineer for review. Plan shall show dimensions and sequence of pours. Panels shall be cast in checkerboard patterns. Minimum lapsed time between placing adjacent panels shall be 24 hours.

7. Vertical construction joints shall be grooved at exposed faces. Grooves subjected to wetting or weather shall be caulked with joint sealer as specified.

8. Girders and floor slabs shall not be constructed over columns or walls until at least one hour has elapsed to allow for shrinkage in the column or wall. No joint will be allowed between a slab and a beam or girder unless otherwise specified. Waterstops shall be provided in construction joints at locations as specified.

9. Where new concrete joins existing concrete, the existing concrete shall be cleaned and roughened as noted above and shall be coated with an epoxy bonding compound prior to placing new concrete. Existing concrete is defined as concrete more than 60 days old.

C. Control Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct control joints for depth equal to at least one-fourth of concrete thickness, as follows:

1. Grooved Joints: Form control joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8-inch. Repeat

grooving of control joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.

2. Sawed Joints: Form control joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

D. Expansion or Isolation Joints: After removing formwork, install joint-filler strips at junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.

2. Terminate full-width joint-filler strips not less than ½ -inch or more than 1-inch below finished concrete surface where joint sealants, specified in Section 07900, JOINT SEALANTS, are indicated.

3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

E. Dowel Joints: Install dowel sleeves and dowels or dowel bar and support assemblies at joints where indicated.

F. Construction Joint with Water Stops:

1. Coat concrete surfaces above and below plastic water stop with bond breaker. Do not get bond breaker on water stop.

2. Avoid damage to water stop.

3. Verify that proper type and size of reinforcing and dowels are provided.

3.02 INSTALLATION OF WATER STOPS

A. General:

1. Join water stops at intersections to provide continuous seal as recommended by the waterstop manufacturer, and as specified hereinafter.

2. Center water stop on joint, unless detailed otherwise on the Drawings.

3. Secure water stop in correct position to avoid displacement during concrete placement.

4. Repair or replace damaged water stop.

5. Vibrate concrete to obtain impervious concrete in the vicinity of all joints.

6. Joints in Footings and Slabs:

   a. Ensure that space beneath plastic water stop is completely filled with concrete.

   b. During concrete placement make a visual inspection of the entire water stop area as shown.

   c. Limit concrete placement to elevation of water stop in first pass, vibrate the concrete under the water stop, lift plastic water stop to confirm full consolidation without voids, then place remaining concrete to full height of slab as shown.

   d. Apply procedure to full length of plastic water stops.

7. Waterstops shall be provided at the following joints:

   1. Joints in parts of structures exposed to ground or water on one side and occupied by nonsubmerged equipment or by personnel on the other.

   2. Wall and slab joints of tanks and channels subject to water pressure. Waterstops shall be provided from the base to at least 6 inches above high water level.

B. Plastic Water Stop: Install in accordance with details shown and manufacturer's written instructions.

C. Hydrophilic Waterstop:

1. Inspect waterstop for premature swelling, discontinuity, and debris contamination prior to concrete pour. Replace unacceptable waterstop.

2. Adhere waterstop to concrete or other surfaces shown utilizing proper primer adhesive. For vertical applications, use nails in addition to the primer adhesive to secure waterstop to concrete.

3. Primer shall be allowed to dry for two hours prior to application of waterstop.

4. Apply waterstop the same day as primer adhesive.

5. Protect waterstop from moisture, dirt, oil, and sunlight during the progress of work.

6. Install waterstop with 2 inches minimum clear cover to concrete face.

7. Waterstop shall be butt spliced pressing ends together ensuring no separation or air pockets.

D. Splices and Joints: In accordance with plastic water stop manufacturer's written instructions using a thermostatically controlled heating iron. Butt splice unless specifically detailed otherwise.

1. Allow at least 10 minutes before the new splice is pulled or strained in any way.

2. Finished splices shall provide a cross-section that is dense and free of porosity with tensile strength of not less than 80 percent of the unspliced material.

3.03 EXPANSION JOINT INSTALLATION

A. General:

1. Place bond breaker above and below water stop when premolded joint filler and pourable joint filler is not used.

2. Premolded Joint Filler:

a. Sufficient in width to completely fill the joint space where shown.

b. If a water stop is in the joint, cut premolded joint filler to butt tightly against the water stop and the side forms.

3. Precut premolded joint filler to the required depth, as detailed, at locations were joint filler or sealant is to be applied.

4. Form cavities for joint filler with either precut, premolded joint filler, or smooth removable accurately-shaped material.

5. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface.

B. Bituminous Type Premolded Joint Filler:

1. Drive nails approximately 1-foot 6- inches on center through the filler to provide anchorage embedment into concrete prior to concrete placement.

2. Secure premolded joint filler in forms before concrete is placed.

3. Install in walks, at changes in direction at intersections, and at each side of driveway entrances.

3.04 CONSTRUCTION JOINT INSTALLATION

A. Locate reinforcing and/or dowels as shown.

B. Install PVC waterstop or hydrophilic waterstop as shown.

C. Concrete surface to be dense and smooth.

D. Install bond breaker to concrete surfaces above and below water stop.

3.05 PREFORMED CONTROL JOINTS

A. Use only where specifically shown.

B. Locate flush, or slightly below the top of slab.

C. Install in accordance with manufacturer's written instructions in straight, maximum full-length pieces.

D. Steel Strip Type with Preformed Groove: Brace to withstand pressure of concrete during and after placement.

3.06 CONCRETE INSTALLATION AT JOINTS

A. As specified in Section 03300, CONCRETE.

END OF SECTION 03251

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section shall include constructing the cast-in-place concrete structures consisting of Portland cement, fine and coarse aggregate, water and selected admixtures, combined, mixed, transported, placed, finished, and cured as herein specified.

B. This section also includes grout for miscellaneous uses, surface hardeners, bonding agents, fiber reinforcement, and other related concrete accessories and construction requirements.

C. Contractor is responsible to repair all cracks in water-holding structures as specified herein. The work shall be done by an experienced and certified applicator as specified herein.

1.02 RELATED WORK

A. Submittals: Section 01300.

B. Quality Control: Section 01400.

C. Concrete Formwork: Section 03100.

D. Concrete Reinforcement: Section 03200.

E. Expansion, Construction, and Control Joints: Section 03251.

1.03 QUALITY ASSURANCE

A. The Contractor shall have available on-site a copy of ACI SP-15 "Specifications for Structural Concrete for Buildings with Selected ACI and ASTM References."

B. The Contractor shall comply with all requirements of the latest editions of the following codes and standards, except as modified herein:

1. ACI 301 "Recommended Practice for Concrete Inspection."

2. ACI 318 "Building Code Requirements for Reinforced Concrete."

3. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete."

4. ACI 305 "Recommended Practice for Hot Weather Concreting."

5. ACI 306 "Recommended Practice for Cold Weather Concreting."

6. ACI 308 "Recommended Practice for Curing Concrete."

C. Other references:

1. ACI 302 - Concrete Floor and Slab Construction

2. ACI 614 - Specification for Concrete Placement

D. Special Inspection: The Contractor shall provide the services of an independent Special Inspector certified by the appropriate jurisdiction to perform the types of inspections specified. Special Inspection requirements shall be as specified hereinafter, in Paragraph 4.12. Costs of Special Inspection shall be borne by the Contractor.

1.04 SUBMITTALS

A. Refer to Section 01300, SUBMITTALS.

B. The Contractor shall submit copies of the manufacturer's data with the application and installation instructions for proprietary materials and items, including reinforcement and forming accessories, admixtures, bonding and patching compounds, joint systems, curing compounds, floor hardeners, grout, and others as requested by the Engineer.

C. A placement schedule with a cold weather concrete placement plan shall be prepared by the Contractor and submitted to the Engineer for review prior to the start of concrete placement operations.

D. The Contractor shall furnish copies of the delivery tickets for each load of concrete delivered to the site and other information as specified under ASTM C94, Certification. A specific batched quantity for each load shall be included.

E. Concrete Mix Design Proposals: Submit each mix design to the Engineer for review at least 14 days before first use is planned. Include substantiating test data and mix design details, including aggregate gradation and source, water/cement ratio, mix proportions, air content, slump, and strength. Substantiating data must include tests by an independent testing laboratory verifying the requirements specified under "Section 2.01 PROPORTIONING AND DESIGN OF MIXES" and "PART 4 TESTING". Submit complete information for each mix design which has different strength, different aggregate size or gradation, different proportions or is to be transported differently. For previously used mix submit copies of at least 10 tests meeting these specifications. Do not use any concrete until the mix design and substantiating data for that concrete has been reviewed.

F. To demonstrate their capabilities and experience, provide qualification data for Contractor’s proposed independent testing agency that will provide the concrete mix design, trial mix batch mixtures, and testing services specified under **PART 4 TESTING.** Do not use the same agency for testing that

provides the mix design proposal specified herein. To qualify for acceptance, the independent testing agency must demonstrate, based on the evaluation criteria in ASTM C1093 that it has the experience and capability to satisfactorily conduct the testing indicated.

G. Water-Holding Basin Repair Methods: As necessary when water holding basins fail tests or if damp spots or observed seepage is present as specified. Cracks shall be repaired by the epoxy or hydrophobic grout injection process. Submit crack injection data and procedures to Engineer for review. Crack repair personnel shall have a minimum of 5 years licensed and documented experience. Submit documentation of certification and past project experience including project name, location, type and amount of repair work completed, and contact name.

H. Crack Repair Report: Epoxy or hydrophobic grout injection materials manufacturer certification that crack repair was performed by a licensed and certified applicator per the manufacturer's recommendations.

PART 2 PRODUCTS

2.01 PROPORTIONING AND DESIGN OF MIXES

A. The following mix properties are required for all concrete placement within forms:

1. Proportion and design concrete mixes shall meet the following requirements:

Strength @ 7 days	2400 psi
Strength @ 28 days	4000 psi
Maximum water/cementitious ratio	0.40 by weight
Slump @ point of placement	
Without superplasticizer	3 inches maximum
With superplasticizer	5-10 inches
Minimum Cement Content (*)	6 sacks/yard or 564 pounds per cubic yard
Fly Ash	15-25% of Cementitious Material
Entrained Air	5-8%
Maximum Aggregate Size	1 ½ -inch, as defined herein, unless shown otherwise on the Drawings.

(*) Contractor Note: Fly Ash will affect set times. Make appropriate adjustments.

2. Design shall be by an approved independent testing laboratory and a trial mix batch shall be made and tested by that laboratory. Average strength of cylinders in trial batch must exceed specified strength by 15 percent.

3. A previously used mix design may be used provided aggregate source is the same, the mixing equipment is the same, and provided at least 10 tests were made by an independent laboratory with results meeting these specifications.

4. If any of the first three 7-day cylinder tests fail to meet the specified 7-day strength, the mix shall be modified for more strength. Submit modified mix for review before use.

5. Adjustment to Concrete Mixes: Mix design adjustments may be requested by the Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, at no additional cost to the Owner. Test data for revised mix designs and strength results must be submitted and accepted before using the mix adjustments.

6. Entrained Air: Air-entraining admixture shall be used unless otherwise shown or specified. Air-entraining admixture shall be added at the manufacturer's prescribed rate to result in concrete at the point of placement with an air content as specified herein (volume basis).

7. Concrete shall be mixed in conformance with ASTM C94.

B. Entrained air admixtures shall be used according to the manufacturer's prescribed rate. Test in accordance with ASTM C231.

C. The use of an accelerating agent is not permitted unless specifically authorized by the Engineer.

D. Combined Aggregate Gradings:

1. Aggregate size shall be 1-inch maximum for slabs, grade beams, interior walls, and sections less than 12 inches thick.

2. Aggregate size shall be 3/4-inch maximum for structures with textured surfaces.

3. Aggregate size shall be 1 ½-inches maximum for all other areas or sections, unless otherwise indicated on the Drawings.

4. Grading limits for coarse aggregate shall be as follows:

Sieve Size	Percentage Passing		
	1-1/2" Max.	1" Max.	3/4" Max.
2"	-100	--	--

1-1/2"	95-100	-100	--
1"	--	95-100	-100
3/4"	25-60	--	90-100
1/2"	--	25-60	--
3/8"	--	--	40-90
No. 4	0-10	0-10	5-20
No. 8	0-5	0-5	0-5

5. Grading limits for fine aggregate shall be as follows:

Sieve Size	Percentage Passing
3/8"	-100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10
No. 200	0-4

6. The combined mixture of fine and coarse aggregate shall be such that not more than 1.5 percent passes the No. 200 sieve.

2.02 PORTLAND CEMENT

A. Meet ASTM C150, Type I or Type II, or Type I-II (sulfate resistant) or Type V.

B. Nonhydraulic Abovegrade Structures: Use either Type I or Type II cement.

C. Hydraulic and Belowgrade Structures: Use Type I-II (sulfate resistant) or Type V cement.

2.03 AGGREGATES

A. Fine: Clean, sharp, natural sand, ASTM C 33. Fineness modulus shall not be less than 2.5 nor more than 3.0. Materials passing 200 sieve shall be 4 percent maximum.

B. Coarse: Crushed stone or gravel, ASTM C 33. Maximum size of coarse aggregate shall be 1 ½-inches as defined hereinbefore, unless otherwise

indicated on the Drawings. Materials passing 200 sieve shall be 0.5 percent maximum.

C. Aggregates shall be natural, free from deleterious coatings, meeting ASTM C 33, nonreactive. Aggregate soundness testing for fine and coarse aggregates shall be in accordance with ASTM C 88 using a sodium sulfate solution. Thoroughly and uniformly wash before use. In accordance with ASTM C33, Appendix XI, paragraph X1.1, evidence of reactive problems on existing structures in the project area will be used to prove sources of aggregates are reactive and are unsuitable for use in the work. Import nonreactive aggregates if local aggregates are reactive.

D. Local aggregates not in compliance with the soundness and durability requirements of this standard shall not be used except with prior written approval of the Engineer and provided it can be shown by special testing or a record of past performance that these aggregates produce concrete of adequate strength and durability.

2.04 WATER

A. All water for concrete mixtures shall be clean, potable, and free from injurious substances and conforming to ASTM C 94. Water containing 2 percent or more common salt shall not be used and chloride levels shall be less than 500 parts per million.

2.05 AIR ENTRAINING ADMIXTURES

A. Air entraining admixtures shall be used in all concrete exposed to the weather and as specified for quality of concrete used, ASTM C 260, except that admixture shall be non-toxic after 30 days and contain no chlorides or other chemicals causing corrosion:

1. "Aerolith," Sonneborn Building Products, Inc.

2. "MB-VR," Master Builders Company.

3. "Sika-AER," Sika Chemical Corp.

4. "Dara Vair AT 60," W.R. Grace and Company.

5. "Protex," Protex Industries, Inc.

B. Must be compatible with water-reducing admixture. Concrete with air-entrainment admixture added shall maintain air percentage as batched, within 2 percent for minimum 1 ½ hours after addition to concrete mix and through concrete pump-up.

2.06 WATER-REDUCING ADMIXTURES

A. Water-reducing admixtures shall conform to ASTM C 494, Type A or Type D.

B. Complex, multi-component, nonchloride, noncorrosive admixture providing unique performance qualities unobtainable from conventional water-reducing admixtures.

C. Manufacturer and Product:

1. Master Builders, Inc., Cleveland, OH, Pozzolith or Pozzolith Polyheed.

2. W.R. Grace & Co., Cambridge, MA, WRDA-27, or WRDA-64.

D. Must be compatible with air entraining admixture.

2.07 SUPERPLASTICIZERS (HIGH RANGE WATER REDUCERS)

A. Meet ASTM C494 and use only Type F or G, of second or third generation type.

B. Hold slump of 5 inches or greater for the time required for placement into the structure, or 2 hours minimum.

C. Type F Superplasticizer: Batch plant added to extend plasticity time, control temperature of fresh concrete, reduce water 20 to 30 percent, and give higher strengths at all ages.

D. Type G Superplasticizer: Batch plant added to extend plasticity time, maintain setting characteristics similar to normal concrete throughout its recommended dosage range and at varying concrete temperatures, reduce water 30 to 40 percent, and give high-early and ultimate strengths.

E. Superplasticizers for Hot Weather Placements:

1. A synthesized sulfonated complex polymer type superplasticizer containing no chlorides or alkalines.

2. Add to concrete mix at manufacturer's recommended dosage to allow placement with concrete temperatures up to 90 degrees F.

F. Manufacturer and Product:

1. Master Builders, Inc., Cleveland, OH, Rheobuild or Pozzolith Polyheed at a dosage greater than 10 ounces per 100 pounds of cement.

2. W.R. Grace & Co., Cambridge, MA, Daracem 19.

3. Euclid Chemical Co., Cleveland, OH, Eucon Super F or 537G.

2.08 FLY ASH

A. Fly ash shall be used with Cement Type V or Type I-II. Submit complete manufacturer's literature. If used conform to ASTM C618, Type F modified to allow SiO_2+Al_2O_3+FeO_3 minimum 66 percent and SiO_2 minimum 40 percent and to require a maximum loss on ignition of 2 percent. Do not use to replace more than 25 percent by weight. Maximum water to cement plus fly ash ratio shall not exceed 0.38 by weight.

2.09 CALCIUM CHLORIDE

A. Calcium chloride and products containing more than 0.1% chloride ions are not permitted. Provide admixture manufacturer's written certification that chloride ion content complies with specified requirements.

2.10 CONCRETE CURING MATERIALS

A. Do not use curing compound where additional finishes such as hardeners, paintings, and other special coatings are required. Use water curing as specified instead.

B. Absorptive cover shall be provided by burlap cloth made from jute or kenaf, weighing approximately 9 ounces per square yard and complying with AASHTO M 182, Class 2.

C. A moisture retaining cover shall comply with one of the following:

1. Waterproof paper, ASTM C 171.

2. Polyethylene film, ASTM C 171.

3. Curing Compound: Resin based compound conforming to ASTM C 309, with additional requirement that the moisture loss shall not exceed 0.030 gm/square cm/72 hours.

D. Manufacturer's certification shall state that curing compound can be applied in one coat and shall show the quantity or coverage required to meet or exceed that above moisture retention.

E. Provide manufacturer's certification that curing compound is acceptable to the appropriate state agency or health department.

2.11 CRACK REPAIR MATERIALS

A. One hundred percent solids, two-component low viscosity epoxy resin for injection, Sikadur 52 or Sikadur 35 HMLV, by Sika Chemical Corp., Lyndhurst, NJ., or approved equivalent. Epoxy cap seal for sealing cracks and mounting injection ports, Sikadur 31 HMGEL, or approved equivalent.

B. In special applications, an expanding polyurethane chemical hydrophobic grout such as Sika Fix HH by Sika Chemical Corp. may also be considered, as approved by the Engineer.

2.12 NON-SHRINK GROUT

A. Nonshrink Grout Category I:

1. Nonshrink, nonmetallic, nongas-liberating grout for use in filling tie holes in concrete, blockouts for gate guides, joints of precast components or members, and grouting baseplates of columns that do not exceed one story in height shall be one of the following:

a. SIKA Grout 212, Sika Chemical Corp., Lyndhurst, NJ

b. GP Grout, US. Spec, Denver, CO

c. EUCO NS grout, Euclid Chemical Co., Cleveland, OH

d. Five Star Special 100, U.S. Grout Corp., Fairfield, CT

e. SET nonshrink grout, Master Builders Co., Cleveland, OH

f. Supreme grout, Gifford Hill & Co., Dallas, TX

g. UPCON "Super Flow", UPCO Co., Cleveland, OH

2. All grout shall be a fluid consistency in use except that for formwork tie holes the grout shall be dry pack consistency and shall fill the conical section with dense grout hammered in with steel tool and steel hammer.

3. Use Category II grouts for patching defects in walls and slabs after form removal, or structural repair mortars such as Sika Top 123 Plus and Sika Top 122 Plus, by Sika Corporation, or equal.

B. Nonshrink Grout Category II:

1. Nonshrink grout with natural aggregate for use in high strength, precision support of machine bases of 25 hp or less; bases for precast

wall sections, columns, and precast members more than one story in height; and patching defects in walls and slabs after form removal shall conform to the Corps of Engineers' Specification for Non-Shrink Grout, CRD-C261 and to these specifications. Fluid grout as determined by the flow cone, CRD-C611, shall have a minimum strength of 4,800 psi at 7 days and 6,800 psi at 28 days as determined by CRD-C227. The following listed grouts are acceptable for use as Category II grout (field test requirement shall be met):

a. Five Star Special 100, U.S. Grout Corp., Fairfield, CT

b. EUCO HI-FLOW Grout, Euclid Chemical Co., Cleveland, OH

c. Master Flow 713, Master Builders, Cleveland, OH

d. Premium Grout, U.S. Spec, Denver, CO

e. UPCON "Super Flow", UPCO Division, Cleveland, OH

f. SIKA Grout 212, Sika Chemical Corp., Lyndhurst, NJ.

2. No material other than water shall be added to the premixed grout at the jobsite. Follow manufacturer's instructions relative to mixing, placing, and curing.

C. Nonshrink Grout Category III:

1. Nonshrink grout for use in high strength, precision support of machine bases for machinery of 30 hp or greater and soleplates where very large loads and stresses from vibration and other dynamic loads are involved and when the equipment will be subject to thermal movements. The following grouts are acceptable for use as Category III grout (field test requirements shall be met):

a. Embeco 636, Master Builders, Cleveland, OH

b. EUCO Hi-Mod grout, Euclid Chemical Co., Cleveland, OH

c. E6 2000, U.S. Spec, Denver, CO

d. SIKA 42 Grout Pak, Sika Chemical Corp., Lyndhurst, NJ

2. The location for use, other than that specified above, shall be as shown on the Drawings and/or as specified hereinafter.

3. The grout shall be free of gas-producing or gas-releasing agents, free of oxidizing catalysts, free of inorganic accelerators, and free of

chlorides. Provide performance characteristics when mixed to fluid consistency, 22 to 25 seconds (flow cone method, CRD-C 611) as follows:

a. When mixed and maintained at 45 degrees F (7 degrees C) or higher, no visible bleeding and/or settlement up to 2 hours on 1/2 gallon grout poured into gallon can, covered with glass plate to prevent evaporation.

b. Grout shall be cured in accordance with grout manufacturer's instructions.

c. Provide (2-inch by 2-inch cube) strengths as specified. Prepare specimens and test in accordance with ASTM C 109 except as follows: Mix grout in accordance with manufacturer's instructions. Fill molds in two layers, puddling each layer gently with gloved finger five times; strike off excess grout; wipe edges of mold clean with rag and cover with steel plate clamped to mold until time to test. Seal cover 24 hours after placement.

4. The grout shall obtain a minimum compressive cube strength of 5,000 psi at 3 days and 9,000 psi at 28 days (2-inch cubes).

2.13 SURFACE HARDENER

A. Surface hardeners shall consist of a colorless aqueous solution of sodium silicate and magnesium and zinc flurosilicates suitable for application to cured or partially cured concrete surfaces and capable of reacting with the soluble calcium compounds present in the concrete to form a thin surface of increased hardness with reduced potential for dusting.

B. Approved proprietary hardeners include:

1. Saniseal 100, Master Builders Company.

2. Hornolith, A.C. Horn Incorporated.

3. Lapidolith, Sonneborn Company.

4. Pena-Lith, W.R. Meadows Incorporated.

C. The solution shall be delivered ready for use at the job site.

2.14 CONTROL JOINT FORMS

A. Control Joint Forms: A standard manufacturer's item causing a control joint in the slab while providing keying across the joint. It shall not leave any portion projecting at the finished surface and it shall interrupt at least 1/4 of the slab depth. The joint or the method of installation shall insure a straight joint deviating not more than 1/2-inch from a straight line.

2.15 EPOXY BONDING AGENT

A. Two component material suitable for use on dry or damp surfaces. Provide material "Type", "Grade", and "Class", to suit project requirements. Meet the requirements of ASTM C 881.

B. Products: Subject to compliance with requirements, provide one of the following:

1. Sonocrete Epogrips, Sonneborne Co.

2. Sikadur 32 Hi-Mod or Sika Armetec 110; Sika Chemical Corp.

3. Euco Epoxy 463 or 615; Euclid Chemical Corp.

4. Patch and Bond Epoxy; The Burke Co.

2.16 FIBER REINFORCEMENT

A. Polypropylene fibers engineered and designed for secondary reinforcement of concrete slabs. Fiber reinforcement shall comply with ASTM C 1116, Type III and the following:

1. Specific gravity: 0.91.

2. Tensile strength: 80 to 110 ksi.

3. Fiber length: As graded by manufacturer for aggregate size.

4. Add fibers at time of batching and mixing grout using manufacturer’s written instructions.

B. Products shall be subject to compliance with the ASTM requirements, as provided by:

1. Fibermesh, Fibermesh Company, Division Synthetic Industries Inc.

2. Forta CR, Forta Corporation.

3. Grace Fibers, W.R. Grace and Company.

C. Add fiber reinforcement to concrete mix at a rate of 1.5 pounds/cubic yard for non-water holding basin concrete slabs and grout toppings for clarifier slabs, unless otherwise recommended by the manufacturer. See Drawings for specific requirements in General Structural Notes.

2.17 CONTROLLED DENSITY FILL, FLOWABLE FILL

A. Controlled density fill (CDF) or flowable fill shall be a concrete slurry composed of Portland cement, fine and coarse aggregate, pozzolan, admixtures, and water. Mix proportioning shall be as follows:

1. Aggregate, cement, pozzolan and water: Proportioned by weight or by volume.

2. Cementitious materials: Consisting of Portland cement and pozzolan.

3. Combined content of cement and pozzolan: Between 300 and 400 pounds per cubic yard with water totaling between 400 and 500 pounds per cubic yard of material produced. Within these limits, the amounts of cement and pozzolan may be varied to produce a fluid workable mix.

4. Minimum 7-day compressive strength: Between 75 psi and 200 psi.

5. Maximum 28-day compressive strength: No greater than 300 psi.

6. Water content: Sufficient to produce the fluid workable mix but not exceeding that required to maintain the fine aggregate in suspension and prevent segregation.

B. Air Entraining Agents:

1. May be added to improve the workability of the mix, provided the air content of the concrete slurry mix does not exceed 15 percent by volume.

2. Conform to ASTM C260.

C. Pozzolan: ASTM C618, Class F.

2.18 GROUT TOPPING FOR CLARIFIER SLABS

A. Purpose of grout topping is to provide a smooth, even surface for clarifier mechanism in the sedimentation basins to operate on. Obtain tolerance and finish requirements from manufacturer in Section 11500, BALLASTED FLOCCULATION / SEDIMENTATION PROCESS EQUIPMENT.

B. Components: Screened sand, water, water reducing admixture, fiber reinforcing, cement, pozzolan, and other admixtures.

C. Consistency: As required for placement, tolerance, bond, and strength, and as specified hereinafter in Part 3 EXECUTION for Screed Finish on Clarifier Slabs.

D. Design Strength: 4,000 psi at 28 days minimum. Provide minimum cement content specified hereinafter, regardless of strength.

E. Minimum Cement Content: 536 pounds per cubic yard. Pozzolan shall be 30 percent of the total cementitious content.

F. Cement: Type II.

G. Water/ Cementitious Ratio: 0.35 maximum.

H. Use water reducing admixtures.

I. Use fiber reinforcing as specified hereinbefore to provide greater control of cracking. Meet toughness and toughness index I5, ASTM C1018.

J. Entrained Air Content: 4% to 6%.

K. Slump shall be as required to maintain a homogeneous mix and to allow placement to meet equipment manufacturer's requirements.

L. Combined Aggregate Gradings:

1. Combine aggregates for grout in proportions that will provide a mixture within grading limits shown below, unless otherwise approved in writing by Engineer:

Sieve Sizes	Percentage Passing Sand for Grout
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	10 – 30
No. 100	2 – 10
No. 200	-

2.19 EXPOSED AGGREGATE CONCRETE

A. A cast-in-place architectural exposed aggregate finish concrete shall be used for the Main Treatment Building Entry 100 floor slab. The concrete in this area shall meet the requirements of this section, with the following changes or additions:

1. Coarse aggregate gradation shall meet the following:

Sieve Size	Percentage Passing
½ -inch	100
3/8-inch	85 – 100
No. 4	10 – 30
No. 8	0 – 10
No. 16	0 - 5

2. Color pigment shall be added for integrally colored concrete. Color pigment shall be ASTM C979, synthetic mineral-oxide pigments or colored water reducing admixtures. Color shall be stable, non-fading, and resistant to lime and other alkalis. Colors shall be in the browns and greens with final color selection to be made by Owner's representative.

PART 3 EXECUTION

3.01 CONCRETE MIXING

A. The materials for concrete shall be mixed at an acceptable concrete batch plant. Meet ACI 304 current edition and other requirements as specified for mix design, testing, and quality control. Each concrete truck delivering concrete to the site shall deliver a copy of the batch ticket to the Contractor and the Engineer.

B. Ready-mix concrete shall comply with the requirements of ASTM C94 and as herein specified:

1. The addition of water to the mix at project site must be approved by the Engineer and the maximum water-cement ratio shall not be exceeded. The delivery ticket shall be noted with amount of additional water added and submitted to the Engineer.

2. Concrete shall be discharged at the job within 1-1/2 hours after water has been added to the cement and aggregates or cement batched with the aggregates, unless a longer time is specifically authorized by the Engineer.

3. During hot weather or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C94 may be required:

    a. When the air temperature is between 85 degrees Fahrenheit and 90 degrees Fahrenheit, the mixing and delivery time shall be reduced from a maximum of 1-1/2 hours to 75 minutes and when the air temperature is above 90 degrees Fahrenheit, the mixing and delivery time shall be reduced to no more than 60 minutes.

C. Truck Mixers:

1. Equip with electrically actuated counters to readily verify the number of revolutions of the drum or blades.

2. Counter:

    a. Resettable, recording type, mounted in driver's cab.

    b. Actuated at time of starting mixers at mixing speeds.

3. Performance Requirements:

    a. Truck mixer operation shall provide a concrete batch as discharged within acceptable limits of uniformity with respect to consistency, mix and grading.

    b. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than 1 inch when specified slump is 3 inches or less, or differing by more than 2 inches when specified slump is more than 3 inches, discontinue use of truck mixer unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

    c. Check mechanical details of mixer, such as water measuring, and discharge apparatus, condition of blades, speed of rotation, general mechanical condition of unit, and clearance of drum before attempting to reuse unit.

4. Do not use nonagitating or combination truck and trailer equipment for transporting ready-mixed concrete.

D. Mixing Process:

1. Concrete Volume in Truck:

a. Limit to 63 percent of total volume capacity per ASTM C94 when truck mixed.

b. Limit to 80 percent of total volume capacity when central mixed.

2. Mix each batch of concrete in truck mixer for minimum 70 revolutions of drum or blades at rate of rotation designated by equipment manufacturer as mixing speed.

3. Perform additional mixing, if required, at speed designated by equipment manufacturer as agitating speed.

4. Place materials, including mixing water, in mixer drum before actuating the revolution counter for determining the number of mixing revolutions.

3.02 PREPARATION

A. Pre-Placement Inspection:

1. Before placing concrete, the Contractor will inspect and complete the formwork installation, placement of reinforcing steel, and items to be embedded or cast-in. Reinforcing shall not be stabbed into freshly placed concrete.

2. The wood forms shall be wetted immediately before placing the concrete when form coatings are not used. Dampen subgrade before placing concrete for slabs on grade unless a vapor barrier is used.

3. The installation of joint materials shall be coordinated with the placement of forms and reinforcing steel.

4. Secure reinforcement in position and allow Engineer to review acceptability before placing concrete.

B. Sleeves, Anchors and Inserts: All sleeves, anchors, and inserts required shall be properly placed, as detailed in the Drawings, in the concrete formwork and securely anchored to prevent displacement during the placing of the concrete.

3.03 CONCRETE PLACEMENT

A. Concrete shall be placed in compliance with the practices and recommendations of ACI Standards 304, 318, and 614, and as herein specified:

1. Concrete shall be placed continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, the Contractor shall provide construction joints as specified in Section 03251, EXPANSION, CONSTRUCTION, AND CONTROL JOINTS. The placement of concrete shall be done at such a rate that concrete is still workable. Concrete shall be placed as near as practicable to its final location to prevent segregation due to rehandling or flowing. Do not subject concrete to any procedure which will cause segregation.

2. In no case shall concrete be allowed to freely drop more than eight feet, or as specified hereinafter for super plasticized concrete.

3. Screed concrete which is to receive other construction to the proper level to avoid excessive skimming or grouting.

4. Concrete which has become non-plastic and unworkable, or does not meet the required quality control limits, or which has been contaminated by foreign material shall not be used. Do not use retempered concrete. Remove rejected concrete from the project site and dispose of it at an approved location.

5. Concrete discharge time shall be less than 90 minutes after adding cement to water and aggregate.

B. Placing Concrete Into Forms:

1. Concrete shall be placed in forms in horizontal layers not deeper than 18 inches and in a manner to avoid inclined or unplanned cold construction joints. Where placement consists of several layers, place each layer while the preceding layer is still workable to avoid cold joints.

2. Temporary spreaders in forms shall be removed when concrete placement has reached the elevation of such spreaders.

3. Concrete placed in forms shall be consolidated by mechanical vibrating equipment supplemented by hand-spading, rodding, and tamping. Use equipment and procedures for consolidation of concrete in accordance with the recommended practices of ACI 309, to suit the type of concrete and project conditions. Vibration of forms and reinforcing will not be permitted.

4. Vibrators shall not be used to transport concrete inside of the forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate the layer of concrete and at least 6

inches into the preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit the duration of the vibration to the time necessary to consolidate the concrete and complete embedment of reinforcement and other embedded items without causing segregation of the mix. Generally, this will be from 5 to 15 seconds in accordance with ACI 301.

5. Allowable Vertical Free Fall Drop to Final Placement:

   a. 5 feet in forms 8-inch or less wide and 8 feet in forms wider than 8 inches, except as hereinafter specified.

   b. Superplasticized Mixes: Up to 15 feet if slump is over 6 inches.

6. Do not use aluminum pipe or other aluminum conveying devices.

7. Provide sufficient illumination for interior of forms so concrete at places of deposit is visible to permit confirmation of consolidation quality.

C. Conveyor Belts and Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system such that concrete passing from them will not become segregated.

2. Do not use chutes longer than 50 feet.

3. Minimum Slopes of Chutes: Angled to allow concrete of specified consistency to readily flow without segregation.

4. Conveyor Belts:

   a. Must be approved by Engineer.

   b. Wipe clean with a device which does not allow mortar adhering to the belt to be wasted.

   c. Cover conveyor belts and chutes.

D. Retempering: For concrete or mortar in which cement has partially hydrated, retempering is not permitted.

E. Pumping of Concrete:

1. General:

a. Pumping is the preferred method of placing concrete.

b. If pumped concrete does not produce satisfactory end results, discontinue pumping operation until the problem is corrected.

c. At Contractor's option, other approved methods of placement may be used.

2. Equipment:

a. Provide standby pump, conveyor system, crane and concrete bucket, or other system acceptable to Engineer, on site during pumping, for adequate redundancy to assure completion of concrete placement without cold joints in case of a primary placing equipment breakdown.

b. Minimum Pump Hose (Conduit) Diameter: 4 inches.

c. Replace pumping equipment and hoses (conduits) that are not functioning properly.

d. Do not use aluminum conduits for conveying concrete.

3. Field Control (For Pumped Concrete): Take concrete samples for air content, for slump (ASTM C143), and for test cylinders (ASTM C31 and C39) at placement (discharge) end of line.

F. Maximum Size of Concrete Placements:

1. Limit size of each pour regardless whether slabs or walls, to allow for strength gain and some volume change due to shrinkage to take place. Size shall be as specified hereinafter.

2. Expansion and Construction Joints: See Section 03251, EXPANSION, CONSTRUCTION, AND CONTROL JOINTS.

G. Removal of Water: Remove all water from space to be occupied by concrete.

H. Consolidation And Visual Observation:

1. Consolidate concrete with internal vibrators with minimum frequency of 8,000 vpm and amplitude required to consolidate concrete in section being placed.

2. Provide at least one standby vibrator in operable condition at placement site prior to placing concrete.

3. Consolidation equipment and methods shall meet ACI 309.

4. Provide sufficient windows in the forms or limit form height to allow visual observation of concrete.

5. Vibrator operator shall be required to see concrete being consolidated to ensure good quality workmanship, or an individual shall actually observe the vibration of concrete at all times and advise vibrator operator of any changes needed to ensure complete consolidation.

6. Consolidation and placement locations shall be planned and accomplished so that vibrators shall be inserted in the concrete as it is placed and in locations not to exceed a distance of 5 feet from point of placement.

I. Placing Concrete Slabs on Grade:

1. Prior to concrete placing, any area of subgrade on which concrete is to be placed shall be properly wetted. Concrete slabs shall be placed in a continuous operation, within the limits of construction joints, until the placement of a panel or section is completed. When in-place concrete has sufficiently set up (at least 36 hours), an alternate section shall be placed. All joints between sections shall be properly keyed. The edges of all sections shall be tooled with a minimum radius or chamfer edging tool.

2. Concrete shall be consolidated during placement operations using vibrating equipment, so that the concrete is thoroughly worked around reinforcement and other embedded items and into the corners.

3. Slab surfaces shall be brought up to the correct level with a straightedge and struck off. Bull floats or darbies may be used to smooth the surface, leaving it free from humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations.

4. Control Joints for Non-Water Holding Slabs on Grade:

a. Locate as shown on the Drawings. Where not indicated, locate at 13 foot maximum intervals in both directions.

b. Construct with a manufactured, embedded, preformed control joint form or stop pour at each control joint using keyway forms. Install form with no offsets and in straight lines as specified elsewhere.

c. Sawn control joints will be permitted. Saw joint 1 ½-inches deep or to depth indicated on the Drawings. Start sawing

within 12-hours of final floating, but delay as necessary to prevent raveling.

5. Reinforcing steel shall be continuously maintained in the proper position during concrete placement operations.

6. All exterior concrete slabs shall be sloped in a manner to prevent the collection of water.

J. Bonding:

1. Surfaces of set concrete at all joints shall be roughened, except where bonding is obtained by use of an approved concrete bonding agent, and the surfaces shall be cleaned of laitance coating, loose particles, and foreign matter. Surfaces shall be roughened in a manner to expose bonded aggregate uniformly and laitance, loose particles of aggregates, or damaged concrete at the surface shall be removed.

2. Bonding of fresh concrete to new concrete that has set, but is less than 60 days old or is not fully cured shall be done as follows:

a. At joints between a footing and walls or columns, and between walls or columns and beams or slabs that they support, and elsewhere unless otherwise specified herein, dampen, but do not saturate, the roughened and cleaned surface of set concrete immediately before placing the fresh concrete.

b. At horizontal joints in exposed work, and at joints designed to contain liquids, dampen, but do not saturate, the roughened and cleaned surface of set concrete immediately before placing the fresh concrete.

c. An approved commercial bonding agent shall be used for water holding structures. The agent shall be applied to cleaned concrete surfaces in accordance with the printed instruction of the bonding agent manufacturer.

3. Epoxy bonding agent shall be applied in accordance with the manufacturer's recommendations for bonding to old concrete (more than 60 days old). Coat contact surfaces with bonding agent after mechanically roughening surface to a clean, rough surface.

K. Cold Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When air temperature has fallen to or is expected to fall below 40 degrees F within 3 days, uniformly heat water and aggregates before

mixing to obtain a concrete mixture temperature of not less than 50 degrees F and not more than 80 degrees F at point of placement.

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators, unless otherwise specified and approved in mix designs.

L. Hot Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 degrees F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.04 JOINTS

A. See Section 03251, EXPANSION, CONSTRUCTION, AND CONTROL JOINTS.

3.05 FINISH OF FORMED SURFACES

A. Rough Form Finish:

1. This finish shall include formed concrete surfaces buried from view by backfill in the finish work or covered by other construction, unless otherwise shown or specified. Any surface which will be exposed to the air or water in the completed structure shall be a smooth form finish.

2. The standard rough form finish shall leave the concrete surface with the texture imparted by the form facing material used, with tie holes and defective areas repaired and patched and all fins and other projections exceeding ¼-inch in height rubbed down or chipped off.

3. Fill snap-tie holes with nonshrink, non-metallic grout as specified herein. Patch honeycomb areas and rock pockets with grout as specified herein. Small air holes do not require patching.

B. Smooth Form Finish (Trowel Finish):

1. This finish includes formed concrete surfaces which will be exposed to the air or water in the completed structure or to be covered with a coating material applied directly to the concrete, or a covering material bonded to the concrete, such as water proofing, damp-proofing, painting, or other similar system.

2. A smooth form finish shall be provided by selecting form materials that will impart a smooth, hard, uniform texture and arranging them orderly and symmetrically with a minimum of seams. All defective areas shall be patched and repaired with all fins or other projections completely removed and smoothed.

3. For smooth form finish walls:

a. Fill snap-tie holes with approved nonshrink, nonmetallic color matched grout as specified herein.

b. Grind off projections, fins, and rough spots.

c. Repair other defects such as honeycomb areas, rock pockets, and rough spots resulting from form release agent failure or other reason with color matched nonshrink grout as specified herein.

4. For smooth form trowel finish slabs:

a. Finish by screeding and floating with straight-edges to bring surface to required finish elevation shown.

b. While concrete is still green, but sufficiently hardened to bear a person' weight without deep imprint, wood float to true, even plane with no coarse aggregate visible.

c. Use sufficient pressure on wood floats to bring moisture to surface.

d. After surface moisture has disappeared, hand trowel concrete to produce smooth, impervious surface, free from trowel marks.

e. Burnish surface with an additional troweling. Final troweling shall produce a ringing sound from trowel.

f. Do not use dry cement or additional water during troweling. No excessive troweling will be permitted.

g. Power Finishing:

i. An approved power machine may be used in lieu of hand finishing for finishing concrete floors and slabs in accordance with directions of machine manufacturer.

ii. Do not use power machine when concrete has not attained the necessary set to allow finishing without introducing high and low spots in slab.

iii. Do first steel troweling for slab by hand.

C. Grout Cleaned Finish:

1. A grout cleaned finish will be applied to all concrete surfaces as specified hereinafter, or which have received smooth form finish treatment, and are exposed to view. Surfaces exposed to water or on the inside of structures below the typical water surface level require a smooth form finish, but do not require a grout cleaned finish.

2. The grout cleaned finish will use one part portland cement to 1-1/2 parts fine sand by volume, and shall be mixed with water to a consistency of thick paint. Proprietary additives may be used at the Contractor's option. Standard portland cement and white portland cement amounts shall be blended as determined by trial patches, so that final color of dry grout will match adjacent surfaces.

3. The concrete surfaces shall be thoroughly wetted before the application of grout to the surfaces and to fill small holes. The entire surface shall be covered in its entirety. Excess grout will be removed by scraping and rubbing with clean burlap.

D. Broomed Finish:

1. Finish as specified for trowel floor finish, except omit final troweling and finish surface by drawing a fine-hair broom lightly across the surface.

2. Brooming: In same direction and parallel to expansion joints, or, in the case of inclined slabs, perpendicular to slope, except for round roof slab, broom surface in radial direction.

E. Sidewalk Finish:

1. Slope walks down ¼-inch per foot away from structures, unless otherwise shown.

2. Strike off surface by means of strike board and float with wood or cork float to a true plane, then flat steel trowel before brooming.

3. Broom surface at right angles to direction of traffic.

4. Lay out sidewalk surfaces in blocks with an approved grooving tool as shown or as directed by Engineer.

F. Screed Finish for Clarifier Slabs:

1. Do not place grout topping on floor of clarifier tanks (sedimentation basins) until equipment for tanks has been completely installed and is in working order.

2. Remove all laitance from surface of concrete with a sandblast or water blast, and thoroughly clean the surface.

3. Keep concrete base constantly wet for a period of 24 hours and then hand sweep with a thick cement-water slurry mixture before placing grout topping.

4. Mix Proportions for Grout Topping: As specified hereinbefore.

5. Mix grout in concrete plant as specified for concrete.

6. Mix grout to a thick, creamy consistency so it can be easily screeded with clarifier mechanism, but not so thin that it will not stand to required thickness.

7. Start placing grout at outside wall with a 4- to 5-foot wide strip and move circumferentially around and toward the center as outer area is covered.

8. Determine area of grout to be placed in any one continuous sequence and divide area to receive grout into several different continuous placement that will account for size of placement crew and equipment used.

9. Place grout in any one placement without cold joints and extend from outside wall toward the center to a radial direction.

10. Place grout to approximately required thickness by hand and then sweep surface with screeds attached to the clarifier mechanism until surface conforms accurately to blade profiles on raking arm.

11. Add additional weight to arm of mechanism to prevent it from riding up during screeding.

12. Keep grout damp by using a hose with fine mist spray to prevent premature drying.

13. As soon as grout topping is sufficiently hard, fill tank with water to a sufficient height to cover entire floor with water and leave for 7 days.

G. Related Unformed Surfaces: At horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, the placed concrete shall be struck off smooth and finished with a texture matching the adjacent formed surfaces. Continue the final surface treatment of the formed surfaces uniformly across the adjacent unformed surfaces, unless otherwise shown on the Drawings.

H. A ¾-inch chamfer shall be provided at the top of all exposed walls, except where support angles are installed, and at exposed vertical corners.

I. In addition to the description of various finishes above, concrete surfaces shall be finished in accordance with ACI Standards 301 and 302 as scheduled below:

Surface	Finish
Interior Slabs	Smooth Trowel Finish
Exterior Slabs	Broom Finish
Exterior Concrete Walls Above Final Grade	Grout Cleaned Finish
Interior Walls of Water Basins Below Low Water Level; Exposed Interior Walls, Columns, Beams and Ceilings	Smooth Finish
Exterior Concrete Below Final Grade	Rough Finish, Correct Defective Areas including Stone Pocket and Fill Tie Holes
Sidewalks	Sidewalk Finish

3.06 CONCRETE CURING AND PROTECTION

A. General:

1. Freshly placed concrete shall be protected from premature drying and excessive cold or hot temperature, and maintained without drying at a relatively constant temperature for the 7 day period of time necessary for the proper hydration of the cement. Concrete damaged by improper curing or placement methods shall be replaced by the Contractor and at no additional expense to the Owner.

2. Curing procedures shall begin immediately after placement of the concrete and continue for at least seven days or until concrete has attained 75 percent of its compressive strength in accordance with ACI 308.

B. Curing Method:

1. Liquid membrane curing shall be provided as follows:

a. The Contractor shall use a commercially produced liquid membrane forming curing compound for curing concrete which meets the requirements of ASTM C309.

b. Apply the specified membrane-forming curing compound to damp concrete surfaces as soon as the water film has disappeared. Apply uniformly in a 2-coat continuous operation by power spray equipment in accordance with the manufacturer's directions. Recoat all areas which are subjected to heavy rainfall within 3 hours after initial application. Maintain the continuity of the coating and repair any damage to the coat during the entire 7 day curing period.

c. Membrane compounds shall not be used on surfaces which are to be covered with a coating material applied directly to the concrete or with a covering material bonded to the concrete, such as other concrete, liquid floor hardener, water-proofing, damp-proofing, flooring, paintings, and other coatings and finish materials.

2. Use approved water curing method where membrane compounds are not allowed.

3. For walls, use one of the following curing methods:

a. Method 1: Leave concrete forms in place and keep entire exposed surfaces wet at all times.

b. Method 2: Apply specified curing compound as specified, where allowed, immediately after removal of forms. Apply curing compound in two coats. Each coat shall be applied at the manufacturers recommended rate for one coat application.

c. Method 3: Continuously sprinkle 100 percent of all exposed surfaces.

4. For slabs, curbs, and sidewalks use one of the following curing methods:

a. Method 1: Protect surface by ponding.

b. Method 2: Cover with burlap or cotton mats and keep continuously wet.

c. Method 3: Cover with 1-inch layer of wet sand, earth, or sawdust, and keep continuously wet.

d. Method 4: Continuously sprinkle exposed surface.

e. Other agreed upon method that will provide moisture to be present and uniform at all times on all surface of slabs.

C. Unformed surfaces shall be cured after finishing operations have been completed and as soon as marring of the concrete will not occur. The curing procedures shall continue for 7 days or until the concrete has attained 70 percent of its compressive strength in accordance with ACI 308.

D. Temperature of Concrete During Curing:

1. When the atmospheric temperature is 40 degrees Fahrenheit and below, the concrete temperature shall be maintained between 50 and 70 degrees Fahrenheit continuously throughout the 7 day curing period. When necessary, the Contractor shall make arrangements before the placement of concrete for heating, covering, insulation or housing as required to maintain the specified temperature and moisture conditions continuously throughout the concrete curing period. Cold weather protections shall comply with the requirements of ACI 306.

a. Where water curing as specified herein for slabs is not possible, use an approved curing compound as herein specified at twice the manufacturer's recommended coverage per gallon.

b. Where specified curing compound cannot be used, special methods using moisture shall be agreed upon prior to pouring the concrete slabs.

c. Protect slabs during cold weather with polyethylene sheeting or other material inside required heated enclosure if foot traffic is permitted on slabs.

2. When the atmospheric temperature is 80 degrees Fahrenheit and above, or during other climatic conditions which will cause a rapid drying of the concrete, the Contractor shall make arrangements before the start of concrete placement for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or a moisture-retaining covering. The concrete shall be protected continuously for the 7 day concrete-curing period. Hot weather concrete protection shall comply with the requirements of ACI 305.

3. The concrete temperature shall be maintained as uniformly as possible, and protected from rapid atmospheric temperature changes. Temperature changes in concrete which exceed 5 degrees Fahrenheit in any one hour and 50 degrees Fahrenheit in any 24-hour period shall be avoided and protected against.

E. During the curing period the concrete shall be protected from damaging mechanical disturbances including load stresses, excessive vibration and from damage caused by rain or flowing water. All finished concrete surfaces shall be protected from damage by subsequent construction operations. Any damage incurred shall be repaired by the Contractor at no additional expense to the Owner.

3.07 CONCRETE REPAIRS

A. Cracks in waterholding structures that are determined to have caused excessive leakage or damp spots, or if seepage is present on exposed surfaces:

1. Inject all cracks with crack repair materials as specified hereinbefore. Crack repairs shall be performed by a licensed applicator as specified hereinbefore and in accordance with the crack repair material manufacturer’s recommendations, unless approved otherwise. Repair of all cracks shall be by the Contractor at no extra cost to the Owner.

B. Defective surface areas shall be repaired and patched with grout or specialized mortar as specified hereinbefore immediately after removal of forms and as directed by the Engineer. All repairs shall be made by the Contractor at no extra cost to the Owner.

C. Repair of Formed Surfaces:

1. Formed surfaces which will be exposed-to-view or air in the completed structure and contain defects which adversely affect the appearance of the finish shall be repaired. The concrete with the defective surfaces shall be removed and replaced at no additional expense to the Owner if the defects cannot be repaired to the satisfaction of the Engineer. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, and holes left by rods and bolts, fins, and other discolorations that cannot be removed by cleaning.

2. Concealed formed concrete surfaces that contain defects that adversely affect the durability of the concrete shall be repaired. If defects cannot be repaired, the defective concrete shall be removed and replaced at no additional expense to the Owner.

D. Repair of Unformed Surfaces:

1. Unformed surfaces such as monolithic slabs may be tested by the Engineer for smoothness and to verify that the surface planeness meets the tolerances specified for each surface and finish. Any low and high areas shall be repaired by the Contractor at no additional expense to the Owner as specified herein.

2. Unformed surfaces that contain defects which adversely affect the durability of the concrete shall be repaired. Surface defects include crazing, cracks in excess of 0.01-inch in width or which penetrate to the reinforcement or completely through non-reinforced sections regardless of width, spalling, popouts, honeycomb, rock pockets, and other objectionable conditions.

3. High areas in unformed surfaces shall be repaired by grinding after the concrete has cured sufficiently so that repairs can be made without any damage to adjacent areas.

4. Low areas in unformed surfaces shall be repaired during, or immediately after, completion of surface finishing operations by cutting out the low areas and replacing with fresh concrete. The repaired areas shall be finished to blend into adjacent concrete. Proprietary patching compounds may be used when approved by the Engineer.

5. Defective areas, except random cracks and single holes not exceeding 1-inch diameter shall be repaired, by cutting the area out and placing fresh concrete. Defective areas shall be removed to sound concrete with clean, square cuts, and shall expose reinforcing steel with at least 3/4-inch clearance all around. Concrete surfaces in

contact with patching concrete shall be dampened and brushed with a neat cement grout coating or approved epoxy adhesive, or a concrete of the same type or class as the original adjacent concrete. Place, compact, and finish as required to blend with the adjacent finished concrete. The repaired area shall be cured in the same manner as adjacent concrete.

6. Isolated random cracks in non-water holding structures and single holes not over 1-inch in diameter shall be repaired by the dry-pack method. Groove the top of cracks, and cut out holes to sound concrete. Clean off all dust, dirt, and loose particles. Dampen all cleaned concrete surfaces and apply by brush a neat grout coating. Place dry-pack before the cement grout takes its initial set. Mix dry-pack, consisting of one part Portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Compact the dry-pack mixture in place and finish to match the adjacent concrete. Keep the patched areas continuously moist for not less than 72 hours.

7. Repair methods not specified above may only be used if approved by the Engineer.

3.08 SURFACE HARDENERS

A. Interior floor slabs of all new buildings shall receive an application of surface hardener as recommended by the manufacturer of the surface hardener.

B. Floors to receive hardener shall be thoroughly cured for at least 28 days, clean, unpainted, free from membrane curing compounds, and perfectly dry with all work above them completed. Apply liquid hardener evenly, using three coats, allowing 24 hours between coats. The first coat shall be 1/3 strength, second coat ½ strength, and third coat 2/3 strength, mix with water. Each coat shall be applied so as to remain wet on the concrete surface for 15 minutes. Apply approved proprietary hardeners in conformance with the manufacturer's instructions. After the final coat is completed and dry, remove surplus hardener from the surface by scrubbing and mopping with water.

3.09 CLEANING AND DISINFECTION OF STRUCTURES

A. General: Refer to Section 13435, DISINFECTION AND CLEANING for more detailed description of cleaning and disinfection requirements.

B. Cleaning: Clean thoroughly all interior concrete surfaces using water under pressure. The cleaning method adopted should accomplish the following: (1) remove all deposits of foreign nature; (2) remove all growths; (3) clean the slopes, walls, top, and bottom; (4) avoid damage to the structure; and (5) avoid pollution or oil deposits by workers and equipment. All water used in

cleaning the concrete structures should be disposed of before allowing water or sludge to the structure.

3.10 MISCELLANEOUS CONCRETE ITEMS

A. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on Drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

B. Grout base plates and foundations as indicated, using specified non-shrink grout. Use non-metallic grout for exposed conditions, unless otherwise indicated. Block out the original concrete or finish off a sufficient distance below the bottom of the machinery base to provide for the thickness of grout shown on the Drawings. After the machinery has been set in position and wedged to the proper elevation by steel wedges, the space between the bottom of the machinery base and the original pour of concrete shall be filled with a pourable nonshrinking type grout as hereinbefore specified.

3.11 REJECTIONS

A. Concrete Strength: Concrete strength shall be considered satisfactory if the average test of the two 28-day specimens exceeds the specified strength and neither specimen test falls below 95% of the specified strength. If the average strength of the two test specimens is less than specified or either specimen test is less than 95% of the specified strength, the concrete represented by the tests is rejected and must be removed and replaced at the Contractor's expense.

B. Alignment: Where concrete slabs or walls do not meet the alignment requirements, the Contractor must grind off irregularities until they comply. However, if such removal leaves less concrete section than indicated, the Engineer may reject concrete if he feels the remaining section would not be adequate.

C. Flatwork: Finished flatwork exceeding the tolerances of these specifications shall be repaired or replaced so that strength or appearance is not adversely affected. Follow paragraph 3.07 for repair work or as directed by Engineer.

D. Appearance: Concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired, if possible in accordance with paragraph 3.07. If, in the opinion of the Engineer, the defects cannot be repaired to equal the specified finish, the concrete shall be rejected.

E. Misplaced Members: Concrete members cast in the wrong location may be rejected if the strength, appearance, or function of the structure is adversely affected or misplaced items interfere with other construction.

F. Rejected Concrete: Rejected concrete shall be removed and replaced. Limits of removal shall be as directed by the Engineer to accomplish a structure equal in strength, serviceability, and appearance, to that which would have been achieved by acceptable concrete.

G. Leakage Repairs: Water holding structures with any visible leakage at joints or due to cracks or other imperfections, or for any other reason does not pass leakage test defined hereinafter shall be replaced or repaired by Contractor.

H. Expense of Repairs: The cost of all repairs, removal, replacement, etc., required by the provisions of this Article shall be borne by the Contractor.

3.12 EXPOSED AGGREGATE CONCRETE FINISH

A. Exposed aggregate finish for the floor in Main Building Entry 100 shall be treated with a surface retarder and then performed with a scrubbed finish:

1. Scrubbed Finish: After concrete has achieved a compressive strength of from 1000 to 1500 psi, apply scrubbed finish. Wet concrete surfaces thoroughly and scrub with stiff fiber or wire brushes, using water freely, until top mortar surface is removed and aggregate is uniformly exposed. Rinse scrubbed surfaces with clean water. Maintain continuity of finish on the entire surface or area of Work. Remove only enough concrete mortar from surfaces to expose the aggregate to the satisfaction of the Owner's representative.

PART 4 TESTING

4.01 TESTS OF AGGREGATE

A. Provide tests of aggregate before concreting per ASTM C33. Tests may be waived by Engineer if aggregates to be used have shown actual use to produce concrete or required strength, durability, water-tightness, fire resistance, and wearing qualities.

4.02 STRENGTH TEST OF CYLINDERS DURING WORK

A. Provide for test purposes, sets of four cylinders each, taken for each 50 cubic yards or portions placed each day. Test one cylinder per set at 7 days, two at 28 days, and retain one for backup.

B. Evaluation will be in accordance with ACI Standard Building Code Requirements for Reinforced Concrete (ACI 318 latest edition), Section 4.7,

"Evaluation and Acceptance of Concrete", and these Specifications. Where the term "building official" is used in Section 5.6 of ACI 318, term shall be redefined to "the Owner's representative".

C. Specimens will be made, cured, and tested by the Contractor's independent testing firm in accordance with ASTM C31 and ASTM C39. The Engineer shall determine which concrete trucks are to be tested in any pour and shall direct the independent testing firm. Only the Engineer or the testing firm may transport specimens or cylinders from the site to the laboratory.

D. Frequency of testing may be increased at discretion of Engineer.

E. Cold Weather Placement Tests:

1. During cold weather concreting, Contractor's independent testing firm will cast cylinders for field curing as follows. Use method which will produce greater number of specimens:

a. Six extra test cylinders from the last 100 cubic yards of concrete.

b. Minimum three specimens for each 2 hours of placing time or for each 100 yards.

2. These specimens shall be in addition to those cast by Contractor for lab testing.

3. Protect test cylinders from the weather until they can be placed under same protection provided for the parts of the structure which they represent.

4. Keep field test cylinders in same protective environment as the parts of the structure they represent, to determine if specified strength has been obtained and no further protection is needed.

5. Test cylinders in accordance with applicable sections of ASTM C31 and C39.

6. Evaluation and Acceptance: As specified herein.

4.03 SLUMP TESTS

A. Take slump tests with each strength test and as directed by the Engineer in accordance with ASTM C143.

4.04 AIR CONTENT

A. ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231, pressure method for normal weight concrete; one for each day's pour of each type of air-entrained concrete or one with each strength test.

4.05 CONCRETE TEMPERATURE

A. ASTM C1064; one test hourly when air temperature is 40 degrees F and below and when 80 degrees F and above, and one test for each set of compressive strength specimens.

4.06 TEST OF HARDENED CONCRETE

A. Acceptance shall be based on concrete cylinder tests in accordance with Paragraph 3.11. Contractor may provide additional test by coring per ASTM C42 or load tests for that portion of job where questionable concrete has been placed. Such additional testing will be accepted in lieu of cylinder tests. Results of rebound hammer tests will not be accepted except in defining problem areas.

4.07 TESTING AGENCY

A. All tests shall be made by an independent testing laboratory approved by the Engineer. Engineer shall direct when and where all tests are made.

4.08 COST OF TESTING

A. The Contractor shall bear all costs of testing required by this section including tests of hardened concrete where cylinder strengths indicate high or low strength concrete.

4.09 TEST RESULTS

A. Submit two (2) copies of all tests to Engineer within 24 hours of testing.

4.10 CURE BOX

A. Provide a cure box at the project site for initial cure of test cylinders. Construct and equip box to provide initial cure in accordance with ASTM C31.

4.11 WATER LEAKAGE TESTS

A. Purpose: Determine integrity of finished concrete and to show exposed wall surfaces are visually acceptable. Exposed shall mean all wall surfaces prior to backfilling and other permanently or temporarily exposed areas for all water holding structures.

B. All Water-Holding Structures:

1. Perform leakage tests after concrete has cured and obtained its design strength, and before backfill, or other work which will cover concrete wall surfaces is begun.

2. Make other equipment, i.e., stop gates, sluice gates, valves, etc., or temporary bulkheads water-tight prior to test.

3. As an alternative to having watertight bulkheads, gates, or valves, accurately measure the leakage through gates, valves, and bulkheads with methods acceptable to Engineer. An assumed leakage through gates and valves based on manufacturer's recommendations is not acceptable.

4. Fill with water to maximum liquid level prior to leak testing, and maintain level for 48 hours for moisture absorption by concrete.

5. Close all valves and gates to the structure and measure the change in water surface for a 24-hour period.

6. During test period, examine exposed portions of structure for dampness or leaks and mark visible leaks or damp spots.

C. Test Evaluation Criteria:

1. An acceptable test shall have a drop in water surface in 24-hour period with basin full less than 1/10 of 1 percent of normal volume of liquid contained in water-holding structure, after accounting for evaporation and precipitation in open basins, and damp spots with water drops or seepage are not present on walls or other areas exposed to view prior to any backfilling.

2. Determine evaporation by floating an evaporation pan in structure during test period.

D. Excessive Leakage and Leakage Test Failure: If drop in water surface exceeds test evaluation criteria or if damp spots with water drops or seepage is visible on exposed surfaces prior to any backfilling, the leak test shall be considered as failing.

E. Repairs:

1. If leakage is excessive, or if damp spots with water drops or observed seepage is present on exposed surfaces, drain water-holding structure, repair all leaks and damp spots previously marked, and make necessary repairs, and retest basin.

2. Repair in accordance with these Specifications and as approved by Engineer.

F. Retest:

1. Refill water-holding structure and test for leakage until structure meets test criteria.

2. Successful Test: If liquid level criteria is met and damp spots and seepage problems are corrected, the retest will be considered acceptable.

G. Cost of all leakage tests, repairs, and retests shall be borne by the Contractor, at no extra cost to the Owner.

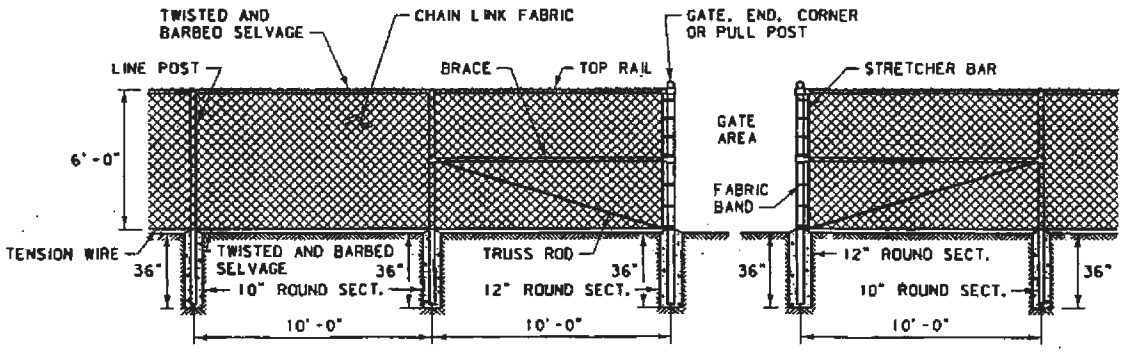
4.12 SPECIAL INSPECTION

A. Special Inspection shall be in accordance with the 2003 International Building Code, Chapter 17 for items as follows:

1. Concrete: Concrete which is part of the structure(s).

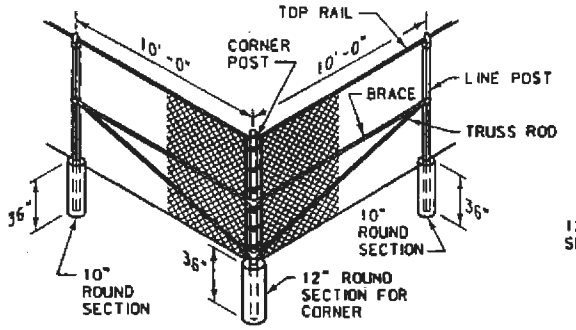
END OF SECTION 03300

APPENDIX A



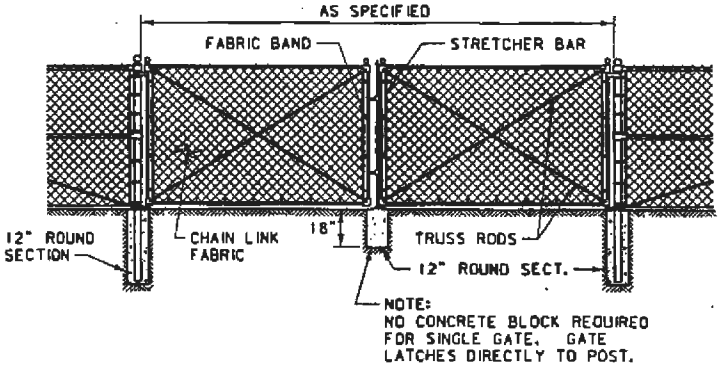
6' CHAIN LINK FENCE

SINGLE PANEL

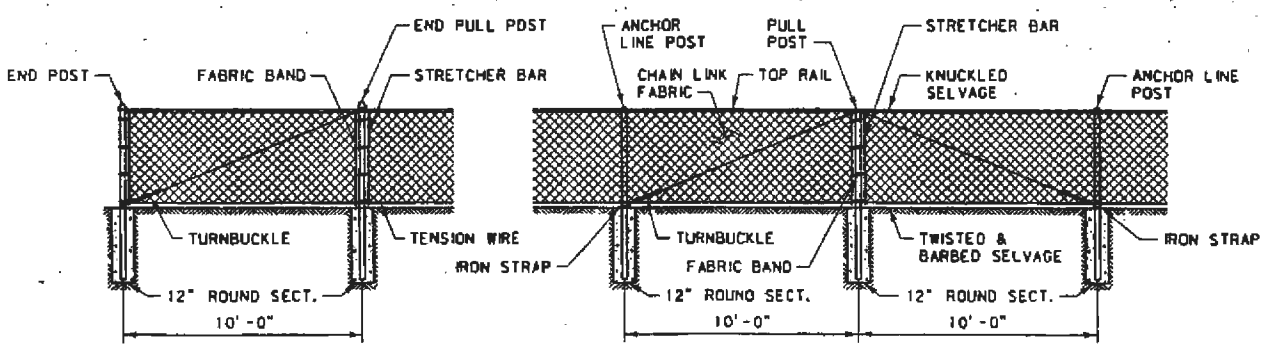


DOUBLE PANEL

PULL POST AND CORNER POST BRACING



GATES



CHAIN LINK FENCE - 3', 4' AND 5'

NOTES:

SEE THE STANDARD SPECIFICATIONS FOR FURTHER REQUIREMENTS.

DO NOT INSTALL DOUBLE PANELS MORE THAN 300' APART ON TANGENTS OR MORE THAN 250' APART ON ANY CURVE. FOR CURVES SHARPER THAN 5°, INSTALL A DOUBLE PANEL ON EACH CURVE END, PLUS ONE ADDITIONAL PANEL FOR EACH 10° OF DEFLECTION, EVENLY SPACED, BETWEEN THE CURVE ENDS.

PULL POST BRACING ON 6 FOOT FENCE IS THE SAME AS CORNER BRACING.

A DROP BAR LOCKING DEVICE IS REQUIRED FOR ALL DOUBLE GATE INSTALLATIONS. THE DROP BAR MUST BE ABLE TO BE INSERTED INTO THE CONCRETE BLOCK AT LEAST SIX INCHES.

ALL CONCRETE IS CLASS "F" OR BETTER.

WHEN FENCE IS LESS THAN 50' FROM THE EDGE OF A DRIVING LANE, USE A ⅜" DIA. GALVANIZED STEEL CABLE IN PLACE OF THE TOP METAL BRACE RAIL.

HEIGHT OF FABRIC	WIRE FABRIC ABOVE GROUND	DEPTH OF CONCRETE	DEPTH OF POST IN CONC. (MIN.)
6'	1" TO 2"	36"	32"
5'	1" TO 2"	36"	32"
4'	1" TO 2"	30"	26"
3'	1" TO 2"	30"	26"

DETAILED DRAWING

REFERENCE STANDARD SPEC. SECTION 607

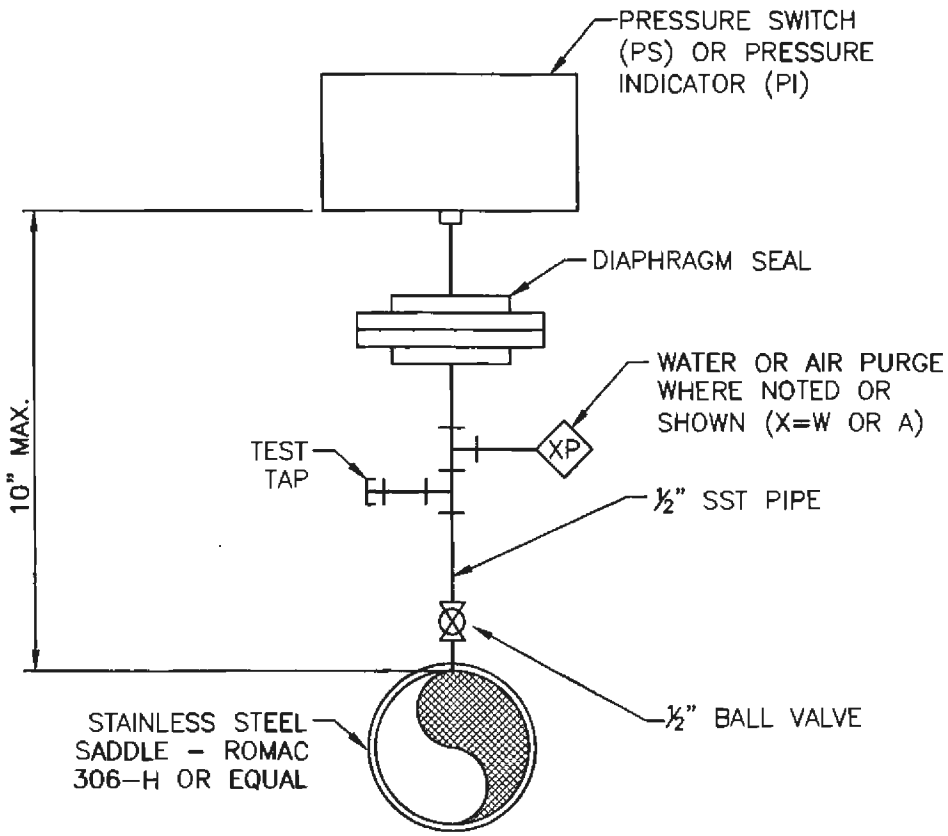
DWG. NO. 607-25

CHAIN LINK FENCE

EFFECTIVE: AUGUST 1999

MONTANA DEPARTMENT OF TRANSPORTATION

MONTANA CADD



DIRECT MOUNTED w/
DIAPHRAGM SEAL

PRESSURE SWITCH & INDICATOR INSTALLATION - DIAPHRAGM SEAL

13402

N.T.S.

NOTE TO DESIGNER:

Use Diaphragm seals in sludge or other non–clean water applications.

DET. NO. 13402

REV. DATE: 6/98

REF. ENGR. R J Morrison

APPENDIX B

Geosynthetic Research Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

Original: February 18, 2002

GRI Test Method GT12*

Standard Specification for

"Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials"

This specification was developed by the Geosynthetic Research Institute (GRI) with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers nonwoven geotextile test properties for subsequent use as protection (or cushioning) materials.

Note 1: The typical use will be as a protective covering or underlayment of a geomembrane against puncture or tear due to rock, stones, concrete or other hard surfaces and/or objects.

1.2 This specification sets forth a set of physical, mechanical and endurance properties that must be met, or exceeded by the geotextile being manufactured.

1.3 In the context of quality systems and management, this specification represents a manufacturing quality control (MQC) document.

Note 2: Manufacturing quality control represents those actions taken by a manufacturer to assure that a product represents the stated objective and properties set forth in the specification.

1.4 This standard specification is intended to assure good quality and performance of fabrics used as geotextile protection materials but is possibly not adequate for the

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

complete specification in a specific situation. Additional tests, or more restrictive values for the tests indicated, may be necessary under conditions of a particular application.

1.5 This standard specification does not address installation practices or design guidance. Both of these items are addressed in the literature dealing with this particular application.

2. Referenced Documents

2.1 ASTM Standards

D 4354 Practice for Sampling of Geosynthetics for Testing
D 4355 Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
D 4533 Test Method for Trapezoidal Tearing Strength of Geotextiles
D 4632 Test Method for Grab Breaking Load and Elongation of Geotextiles
D 4759 Practice for Determining the Specification Conformance of Geosynthetics
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 4873 Guide for Identification, Storage and Handling of Geotextiles
D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles
D 5494 Test Method for the Determination of Pyramid Puncture Resistance of Unprotected and Protected Geomembranes
D 6241 Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Product Using a 50-mm Probe

2.2 AASHTO Specification

M288-00 Geotextile Specification for Highway Applications

3. Definitions

3.1 Formulation - The mixture of a unique combination of ingredients identified by type, properties and quantity. For nonwoven geotextiles, a formulation is defined as the exact percentages and types of resin(s), additives and/or carbon black.

3.2 Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications [ref. EPA/600/R-93/182].

Note 3: This particular specification for nonwoven protection geotextiles falls under the concept of MQC.

3.3 Minimum Average Roll Value (MARV) – For geosynthetics, a manufacturing quality control tool used to allow manufacturers to establish published values such that the user/purchaser will have a 97.7% confidence that the property in question will meet published values. For normally distributed data, "MARV" is calculated as the typical value minus two (2) standard deviations from documented quality control test results for a defined population from one specific test method associated with one specific property.

4. Material Classification and Formulation

4.1 This specification covers geotextiles used as protection (or cushioning) materials.

4.2 The type of resins are usually polypropylene, polyester or polyethylene, but other resins are also possible in this regard.

4.3 The type of geotextile style is designated as a nonwoven since research has shown these fabrics to be most effective in the typical applications toward which this specification is directed. While needle-punched nonwovens are usually used, heat bonded and resin dipped manufacturing styles (or others) can also be considered.

5. Specification Requirements

5.1 The geotextiles for use as protection (or cushioning) materials shall conform to Table 1. The table is given in English units and in SI (Metric) units. The conversion from English to SI units is "soft".

5.2 Since there are a number of geotextile puncture test methods available, Table 2 is provided. Either of these tests can be considered to be an alternative test replacing ASTM D4833 in Table 1. The decision to make such a replacement must be agreed upon by the parties involved. The table is given in English units and in SI (Metric) units. The conversion from English to SI units is "soft".

5.3 The required values for all properties in Tables 1 and 2 are to be minimum average roll values (MARV) except UV resistance which is a minimum value.

6. Workmanship and Appearance

6.1 The finished geotextile shall have good appearance qualities. It shall be free from such defects that would affect the specific properties of the geotextile, or its proper functioning.

6.2 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

7. MQC Sampling, Testing, and Acceptance

7.1 Geotextiles shall be subject to sampling and testing to verify conformance with this specification. Sampling shall be in accordance with the most current modification of ASTM Standard D 4354, using the section titled, "Procedure for Sampling for Purchaser's Specification Conformance Testing." In the absence of purchaser's testing, verification may be based on manufacturer's certifications as a result of testing by the manufacturer of quality assurance samples obtained using the procedure for Sampling for Manufacturer's Quality Assurance (MQA) Testing. A lot size shall be considered to be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

7.2 Testing shall be performed in accordance with the method referenced in this specification for the indicated application. The number of specimens to test per sample is specified by each test method. Geotextile product acceptance shall be based on ASTM D4759. Product acceptance is determined by comparing the average test results of all specimens within a given sample to the specification MARV. Refer to ASTM D 4759 for more details regarding geotextile acceptance procedures.

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Shipment and Storage

9.1 Geotextile labeling, shipment, and storage shall follow ASTM D 4873. Product labels shall clearly show the manufacturer or supplier name, style, and roll number. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.

9.2 Each geotextile roll shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage due to shipment, water, sunlight and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

9.3 During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 160°F (71°C), and any other environmental condition that may damage the property values of the geotextile.

10. Certification

10.1 The contractor shall provide to the engineer a certificate stating the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to fully describe the geotextile.

10.2 The manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available upon request.

10.3 The manufacturer's certificate shall state that the finished geotextile meets MARV requirements of the specification as evaluated under the manufacturer's quality control program. A person having legal authority to bind the manufacturer shall attest to the certificate.

10.4 Either mislabeling or misrepresentation of materials shall be reason to reject those geotextile products.

English Units

Table 1(a) – Required Properties, Test Methods and Values for Geotextiles Used as Geomembrane Protection (or Cushioning) Materials

Property[1]	Test Method ASTM	Unit	Mass/Unit Area (oz/yd²)					
Mass per unit area	D5261	oz/yd²	10	12	16	24	32	60
Grab tensile strength	D4632	lb	230	300	370	450	500	630
Grab tensile elongation	D4632	%	50	50	50	50	50	50
Trap. tear strength	D4533	lb	95	115	145	200	215	290
Puncture (pin) strength	D4833	lb	120	140	170	250	300	390
UV resistance[2]	D4355	%	70	70	70	70	70	70

Notes:

(1) All values are MARV except UV resistance; it is a minimum value.

(2) Evaluation to be on 2.0 inch strip tensile specimens after 500 hours exposure.

Table 2(a) – Alternative Puncture Test Methods to be Considered in Place of Pin Puncture, ASTM D4833, in Table 1(a)

Property[1]	Test Method ASTM	Unit	Mass/Unit Area (oz/yd²)					
Mass per unit area	D5261	oz/yd²	10	12	16	24	32	60
Puncture (pyramid) strength	D5494	lb	300	320	410	440	510	760
Puncture (CBR) strength	D6341	lb	700	800	900	1100	1700	2400
Puncture (CBR) elongation	D6241	in.	1.5	1.5	1.5	1.5	1.5	1.5

(1) All values are MARV

S.I. (Metric) Units

Table 1(b) – Required Properties, Test Methods and Values for Geotextiles Used as Geomembrane Protection (or Cushioning) Materials

Property[1]	Test Method ASTM	Unit	Mass/Unit Area (g/m^2)					
Mass per unit area	D5261	g/m^2	340	406	542	812	1080	2000
Grab tensile strength	D4632	kN	1.02	1.33	1.64	2.00	2.25	2.80
Grab tensile elongation	D4632	%	50	50	50	50	50	50
Trap. tear strength	D4533	kN	0.42	0.51	0.64	0.89	0.96	1.27
Puncture (pin) strength	D4833	kN	0.53	0.62	0.75	1.11	1.33	1.71
UV resistance[2]	D4355	%	70	70	70	70	70	70

Notes:

(3) All values are MARV except UV resistance; it is a minimum value.

(4) Evaluation to be on 50 mm strip tensile specimens after 500 hours exposure.

Table 2(b) – Alternative Puncture Test Methods to be Considered in Place of Pin Puncture, ASTM D4833, in Table 1(b)

Property[1]	Test Method ASTM	Unit	Mass/Unit Area (g/m^2)					
Mass per unit area	D5261	g/m^2	340	406	542	812	1080	2000
Puncture (pyramid) strength	D5494	kN	1.33	1.42	1.82	1.96	2.27	3.37
Puncture (CBR) strength	D6241	kN	3.11	3.56	4.00	4.90	7.56	10.60
Puncture (CBR) elongation	D6241	mm	38	38	38	38	38	38

(1) All values are MARV

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Rev. 4: December 13, 2000
Revision schedule on pg. 13

GRI Test Method GM13*

Standard Specification for

"Test Properties, Testing Frequency and Recommended Warranty for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers high density polyethylene (HDPE) geomembranes with a formulated sheet density of 0.940 g/ml, or lower, in the thickness range of 0.75 mm (30 mils) to 3.0 mm (120 mils). Both smooth and textured geomembrane surfaces are included.

1.2 This specification sets forth a set of minimum, physical, mechanical and chemical properties that must be met, or exceeded by the geomembrane being manufactured. In a few cases a range is specified.

1.3 In the context of quality systems and management, this specification represents manufacturing quality control (MQC).

Note 1: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this specification.

1.4 This standard specification is intended to ensure good quality and performance of HDPE geomembranes in general applications, but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive

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values for test indicated, may be necessary under conditions of a particular application.

1.5 This specification also presents a recommended warrant which is focused on the geomembrane material itself.

1.6 The recommended warrant attached to this specification does not cover installation considerations which is independent of the manufacturing of the geomembrane.

Note 2: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

2. Referenced Documents

2.1 ASTM Standards

D 638 Test Method for Tensile Properties of Plastics
D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black in Olefin Plastics
D 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5397 Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix
D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes

2.2 GRI Standards

GM10 Specification for the Stress Crack Resistance of Geomembrane Shet

GM 11 Accelerated Weathering of Geomembranes using a Fluorescent UVA-Condensation Exposure Device

GM 12 Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage

2.3 U. S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Definitions

Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications.
ref. EPA/600/R-93/182

Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project.
ref. EPA/600/R-93/182

Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For HDPE polyethylene geomembranes, a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

4. Material Classification and Formulation

4.1 This specification covers high density polyethylene geomembranes with a formulated sheet density of 0.940 g/ml, or lower. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.932 g/ml or higher, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min.

4.3 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be a similar HDPE as the parent material.

4.4 No post consumer resin (PCR) of any type shall be added to the formulation.

5. Physical, Mechanical and Chemical Property Requirements

5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for smooth HDPE geomembranes and Table 2 is for single and double sided textured HDPE geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) is soft.

Note 3: There are several tests often included in other HDPE specifications which are omitted from this standard because they are outdated, irrelevant or generate information that is not necessary to evaluate on a routine MQC basis. The following tests have been purposely omitted:

- Volatile Loss
- Dimensional Stability
- Coeff. of Linear Expansion
- Resistance to Soil Burial
- Low Temperature Impact
- ESCR Test (D 1693)
- Wide Width Tensile
- Water Vapor Transmission
- Water Absorption
- Ozone Resistance
- Modulus of Elasticity
- Hydrostatic Resistance
- Tensile Impact
- Field Seam Strength
- Multi-Axial Burst
- Various Toxicity Tests

Note 4: There are several tests which are included in this standard (that are not customarily required in other HDPE specifications) because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Oxidative Induction Time
- Oven Aging
- Ultraviolet Resistance
- Asperity Height of Textured Sheet

Note 5: There are other tests in this standard, focused on a particular property, which are updated to current standards. The following are in this category:

- Thickness of Textured Sheet
- Puncture Resistance
- Stress Crack Resistance

- Carbon Black Dispersion (In the viewing and subsequent quantitative interpretation of ASTM D 5596 only near spherical agglomerates shall be included in the assessment).

Note 6: There are several GRI tests currently included in this standard. Since these topics are not covered in ASTM standards, this is necessary. They are the following:

- UV Fluorescent Light Exposure
- Asperity Height Measurement

5.2 The values listed in the tables of this specification are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

5.3 The properties of the HDPE geomembrane shall be tested at the minimum frequencies shown in Tables 1 and 2. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

Note 7: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively.

6. Workmanship and Appearance

6.1 Smooth geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the geomembrane.

6.2 Textured geomembrane shall generally have uniform texturing appearance. It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

6.3 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Tables 1 and 2. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Tables 1 and 2.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave."

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marketing

9.1 The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

10. Certification

10.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

11. Warranty

11.1 Upon request of the purchaser in the contract or order, a manufacturer's warrant of the quality of the material shall be furnished at the completion of the terms of the contract.

11.2 A recommended warranty for smooth and textured HDPE geomembranes manufactured and tested in accordance with this specification is given in Appendix A.

11.3 The warranty in Appendix A is for the geomembrane itself. It does not cover subgrade preparation, installation, seaming, or backfilling. These are separate operations that are often beyond the control, or sphere of influence, of the geomembrane manufacturer.

Note 8: If a warrant is required for installation, it is to be developed between the installation contractor and the party requesting such a document.

Table 1(a) – High Density Polyethylene (HDPE) Geomembrane -Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.)	D5199	nom.	Nom.	Nom.	Nom.	Nom.	Nom.	Nom.	Per roll
• lowest individual of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	
Density mg/l (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,00 lb
Tensile Properties *(1)* (min. ave.)	D 638 Type IV								20,000 lb
• yield strength		63 lb/in.	84 lb/in.	105 lb/in.	126 lb/in.	168 lb/in.	210 lb/in.	252 lb/in.	
• break strength		114 lb/in.	152 lb/in.	190 lb/in.	228 lb/in.	304 lb/in.	380 lb/in.	456 lb/in.	
• yield elongation		12%	12%	12%	12%	12%	12%	12%	
• break elongation		700%	700%	700%	700%	700%	700%	700%	
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	54 lb	72 lb	90 lb	108 lb	144 lb	180 lb	216 lb	45,000 lb
Stress Crack Resistance *(2)*	D5397 (App.)	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	per GRI-GM10
Carbon Black Content (range)	D 1603 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(5)*									200,000 lb
(a) Standard OIT	D 3895	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	
— or —									
(b) High Pressure OIT	D 5885	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	
Oven Aging at 85°C *(5), (6)*	D 5721								
(a) Standard OIT (min. ave.) - % retained after 90 days	D 3895	55%	55%	55%	55%	55%	55%	55%	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5885	80%	80%	80%	80%	80%	80%	80%	
UV Resistance *(7)*	GM 11								
(a) Standard OIT (min. ave.)	D 3895	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 5885	50%	50%	50%	50%	50%	50%	50%	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 in.

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

SI (METRIC) UNITS

Table 1(b) – High Density Polyethylene (HPDE) Geomembrane - Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness - mils (min. ave.) • lowest individual of 10 values	D5199	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	per roll
Density (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties *(1)* (min. ave.) • yield strength • break strength • yield elongation • break elongation	D 638 Type IV	 11 kN/m 20kN/m 12% 700%	 15 kN/m 27 kN/m 12% 700%	 18 kN/m 33 kN/m 12% 700%	 22 kN/m 40 kN/m 12% 700%	 29 kN/m 53 kN/m 12% 700%	 37 kN/m 67 kN/m 12% 700%	 44 kN/m 80 kN/m 12% 700%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	240 N	320 N	400 N	480 N	640 N	800 N	960 N	20,000 kg
Stress Crack Resistance *(2)*	D 5397 (App.)	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	per GRI GM-10
Carbon Black Content - %	D 1603 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	9,000 kg
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(5)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(5), (6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 3895 D 5885	N. R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	per each formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

Table 2(a) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness mils (min. ave.) • **lowest individual for 8 out of 10 values** • lowest individual for any of the 10 values	D 5994	nom. (-5%) **-10%** -15%	nom. (-5%) **-10%** -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) **-10%** -15%	nom. (-5%) **-10%** -15%	per roll
Asperity Height mils (min. ave.) *(1)*	GM 12	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties (min. ave.) *(3)* • **yield strength** • break strength • yield elongation • break elongation	D 638 **Type IV**	**63 lb/in.** 45 lb/in. 12% 100%	**84 lb/in.** 60 lb/in. 12% 100%	**105 lb/in.** 75 lb/in. 12% 100%	**126 lb/in.** 90 lb/in. 12% 100%	**168 lb/in.** 120 lb/in. 12% 100%	**210 lb/in.** 150 lb/in. 12% 100%	**252 lb/in.** 180 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	**D 4833**	**45 lb**	**60 lb**	**75 lb**	**90 lb**	**120 lb**	**150 lb**	**180 lb**	**45,000 lb**
Stress Crack Resistance *(4)*	D 5397 (App.)	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	per GR1 GM10
Carbon Black Content (range)	D 1603 *(5)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	20,000 lb
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT (min. ave.) — or — (b) **High Pressure OIT (min. ave.) - % retained after 1600 hrs** *(11)*	GM11 D 3895 **D 5885**	 N.R. *(10)* **50%**	 N.R. *(10)* **50%**	 N.R. *(10)* **50%**	 N.R. *(10)* **50%**	 N.R. *(10)* **50%**	 N.R. *(10)* **50%**	 N.R. *(10)* **50%**	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils

(2) Alternate the measurement side for double sided textured sheet

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches

(4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(6) **Carbon black dispersion (only near spherical agglomerates) for 10 different views:**
- 9 in Categories 1 or 2 and 1 in Category 3

(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(11) **UV resistance is based on percent retained value regardless of the original HP-OIT value.**

Table 2(b) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.) *(1)*	GM 12	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties (min. ave.) *(3)* • yield strength • break strength • yield elongation • break elongation	D 638 Type IV	 11 kN/m 8 kN/m 12% 100%	 15 kN/m 10 kN/m 12% 100%	 18 kN/m 13 kN/m 12% 100%	 22 kN/m 16 kN/m 12% 100%	 29 kN/m 21 kN/m 12% 100%	 37 kN/m 26 kN/m 12% 100%	 44 kN/m 32 kN/m 12% 100%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	200N	267 N	333 N	400 N	534 N	667 N	800 N	20,000 kg
Stress Crack Resistance *(4)*	D 5397 (App.)	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	per GRI GM10
Carbon Black Content (range)	D 1603 *(5)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	9,000 kg
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(11)*	GM11 D 3895 D 5885	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 0.18 mm, and lowest individual reading must be ≥ 0.13 mm

(2) Alternate the measurement side for double sided textured sheet

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(6) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3

(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(11) UV resistance is based on percent retained value regardless of the original HP-OIT value.

Appendix "A"

Typical HDPE Geomembrane Warranty

Reviewed by: Donald J. Weiss, Esq.
General Council for GSI

ABC GEOMEMBRANE COMPANY
LIMITED WARRANTY

Warranty No:_____
Project No: _____
Effective Date: _____

PURCHASER NAME: _____ PROJECT NAME: _____

ADDRESS: _____ ADDRESS/LOCATION: _____

CITY, STATE, ZIP, COUNTRY_____ CITY, STATE, ZIP, COUNTRY _____

GEOMEMBRANE TYPE/DESCRIPTION _____

ABC Geomembrane Company warrants each ABC geomembrane to be free from manufacturing defects (as defined by the contract's material specifications) and to be able to withstand normal weathering for a period of 5 years from the above effective date for normal use in approved applications.

This Limited Warranty does not include damages or defects in the ABC geomembrane resulting from acts of God, casualty or catastrophe including but not limited to: earthquakes, floods, piercing hail, tornadoes or force majeure. The term "normal use" as used herein does not include, among other things the exposure of ABC geomembranes to harmful chemicals, abuse of ABC geomembranes by machinery, equipment or people; improper site preparation or covering materials, excessive pressures or stresses from any source or improper application or installation. ABC geomembrane material warranty is intended for commercial use only and is not in effect for the consumer as defined in the Magnuson Moss Warranty or any similar federal, state, or local statues. The parties expressly agree that the sale hereunder is for commercial or industrial use only.

Should defects or premature loss of use within the scope of the above Limited Warranty occur, ABC Geomembrane Company will, at its option, repair or replace the ABC geomembrane on a pro-rata basis at the then current price in such manner as to charge the Purchaser/User only for that portion of the warranted life which has elapsed since purchase of the material. ABC Geomembrane Company will have the right to inspect and determine the cause of any alleged defect in the ABC geomembrane and to take appropriate steps to repair or replace the ABC geomembrane if a defect exists which is covered under this warranty. This Limited Warranty extends only to ABC's geomembrane, and does not extend to the installation service of ABC Geomembrane Company or third parties.

Any claim for any alleged breach of this warranty must be made in writing, by certified mail, to the President of ABC Geomembrane within ten (10) days of becoming aware of the alleged defect. Should the required notice not be given, the defect and all warranties are waived by the Purchaser, and Purchaser shall not have any rights under this warranty. ABC Geomembrane Company shall not be obligated to perform repairs or replacements under this warranty unless and until the area to be repaired or replaced is clean, dry, and unencumbered. This includes, but is not limited to, the area made available for repair and/or replacement of ABC geomembrane to be free from all water, dirt, sludge, residuals and liquids of any kind. If after inspection it is determined that there is no claim under this Limited Warranty, Purchaser shall reimburse ABC Geomembrane Company for its costs associated with the site inspection.

In the event the exclusive remedy provided herein fails in its essential purpose, and in that event only, the Purchaser shall be entitled to a return of the purchase price for so much of the material as ABC Geomembrane Company determines to have violated the warranty provided herein. ABC Geomembrane Company shall not be liable for direct, indirect, special, consequential or incidental damages resulting from a breach of this warranty including, but not limited to, damages for loss of production, lost profits, personal injury or property damage. ABC Geomembrane Company shall not be obligated to reimburse Purchaser for any repairs, replacement, modifications or alterations made by Purchaser unless ABC Geomembrane Company specifically authorized, in writing, said repairs, replacements, modifications or alteration in advance of them having been made. ABC Geomembrane Company's liability under this warranty shall in no event exceed the replacement cost of the material sold to the Purchaser for the particular installation in which it failed.

ABC Geomembrane Company neither assumes nor authorizes any person other than the undersigned of ABC Geomembrane Company to assume for it any other or additional liability in connection with the ABC geomembrane made on the basis of the Limited Warranty. The Limited Warranty on the ABC geomembrane herein is given in lieu of all other possible material warranties, either expressed or implied, and by accepting delivery of the material, Purchaser waives all other possible warranties, except those specifically given.

Limited Warranty is extended to the purchaser/owner and is non-transferable and non-assignable; i.e., there are no third-party beneficiaries to this warranty.

Purchaser acknowledges by acceptance that the Limited Warranty given herein is accepted in preference to any and other possible materials warranties.

ABC GEOMEMBRANE COMPANY MAKES NO WARRANTY OF ANY KIND OTHER THAN THAT GIVEN ABOVE AND HEREBY DISCLAIMS ALL WARRANTIES, BOTH EXPRESSED OR IMPLIED, OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THIS IS THE ONLY WARRANTY THAT APPLIES TO THE MATERIALS REFERRED TO HEREIN AND ABC DISCLAIMS ANY LIABILITY FOR ANY WARRANTIES GIVEN BY ANY OTHER PERSON OR ENTITY, EITHER WRITTEN OR ORAL.

ABC GEOMEMBRANE COMPANY'S WARRANTY BECOMES AN OBLIGATION OF ABC GEOMEMBRANE COMPANY TO PERFORM UNDER THE WARRANTY ONLY UPON RECEIPT OF FINAL

I hereby state that I have read and understand the above and foregoing Limited Warranty and agree to such by signing hereunder.

DATE:_____

PURCHASER NAME: _____

ABC GEOMEMBRANE COMPANY: _____
(President or Authorized Representative)

SIGNATURE: _____ DATE_____

SIGNATURE:_____ DATE_____

TITLE:_____

Sworn before me this _____ day of _____ 200____

Adoption and Revision Schedule

for

GRI Test Method GM13

"Test Properties, Testing Frequency and Recommended Warrant for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"

Adopted:	June 17, 1997
Revision 1:	November 20, 1998; changed CB dispersion from allowing 2 views to be in Category 3 to requiring all 10 views to be in Category 1 or 2. Also reduced UV percent retained from 60% to 50%.
Revision 2:	April 29, 1999: added to Note 5 after the listing of Carbon Black Dispersion the following: "(In the viewing and subsequent quantitative interpretation of ASTM D5596 only near spherical agglomerates shall be included in the assessment)" and to Note (4) in the property tables.
Revision 3:	June 28, 2000: added a new Section 5.2 that the numeric table values are neither MARV or MaxARV. They are to be interpreted per the the designated test method.
Revision 4:	December 13, 2000: added one Category 3 is allowed for carbon black dispersion. Also, unified terminology to "strength" and "elongation".

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FAX (610) 522-8441

Original: February 18, 2002

GRI Test Method GM19*

Standard Specification for

Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification addresses the required seam strength and related properties of thermally bonded polyolefin geomembranes; in particular, high density polyethylene (HDPE), linear low density polyethylene (LLDPE) and flexible polypropylene both nonreinforced (fPP) and scrim reinforced (fPP-R).

1.2 Numeric values of seam strength and related properties are specified in both shear and peel modes.

Note 1: This specification does not address the test method details or specific testing procedures. It refers to the relevant ASTM test methods where applicable.

1.3 The thermal bonding methods focused upon are hot wedge (single and dual track) and extrusion fillet.

Note 2: Other acceptable, but less frequently used, methods of seaming are hot air and ultrasonic methods. They are inferred as being a subcategory of hot wedge seaming.

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

1.4 This specification also suggests the distance between destructive seam samples to be taken in the field, i.e., the sampling interval. However, project-specific conditions will always prevail in this regard.

1.5 This specification is only applicable to laboratory testing.

1.6 This specification does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards

D751 Standard Test Methods for Coated Fabrics

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

2.2 EPA Standards

EPA 600/2.88/052 (NTIS PB-89-129670)
Lining of Waste Containment and Other Containment Facilities

2.3 NSF Standards

NSF International Standard, Flexible Membrane Liners, NSF 54-1993 (depreciated)

2.4 GRI Standards

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

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

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

GM18 Test Properties, Testing Frequency and Recommended Warranty for Flexible Polypropylene (fPP and fPP-R) Geomembranes

3. Definition

3.1 Geomembrane, n – An essentially impermeable geosynthetic composed of one or more synthetic sheets used for the purpose of liquid, gas or solid containment.

3.2 Hot Wedge Seaming – A thermal technique which melts the two opposing geomembrane surfaces to be seamed by running a hot metal wedge or knife between them. Pressure is applied to the top or bottom geomembrane, or both, to form a continuous bond. Seams of this type can be made with dual bond tracks separated

by a nonbonded gap. These seams are referred to as dual hot wedge seams or double-track seams.

3.3 Hot Air Seaming – This seaming technique introduces high-temperature air or gas between two geomembrane surfaces to facilitate localized surface melting. Pressure is applied to the top or bottom geomembrane, forcing together the two surfaces to form a continuous bond.

3.4 Ultrasonic Seaming - A thermal technique which melts the two opposing geomembrane surfaces to be seamed by running a ultrasonically vibrated metal wedge or knife between them. Pressure is applied to the top or bottom geomembrane, or both, to form a continuous bond. Some seams of this type are made with dual bond tracks separated by a nonbonded gap. These seams are referred to as dual-track seams or double-track seams.

3.5 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. Significance and Use

4.I The various methods of field fabrication of seams in polyolefin geomembranes are covered in existing ASTM standards mentioned in the referenced document section. What is not covered in those documents is the numeric values of strength and related properties that the completed seam must meet, or exceed. This specification provides this information insofar as minimum, or maximum, property values are concerned when the field fabricated seams are sampled and laboratory tested in shear and peel. The specification also provides guidance as to what spacing intervals the samples should be taken at typical field installation projects.

5. Sample and Specimen Preparation

5.1 The spacing for taking field seam samples for destructive testing is to be 1 per 500 feet (I per 150 m) of seam length, or as by directed by the construction quality assurance inspector. As the project continues and data is accumulated, however, this sampling interval should be varied according to the procedure set forth in GRI GM14. Following this procedure three different situations can result.

5.1.1 Good seaming with fewer rejected test results than the preset historic average can result in a sequential increase in the spacing interval, i.e., one per greater than 500 ft. (one per greater than 150 m).

5.1.2 Poor seaming with more rejected test results than the preset historic average can result in a sequential decrease in the spacing interval, i.e., one per less than 500 ft. (one per less than 150 m).

5.1.3 Average seaming with approximately the same test results as the preset historic average will result in the spacing interval remaining the same, i.e., one per 500 ft. (one per 150 m).

Note 3: The method of attributes referred to in GRI GM14 is only one of several statistical strategies that might be used to vary sampling frequency. The use of control charts should also be considered in this regard.

5.2 The size of field seam samples is to be according to the referenced test method, e.g., ASTM D6392 or site-specific CQA plan.

5.3 The individual test specimens taken from the field seam samples are to be tested according to the referenced test method, i.e., ASTM D6392 for HDPE, LLDPE and fPP, and ASTM D751 (as modified by NSF 54) for fPP-R. The specimens are to be conditioned prior to testing according to these same test methods and evaluated accordingly.

6. Assessment of Seam Test Results

6.1 HDPE seams – For HDPE seams (both smooth and textured), the strength of four out of five 1.0 inch (25 mm) wide strip specimens in shear should meet or exceed the values given in Tables 1(a) and 1(b). The fifth must meet or exceed 80% of the given values. In addition, the shear percent elongation, calculated as follows, should exceed the values given in Tables 1(a) and 1(b):

$$E = \frac{L}{L_o}(100) \qquad (1)$$

where

E = elongation (%)
L = extension at end of test (in. or mm)
L_o = original average length (usually 1.0 in. or 25 mm)

Note 4: The assumed gage length is considered to be the unseamed sheet material on either side of the welded area. It generally will be 1.0 in. (25 mm) from the edge of the seam to the grip face.

For HDPE seams (both smooth and textured), the strength of four out of five 1.0 in. (25 mm) wide strip specimens tested in peel should meet or exceed the values given in Tables 1(a) and 1(b). The fifth must meet or exceed 80% of the given values.

In addition, the peel separation (or incursion) should not exceed the values given in Tables 1(a) and 1(b). The value shall be based on the proportion of area of separated bond to the area of the original bonding as follows:

$$S = \frac{A}{A_o}(100) \qquad (2)$$

where

S = separation (%)
A = average area of separation, or incursion (in^2 or mm^2)
A_0 = original bonding area (in^2 or mm^2)

Note 5: The area of peel separation can occur in a number of nonuniform patterns across the seam width. The estimated dimensions of this separated area is visual and must be done with care and concern. The area must not include squeeze-out which is part of the welding process.

Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D6392 (in this regard, SIP is an acceptable break code);

Hot Wedge: AD and AD-Brk < 25%
Extrusion Fillet: AD1, AD2 and AD-WLD (unless strength is achieved)

6.2 LLDPE seams – For LLDPE seams (both smooth and textured), the strength of four out of five 1.0 in. (25 mm) wide strip specimens in shear should meet or exceed the values given in Table 2(a) and 1(b). The fifth must meet or exceed 80% of the given values. In addition, the shear percent elongation, calculated as follows, should exceed the values given in Tables 2(a) and 2(b).

$$E = \frac{L}{L_o}(100) \qquad (1)$$

where

E = elongation (%)
L = extension at end of test (in. or mm)
L_o = original average length (usually 1.0 in. or 25 mm)

Note 4: The assumed gage length is considered to be the unseamed sheet material on either side of the welded area. It generally will be 1.0 in. (25 mm) from the edge of the seam to the grip face.

For LLDPE seams (both smooth and textured), the strength of four out of five 1.0 in. (25 mm) wide strip specimens tested in peel should meet or exceed the values given in Tables 2(a) and 2(b). The fifth must meet or exceed 80% of the given values.

In addition, the peel separation (or incursion) should not exceed the values given in Tables 2(a) and 2(b). The value shall be based on the proportion of area of separated bond to the area of the original bonding as follows:

$$S = \frac{A}{A_o}(100) \qquad (2)$$

where

S = separation (%)
A = average depth of separation, or incursion ($in.^2$ or mm^2)
A_0 = original bonding distance ($in.^2$ or mm^2)

Note 5: The area of peel separation can occur in a number of nonuniform patterns across the seam width. The estimated dimensions of this separated area is visual and must be done with care and concern. The area must not include squeeze-out which is part of the welding process.

Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D6392 (in this regard, SIP is an acceptable break code);

Hot Wedge: AD and AD-Brk < 25%
Extrusion Fillet: AD1, AD2, AD-WLD (unless strength is achieved)

6.3 fPP Seams – For fPP seams (both nonreinforced and scrim reinforced), the strength of four out of five specimens in shear should meet or exceed the values given in Tables 3(a) and 3(b). The fifth must meet or exceed 80% of the given values. Note that the unreinforced specimens are 1.0 in. (25 mm) wide strips and the scrim reinforced specimens are 4.0 in. (100 mm) wide grab tests. In addition, the shear percent elongation on the unreinforced specimens, calculated as follows, should exceed the values given in Tables 3(a) and 3(b).

$$E = \frac{L}{L_o}(100) \qquad (1)$$

where
E = elongation (%)
L = extension at end of test (in. or mm)
L_o = original gauge length (usually 1.0 in. or 25 mm)

Note 4: The assumed gage length is considered to be the unseamed sheet material on either side of the welded area. It generally will be 1.0 in. (25 mm) from the edge of the seam to the grip face.

Shear elongation is not relevant to scrim reinforced geomembranes and as such is listed as "not applicable" in Table 3(a) and 3(b).

For fPP seams (both nonreinforced and scrim reinforced), the strength of four out of five specimens in peel should meet or exceed the values given in Tables 3(a) and 3(b). The fifth must meet or exceed 80% of the given values. Note that the unreinforced specimens are 1.0 in. (25 mm) wide strips and the scrim reinforced specimens are grab tests. In addition, the peel percent separation (or incursion) should not exceed the values given in Tables 3(a) and 3(b). The values should be based on the proportion of area of separated bond to the area of the original bonding as follows.

$$S = \frac{A}{A_o}(100) \qquad (2)$$

where

S = separation in (%)
A = average depth of separation, or incursion (in.^{2} or mm^2)
A_o = original bonding distance (in.^{2} or mm^2)

Note 5: The area of peel separation can occur in a number of nonuniform patterns across the seam width. The estimated dimensions of this separated area is visual and must be done with care and concern. The area must not include squeeze-out which is part of the welding process.

Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D6392 (in this regard, SIP is an acceptable break code);

Hot Wedge: AD and AD-Brk < 25%
Extrusion Fillet: AD1, AD2 and AD-WLD (unless strength is achieved)

7. Retest and Rejection

7.1 If the results of the testing of a sample do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the construction quality control or construction quality assurance plan for the particular site under construction.

8. Certification

8.1 Upon request of the construction quality assurance officer or certification engineer, an installer's certification that the geomembrane was installed and tested in accordance with this specification, together with a report of the test results, shall be furnished at the completion of the installation.

Table 1(a) – Seam Strength and Related Properties of Thermally Bonded Smooth and Textured High Density Polyethylene (HDPE) Geomembranes **(English Units)**

Geomembrane Nominal Thickness	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams[1]							
shear strength[2], lb/in.	57	80	100	120	160	200	240
shear elongation at break[3], %	50	50	50	50	50	50	50
peel strength[2], lb/in.	39	52	65	78	104	130	156
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams							
shear strength[2], lb/in.	57	80	100	120	160	200	240
shear elongation at break[3], %	50	50	50	50	50	50	50
peel strength[2], lb/in.	39	52	65	78	104	130	156
peel separation, %	25	25	25	25	25	25	25

Notes for Tables 1(a) and 1(b):

1. Also for hot air and ultrasonic seaming methods
2. Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing

Table 1(b) – Seam Strength and Related Properties of Thermally Bonded Smooth and Textured High Density Polyethylene (HDPE) Geomembranes **(S.I. Units)**

Geomembrane Nominal Thickness	0.75 mm	1.0 mm	1.25 mm	1.5 mm	2.0 mm	2.5 mm	3.0 mm
Hot Wedge Seams[1]							
shear strength[2], N/25 mm.	250	350	440	525	700	875	1050
shear elongation at break[3], %	50	50	50	50	50	50	50
peel strength[2], N/25 mm	170	225	285	340	455	570	680
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams							
shear strength[2], N/25 mm	250	350	440	525	700	875	1050
shear elongation at break[3], %	50	50	50	50	50	50	50
peel strength[2], N/25 mm	170	225	285	340	455	570	680
peel separation, %	25	25	25	25	25	25	25

orig: 2/18/02

Table 2(a) – Seam Strength and Related Properties of Thermally Bonded Smooth and Textured Linear Low Density Polyethylene (LLDPE) Geomembranes **(English Units)**

Geomembrane Nominal Thickness	20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams[1]								
shear strength[2], lb/in.	26	40	53	66	79	105	133	160
shear elongation[3], %	50	50	50	50	50	50	50	50
peel strength[2], lb/in.	22	34	44	57	66	88	114	136
peel separation, %	25	25	25	25	25	25	25	25
Extrusion Fillet Seams								
shear strength[2], lb/in.	26	40	53	66	79	105	133	160
shear elongation[3], %	50	50	50	50	50	50	50	50
peel strength[2], lb/in.	22	34	44	57	66	88	114	136
peel separation, %	25	25	25	25	25	25	25	25

Notes for Tables 2(a) and 2(b):

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing

Table 2(a) – Seam Strength and Related Properties of Thermally Bonded Smooth and Textured Linear Low Density Polyethylene (LLDPE) Geomembranes **(S.I. Units)**

Geomembrane Nominal Thickness	0.50 mm	0.75 mm	1.0 mm	1.25 mm	1.5 mm	2.0 mm	2.5 mm	3.0 mm
Hot Wedge Seams[1]								
shear strength[2], N/25 mm	115	175	230	290	345	460	580	700
shear elongation[3], %	50	50	50	50	50	50	50	50
peel strength[2], N/25 mm	95	150	190	250	290	385	500	595
peel separation, %	25	25	25	25	25	25	25	25
Extrusion Fillet Seams								
shear strength[2], N/25 mm	115	175	230	290	345	460	580	700
shear elongation[3], %	50	50	50	50	50	50	50	50
peel strength[2], N/25 mm	95	150	190	250	290	385	500	595
peel separation, %	25	25	25	25	25	25	25	25

Table 3(a) – Seam Strength and Related Properties of Thermally Bonded Nonreinforced and Reinforced Flexible Polypropylene (fPP) Geomembranes (**English Units**)

Geomembrane Nominal Thickness	30 mil-NR	40 mil-NR	36 mil-R[4]	45 mil-R[4]
Hot Wedge Seams[1]				
shear strength[2], lb/in. (NR); lb (R)	25	30	200	200
shear elongation[3], %	50	50	n/a	n/a
peel strength[2], lb/in. (NR); lb (R)	20	25	20	20
peel separation, %	25	25	n/a	n/a
Extrusion Fillet Seams				
shear strength[2], lb/in. (NR); lb (R)	25	30	200	200
shear elongation[3], %	50	50	n/a	n/a
peel strength[2], lb/in. (NR); lb (R)	20	25	20	20
peel separation, %	25	25	n/a	n/a

Notes for Tables 3(a) and 3(b):

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing
4. Values are based on grab tensile strength and elongations per D751 for laboratory tested specimens

Table 3(a) – Seam Strength and Related Properties of Thermally Bonded Nonreinforced and Reinforced Flexible Polypropylene (fPP) Geomembranes (**S.I. Units**)

Geomembrane Nominal Thickness	0.75 mm-NR	1.0 mm-NR	0.91 mm-R[4]	1.14 mm-R[4]
Hot Wedge Seams[1]				
shear strength[2], N/25 mm (NR); N (R)	110	130	890	890
shear elongation[3], %	50	50	n/a	n/a
peel strength[2], N/25 mm (NR); N (R)	85	110	90	90
peel separation, %	25	25	n/a	n/a
Extrusion Fillet Seams				
shear strength[2], N/25 mm (NR); N (R)	110	130	890	890
shear elongation[3], %	50	50	n/a	n/a
peel strength[2], N/25 mm (NR); N (R)	85	110	90	90
peel separation, %	25	25	n/a	n/a

orig: 2/18/02

APPENDIX C

NORTHWEST LININGS &
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NORTHWEST LININGS & GEOTEXTILES PRODUCTS, INC.
CONSTRUCTION QUALITY CONTROL MANUAL
FOR HDPE AND LLDPE CONTAINMENT MEMBRANE
FIELD INSTALLATIONS

ASTM D5641, D5820, D6365, D6392, GRI GM19

NORTHWEST LININGS AND GEOTEXTILES
HDPE/LLDPE-FIELD QUALITY CONTROL MANUAL

I. INTRODUCTION

A. This manual describes the Quality Control Procedures utilized by Northwest Linings (NWL) Installation Personnel to assure quality workmanship and installation integrity of HDPE/LLDPE Geomembranes.

B. Geosynthetic components of lining systems which are addressed in this manual are HDPE/LLDPE Geomembranes. NWL recognizes that specific documentation of the specific installation is required to substantiate this Quality Control Program.

II. HDPE/LLDPE GEOMEMBRANE INSTALLATION

A. Earth Work

1. The general and/or earthwork contractor shall be responsible for preparing and maintaining the subgrade in a condition suitable for liner installation unless agreed otherwise.

2. Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks to a depth of four (4) inches. All fill shall consist of well-graded material free of organics, trash, clayballs or other harmful matter. No sharp edged stones, stones larger than one (1) inch diameter or hard objects shall be allowed within the top four (4) inches of the subgrade. The surface shall be compacted in accordance with project specifications but in no event below the minimum required to provide a firm unyielding foundation sufficient to permit the movement of vehicles and welding equipment over the surface without causing rutting or other harmful effects. The subgrade shall have no sudden sharp or abrupt changes in grade.

3. The earthwork contractor shall protect the subgrade from becoming too dry, flooding and freezing. Protection, if required, may consist of a thin plastic protective cover (or other material as approved by the engineer) installed over the subgrade until the placement of the liner begins. Subgrade found to have cracks greater than 1/2 inch in width or depth or which exhibit swelling, heaving or other similar conditions shall be reworked by the general contractor to remove these defects.

4. Surface acceptance: Upon request, NWL will provide the Owner's Representative with a written acceptance of the surface to be lined. This acceptance will be limited to an amount of area that NWL is capable of lining in a particular work shift. Subsequent repairs to the subgrade and the surface shall remain the responsibility of the earthwork contractor.

B. Crest Anchorage System

1. The anchor trench shall be excavated by the earthwork contractor to lines and widths shown on the design drawings prior to geomembrane placement.

2. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential for cracking of the clay soils.

3. Corners in the anchor trench shall be slightly rounded where the geomembrane enters the trench to minimize sharp bends in the liner.

C. Preparation for Geomembrane Deployment

1. Panel Layout: Prior to liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams.

2. Identification: Each panel used shall be given a numeric or alpha-numeric identifier consistent with the layout drawing. This identification number shall be related to a manufacturing roll number.

D. Field Panel Placement

1. Location: NWL will attempt to install field panels at the location indicated on the layout drawing. If panels are positioned in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

2. Weather Conditions: Geomembrane deployment shall not be done during any precipitation, in the presence of excessive moisture (i.e. fog, dew), in an area of standing or ponded water, or during high winds.

3. Method of Deployment:

    1. The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface. The supporting sub-grade must be prepared and maintained in a condition to support the equipment needed for the installation.

    2. The rolls of liner will be deployed from a spreader bar apparatus supported by a fork lift, loader or other piece of heavy equipment that can safely lift and move the rolls. Heavy equipment will not be allowed to operate directly on geomembrane.

    3. No personnel working on the liner will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane.

    4. Adequate temporary ballast and/or anchoring, (i.e. sandbags,) which will not damage the geomembrane, will be placed to prevent uplift of the liner by wind.

    5. The geomembrane will be deployed in a manner to minimize wrinkles.

    6. Rubber tired and tracked ATV's and similar equipment are acceptable to operate on the geomembrane with ground pressure less than 8 psi. Tires and tracks will be checked for sharp edges, rocks or debris that may damage the liner before operating on the geomembrane. Driving paths will be as straight as possible avoiding sharp turns, sudden stops and starts.

    7. Any damage to a panel of geomembrane will be repaired in accordance with Section IV. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out, and removed from the work area with resulting seaming and/or repairs performed in accordance with Section IV of this document.

E. Field Seaming

1. General Requirements:

    1. Layout: In general, seams shall be oriented parallel to the slope, (down hill) not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam shall be numbered in a manner compatible with the panel layout drawing for documentation of seam testing results.

    2. Personnel: All personnel performing seaming operations shall be trained in the operation of the equipment being used and will qualify by successfully welding a test seam as described herein. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed.

F. Equipment:

1. Fusion Welding: Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that both sheets are heated to

temperatures ranging from 600 degrees F. to 950 degrees F. After being heated by the wedge, the overlapped edges pass through a set of preset pressure rollers which compress the panels together forming a continuous homogenous fusion weld. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge.

2. Extrusion Fillet Welding: Extrusion welding consists of introducing a ribbon of molten resin along the edge of the seam overlap to the two sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

G. Seam Preparation:

1. Fusion Welding:
    1. Overlap the panels approximately four (4) inches.
    2. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt and debris.
    3. No grinding is required for fusion welding.
    4. Adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths".
2. Extrusion Welding:
    1. Overlap the panels a minimum of three (3) inches.
    2. Temporarily bond the panels to be welded taking care not to damage the geomembrane.
    3. Grind seam overlap prior to welding within 15 minutes of welding operation in manner that does not damage the geomembrane.
    4. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust dirt and debris of any kind.
    5. Purge the extruder prior to beginning the seam to remove all heat-degraded Extrudate from the barrel.
    6. Keep welding rod clean and off the ground.

H. Test Seams:

Test seams shall be performed at the beginning of each seaming period and at least once each five hours for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the liner and under the same conditions as actual seams.

1. Test Seam Length:

    The test seam shall be at least three feet long, made by joining 2 pieces at least 9" in width.

2. Sample Procedures:
    1. Visually inspect the seam for squeeze out, footprint, pressure and general appearance.
    2. Two samples one inch wide shall be cut from the test seam. The samples shall then be tested in peel and shall not fail in the seam. Failure shall be a film tear bond (FTB). If a

sample fails, the entire procedure shall be repeated. ASTM D6392 will be method of testing samples GRI GM19 will be used for strength and locus of break.

3. If any of the second set of samples fail, the machine shall not be accepted and used for seaming until the problem is corrected and 2 passing tests are achieved.

4. After completion of the test the remaining portion of the test seam shall be discarded. Documentation of the test seams will be maintained by listing machine I.D. number, operators name, temperature control setting and test results.

5. Passing test results records shall be maintained on NWL's test weld report form.

6. If test samples are to act as destructive samples then the sample shall be marked, logged and saved. If samples are to be cut from the actual finished seam for Lab Testing, the test seams shall be discarded per above.

I. General Seaming Procedures:

1. Seaming shall extend to the outside edge of panels to be placed in the anchor trench.

2. While welding a seam, monitor and maintain the proper overlap.

3. Inspect seam area to assure area is clean and free of moisture, dust, dirt and debris of any kind.

4. While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the machine is operating properly.

5. Align wrinkles at the seam overlap to allow welding through a wrinkle.

6. Fishmouths or wrinkles at seam overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut area shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch extending six inches beyond the cut in all directions.

7. All cross/butt seams between two rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

8. All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind two inches on either side of the seam and extrusion weld all of the area prepared by grinding.

J. Weather Conditions:

NWL relies on the experience of the Project Superintendent and the results of test seams to determine seaming restriction by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can effect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Test seams are required prior to daily production seaming to determine if the weather conditions will effect NWL's ability to produce quality seams. Additional non-destructive and destructive testing of production seams substantiate the decision made by the Project Superintendent to seam on any given day.

SECTION III Seam Testing-Quality & Control-Geomembranes

A. Concept:

NWL installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved method, to verify the continuity and integrity of the seams.

B. Air Pressure Testing:

The weld seam created by the fusion welding process is composed of two welded seams separated by an unwelded channel approximately 3/8 of an inch wide. This channel permits seams to be tested by inflating the sealed channel with air to a predetermined pressure and observing the stability of the pressurized channel over time. Method of test ASTM D5820 Practice for Pressurized Air Channel Eval of Dual Seamed Geomembranes.

C. Equipment for air testing:

1. An air pump (manual or motor driven) capable of generating and sustaining a pressure of 30 PSI.
2. A rubber hose with fittings and connections.
3. A sharp hollow needle with a pressure gauge capable of reading and sustaining a pressure of 30 PSI.
4. Procedure for air testing:
5. Seal both ends of the seam to be tested.
6. Insert needle in the sealed channel.
7. Inflate the test channel to a pressure between 25 to 30 PSI, in accordance with the following schedule, close valve, and allow 2 minutes for the injected air to come into equilibrium in the channel. Observe initial pressure after approximately 2 minutes.

INITIAL PRESSURE SCHEDULE*				MAX. PRESSURE DIFF.
MATERIAL	(MIL)	MIN. PSI	MAX. PSI	AFTER 5 MINUTES
	40	25	30	4
	50	26	30	4
	60	27	30	4
	80	30	30	4
	100	30	30	4

* Initial pressure settings are read after a two minute relaxing period. The purpose of this period is to permit the air temperature and pressure to stabilize.

8. Observe and record the air pressure five minutes after the relaxing period ends. If loss of pressure exceeds the value above or if the pressure does not stabilize, locate the faulty area and repair.
9. Upon completion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered blocked and the test will be repeated after the blockage is corrected.
10. Remove needle and seal resulting hole by extrusion welding.
11. Record test results on non-destructive test form
12. In the event of a Non-Complying Air pressure test, the following procedure shall be followed.
13. Check seam-end seals and retest seams.

14. If non-compliance reoccurs, cut one inch samples from each end of the seam and additional samples at the distance specified.

15. Perform destructive field peel test on the samples.

16. If all samples pass destructive testing remove the overlap left by the wedge welder and perform an Air Pressure/Soap Test or vacuum test.

17. If a leak is detected by the air pressure/soap or the vacuum test, repair by extrusion welding. Test repair by vacuum testing.

18. If no leak is discovered air pressure/soap testing, the seam will pass non-destructive testing.

19. If no leak is discovered by vacuum testing, the seam will pass non-destructive testing.

20. If one or more samples fail the peel test, additional samples will be taken.

21. When two passing samples are located, the seam between these two locations will be considered complying. The area outside of this length will be considered non-complying and the entire length extrusion welded.

22. Test the entire length of the repaired seam by vacuum testing.

D. Air Pressure Testing/Soap Testing:

This test is used when the seam fails the air pressure test due to slow pressure loss. The procedure is to constantly supply pressure to the seam air channel while spraying the length with a soap and water solution and visually examining the seam for bubbles. Note: This option is not recommended during high wind conditions.

1. Equipment for Air Pressure/Soap Testing:
    1. The same equipment as the air pressure test.
    2. A soap solution and means to apply the solution.
2. Procedure for Air Pressure/Soap Testing:
    1. Trim excess overlap material off at edge of seam
    2. Insert needle gauge assembly in opposite ends of the seam to be tested to show that pressure is continuous throughout the channel.
    3. Maintain 30 psi
    4. Apply soap solution to the weld edge and visually examine for bubbles.
    5. If no bubbles appear the problem is with the inside track "secondary weld". This seam is acceptable providing it has passed peel tests.
    6. If any bubbles appear on the outside track "Primary weld", repair defect by extrusion welding and vacuum test the repair.

E. Vacuum Testing:

This test is used when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. Method of testing is based on ASTM D5641 Practice for Geomembrane Seam Eval by Vacuum Chamber.

1. Equipment for vacuum testing:

    1. Vacuum box consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly and a vacuum gauge.

    2. Vacuum pump assembly or compressor with a venturi equipped with a pressure controller and pipe connections.

    3. A rubber pressure/vacuum hose with fittings and connections.

    4. A soap solution with a means to apply the solution.

2. Procedure for Vacuum Testing:

    1. Trim excess overlap from seam.

    2. Apply soap solution to the area to be tested.

    3. Place the vacuum box over the area and apply sufficient downward pressure to seal the box against the liner.

    4. Open the vacuum valve and apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the box.

    5. Ensure that a leak-tight seal is created.

    6. For a period of not less than five seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

    7. If no bubbles appear after five to ten seconds, close the valve and move overlap and repeat the process.

3. Procedure for non-complying test:

    1. Mark all areas where soap bubbles appear and repair the marked areas.

    2. Retest repaired areas.

4. Procedure for non-destructive testing of extrusion welds that are not on flat surfaces or accessible for the equipment: ASTM D6365 Practice for Nondestructive Testing of Geomembranes Seams using the Spark Test.

F. Destructive Testing:

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs required.

1. Procedure for Destructive Testing:

1.1. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 700 feet of seam length.

1.2. Additional test may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds.

1.3. ASTM D6392 will be method of testing samples GRI GM19 will be used for strength and locus of break standards.

1) Sample Size:

a) The sample should be twelve inches wide with a seam fourteen inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent lab testing by the owner or by specific project specifications.

b) A one inch sample shall be cut from each end of the test seam for field testing on a calibrated field tensiometer.

2) The one inch wide samples shall be tested in the field for peel. If any field sample fails to pass FTB, it will be assumed the sample fails destructive testing. The procedures outlined in Section 2 shall be followed to locate passing samples to send to the laboratory.

i) If the sample passes the field test, the remaining portion of the sample test strip may be sent to Northwest Linings for laboratory testing to evaluate seam strength and confirm field testing.

1. Procedure in the event of Destructive Test Failure:

1. Cut additional field samples for testing. In the case of a field production seam, the samples must lay a minimum of ten feet in each direction from the location of the failed sample. Perform a field test with the tensiometer for peel strength. and confirm field testing.

2. If the laboratory samples pass, then reconstruct the seam up to the two passing sample locations.

1. Heat tack the overlap along the length of the seam to be reconstructed and extrusion weld.

2. Vacuum test the extrusion weld.

3. If either of the samples fails then additional samples are taken in accordance with the above procedure until two passing samples are found to establish the zone in which the seam should be reconstructed.

4. All passing seams must be bounded by two locations from which samples passing destructive test have been taken.

5. In the case of reconstructed seams exceeding 150 feet, a sample must be taken and pass destructive testing.

6. All destructive seam samples sent to Northwest Linings shall be numbered and recorded on a destructive seam test form.

3. Northwest Linings Quality Assurance Laboratory Testing:

The remaining destructive sample will be sent to a qualified laboratory and will be tested in "Seam Strength" and "Peel Adhesion" (ASTM D6392 will be method of testing samples GRI GM19 will be used for strength and locus of break). Five specimens shall be tested for each test method with

data recorded. Four out of the five specimens must pass for each test in order for the seam to pass the destructive test.

SECTION IV Defects and Repairs

A. Inspection

1. Northwest Linings Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation.

2. All other NWL installation personnel shall at all times be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

B. Procedure

1. Repair procedures: Any portion of the geomembrane showing a flaw, or failing destructive or non-destructive test shall be repaired. Several methods exist for repairs, and the decision as to the appropriate method shall be made by NWL's Project Superintendent. Methods available for repair:

1. Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six inches beyond the defect and all corners of patches shall be rounded.

2. Grinding and welding - used to repair sections of extruded seams.

3. Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws.

4. Capping - used to repair lengths of failed extruded areas.

5. Removal of a bad seam and replacement with a strip of new material seamed into place.

C. Verification of Repairs:

1. Every repair shall be non-destructively tested using the methods set out in this manual Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged on a repair report form. The repair location shall be recorded on a record drawing.

APPENDIX D

Concrete Materials of Montana
1059 Amsterdam Rd
Belgrade, MT 59714
406-388-6100

Mix ID: HSGrout
Compressive Strength: 5000psi Not Guaranteed
Max w/c ratio: .45

Contractor:	Morrison-Maierle
Project:	Yellowstone Club
Source of Concrete:	Concrete Materials Belgrade Plant
Construction Type:	Grout
Placement:	Truck or Pump

Weights per Cubic Yard (Saturated, Surface-Dry)

	Quantity	Density	Yield, ft^3
Ash Grove ASTM C-150-02 Type I-II Cement, lb	1000	3.150	5.09
ASTM C-618 Class F Fly Ash, lb	0	2.620	0.00
Potable Well Water, gal (US)	46	1.000	6.15
TMC ASTM C-33 #67 Concrete Rock, lb	0	2.646	0.00
TMC Concrete Sand	2464	2.658	14.81
Glenium 3030 HRWR, oz (US)	120.0	1.100	0.13
Delvo Stabilizer, oz (US)	90.0	1.200	0.09
SRA, oz (US)	192.0	1.100	.54
Total Air, %	2+/-1		1.62
			27.00

Water/Cement Ratio, lbs/lb	0..38
Slump, High, in	11.00
Low, in	6.00
Concrete Unit Weight, pcf	143.48
Yield, %	100.00

Exposure Condition : Severe Freeze/Thaw

There is no guarantee of any kind for this mix design for strength, set time, etc.

BASF

The Chemical Company

3 | 03 30 00 Cast-in-Place Concrete | 03 40 00 Precast Concrete | 03 70 00 Mass Concrete

Product Data

DELVO® STABILIZER

Hydration Controlling Admixture

Description

Delvo Stabilizer ready-to-use, liquid admixture is used for making more uniform and predictable high-performance concrete. Delvo Stabilizer admixture retards setting time by controlling the hydration of portland cement and other cementitious materials while facilitating placing and finishing operations. It can be used to stabilize returned plastic concrete and concrete washwater to reduce waste and increase profits. Delvo Stabilizer admixture meets ASTM C 494/C 494M requirements for Type B, retarding, and Type D, water-reducing and retarding, admixtures.

Applications

Recommended for use in:

- Stabilization of concrete washwater
- Stabilization of returned plastic concrete
- Stabilization of freshly batched concrete for long hauls
- 4x4™ Concrete
- Pumped concrete, shotcrete (wet mix) and conventionally-placed concrete
- Plain, reinforced, precast, prestressed, lightweight and normal weight concrete
- Pervious concrete

Features

- Reduced water content required for a given workability
- Retarded setting time characteristics
- Improved workability
- Reduced segregation

Benefits

- Provides flexibility in the scheduling of placing and finishing operations
- Offsets the effects of slump loss during extended delays between mixing and placing
- Reduces waste associated with concrete washwater and returned concrete
- Increased strength – compressive and flexural

Performance Characteristics

Rate of Hardening: The temperature of a concrete mixture and the ambient temperature (forms, earth, air, etc.) affect the hardening rate of concrete. At higher temperatures, concrete hardens more rapidly which may cause problems with placing and finishing.

One of the functions of Delvo Stabilizer admixture is to retard the set of concrete. Within the normal dosage range, it will generally extend the working and setting times of concrete containing normal portland cement, fly ash, slag cement and silica fume approximately 1 hour to 5 hours compared to a plain concrete mixture. This depends on job materials and temperatures. Trial mixes should be made under approximate job conditions to determine the dosage required.

Compressive Strength: Concrete produced with Delvo Stabilizer admixture will develop higher early (within 24 hours) and higher ultimate strengths than plain concrete when used within the recommended dosage range and under normal, comparable curing conditions. When Delvo Stabilizer admixture is used in heat-cured concrete, the length of the preheating period should be increased until the initial set of the concrete is achieved. The actual heat-curing period is then reduced accordingly to maintain existing production cycles without sacrificing early or ultimate strengths.

Guidelines for Use

Dosage: Delvo Stabilizer admixture is recommended for use at a dosage of 4 ± 1 fl oz/cwt (260 ± 65 mL/100 kg) of cementitious materials for most concrete mixtures using average concrete ingredients. Because of variations in job conditions and concrete materials, dosages other than the recommended amounts may be required. In such cases, contact your BASF Construction Chemicals representative. For concrete washwater and returned concrete stabilization, utilize Delvo charts or the Delvomatic™ software to determine the appropriate dosage rates.

Master Builders

Product Data: DELVO® STABILIZER

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: Delvo Stabilizer admixture will neither initiate nor promote corrosion of reinforcing steel in concrete. This admixture does not contain intentionally-added calcium chloride or other chloride-based ingredients.

Compatibility: Delvo Stabilizer admixture may be used in combination with any BASF Construction Chemicals admixture. When used in conjunction with another admixture, each admixture must be dispensed separately into the mix.

Storage and Handling

Storage Temperature: If Delvo Stabilizer admixture freezes, thaw at 35 °F (2 °C) or above and completely reconstitute by mild mechanical agitation. **Do not use pressurized air for agitation.**

Shelf Life: Delvo Stabilizer admixture has a minimum shelf life of 12 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your BASF Construction Chemicals representative regarding suitability for use and dosage recommendations if the shelf life of Delvo Stabilizer admixture has been exceeded.

Packaging

Delvo Stabilizer admixture is supplied in specially designed 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Material Safety Data Sheets: Delvo Stabilizer admixture.

Additional Information

For more information on Delvo Stabilizer admixture, contact your local sales representative.

The Admixture Systems business of BASF's Construction Chemicals division is a leading provider of innovative admixtures for specialty concrete used in the ready-mixed, precast, manufactured concrete products, underground construction and paving markets throughout the North American region. The Company's respected Master Builders brand products are used to improve the placing, pumping, finishing, appearance and performance characteristics of concrete.

BASF Corporation
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www.masterbuilders.com
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Canada 1800 Clark Boulevard, Brampton, Ontario L6T 4M7 ○ Tel: 800 387-5862 ○ Fax: 905 792-0651

BASF

The Chemical Company

December 6, 2010

Project: General
Project location: General

Certificate of Conformance
GLENIUM® 3030 NS
BASF Corporation* Admixture for Concrete

*(successor in interest to BASF Construction Chemicals, LLC , which is successor by merger to BASF Admixtures, Inc., formerly known as Degussa Admixtures, Inc., formerly known as Master Builders, Inc.)

I, Richard Hubbard, Sr. Technical Marketing Specialist for BASF Corporation, Cleveland, Ohio,certify:

That GLENIUM 3030 NS is a BASF Corporation Full Range Water-Reducing Admixture for concrete; and

That no calcium chloride or chloride based ingredient is used in the manufacture of GLENIUM 3030 NS; and

That GLENIUM 3030 NS, based on the chlorides originating from all the ingredients used in its manufacture, contributes less than 0.00014 percent (1.4 ppm) chloride ions by weight of the cement when used at the rate of 65 mL per 100kg (1 fluid ounce per 100 pounds) of cement; and

That GLENIUM 3030 NS meets the requirements for a Type F, Water-Reducing, High Range Admixture specified in ASTM C 494, Corps of Engineers' CRD-C 87 and AASHTO M194, the Standard Specifications for Chemical Admixtures for Concrete; and

That GLENIUM 3030 NS meets the requirements for a Type 1, Plasticizing Admixture specified in ASTM C 1017, the Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.

Richard Hubbard
Sr. Technical Marketing Specialist, BASF Corporation

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Master Builders
Admixture Solutions

BASF

The Chemical Company

3 4 | 03 30 00 Cast-in-Place Concrete | 03 40 00 Precast Concrete | 03 70 00 Mass Concrete | 04 05 16 Masonry Grouting

Product Data

GLENIUM® 3030 NS

Full-Range Water-Reducing Admixture

Description

Glenium 3030 NS ready-to-use full-range water-reducing admixture is a patented new generation of admixture based on polycarboxylate chemistry. Glenium 3030 NS admixture is very effective in producing concretes with different levels of workability including applications that require the use of Rheodynamic® Self-Consolidating Concrete (SCC). Glenium 3030 NS admixture meets ASTM C 494/C 494M requirements for Type A, water-reducing, and Type F, high-range water-reducing, admixtures.

Applications

Recommended for use in:

- Concrete where high flowability, high-early and ultimate strengths and increased durability are needed
- Self-consolidating concrete
- Concrete where normal, mid-range, or high-range water-reduction is desired
- Concrete where normal setting times are required
- 4x4™ Concrete for fast track construction
- Pervious Concrete
- Self-consolidating grout

Features

- Dosage flexibility for normal, mid and high-range water reduction
- Reduced water content for a given slump
- Produces cohesive and non-segregating concrete mixture
- Increased compressive strength and flexural strength performance at all ages
- Providing faster setting times and strength development
- Enhanced finishability and pumpability

Benefits

- Providing economic benefits to the entire construction team through higher productivity and reduced variable costs

Performance Characteristics

The dosage flexibility of Glenium 3030 NS allows it to be used as a normal, mid-range and high-range water reducer.

Mixture Data: 600 lb/yd^3 of Type I cement (360 kg/m^3); slump, 8.5-9.25 in. (210-235 mm); non-air-entrained concrete; dosage rate adjusted to obtain 25-30% water reduction.

Setting Time

Mixture	Initial Set (h:min)	Difference (h:min)
Plain	4:24	–
Conventional Superplasticizer	6:00	+ 1.36
Glenium 3030 NS admixture	5:00	+0.36

Compressive Strength

Mixture	1 day		7 days	
psi	psi	MPa	psi	MPa
Plain	1700	12	4040	28
Conventional Superplasticizer	3460	24	6380	44
Glenium 3030 NS admixture	4120	28	7580	52

Slump Retention - in. (mm)

Mixture	Minutes		
	15	30	45
Plain	8.5 (215)	8.5 (215)	7.5 (200)
Conventional Superplasticizer	8.5 (215)	4.25 (110)	3.5 (90)
Glenium 3030 NS admixture	9.25 (235)	9.25 (235)	8.25 (210)

Master Builders

Product Data: GLENIUM® 3030 NS

Rate of Hardening: Glenium 3030 NS admixture is formulated to produce normal setting characteristics throughout its recommended dosage range. Setting time of concrete is influenced by the chemical and physical composition of the basic ingredients of the concrete, temperature of the concrete and ambient conditions. Trial mixtures should be made with actual job materials to determine the dosage required for a specified setting time and a given strength requirement.

Guidelines for Use

Dosage: Glenium 3030 NS admixture has a recommended dosage range of up to 3 fl oz/cwt (195 mL/100 kg) for Type A applications, 3-6 fl oz/cwt (195-390 mL/100 kg) for mid-range use and up to 18 fl oz/cwt (1,170 mL/100 kg) for Type F applications. The dosage range is applicable to most mid to high-range concrete mixtures using typical concrete ingredients. However, variations in job conditions and concrete materials, such as silica fume, may require dosages outside the recommended range. In such cases, contact your local BASF Construction Chemicals representative.

Mixing: Glenium 3030 NS admixture can be batched with the initial mixing water or as a delayed addition. However, optimum water reduction is generally obtained with a delayed addition.

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: Glenium 3030 NS admixture will neither initiate nor promote corrosion of reinforcing steel embedded in concrete, prestressed concrete or of galvanized steel floor and roof systems. Neither calcium chloride nor other chloride-based ingredients are used in the manufacture of Glenium 3030 NS admixture.

Compatibility: Glenium 3030 NS admixture is compatible with most admixtures used in the production of quality concrete, including normal, mid-range and high-range water-reducing admixtures, air-entrainers, accelerators, retarders, extended set control admixtures, corrosion inhibitors, and shrinkage reducers.

Do not use Glenium 3030 NS admixture with admixtures containing beta-naphthalene-sulfonate. Erratic behaviors in slump, slump flow, and pumpability may be experienced.

For directions on the proper evaluation of Glenium 3030 NS admixture in specific applications, contact your BASF Construction Chemicals representative.

Storage and Handling

Storage Temperature: If Glenium 3030 NS admixture freezes, thaw at 45 °F (7 °C) or above and completely reconstitute by mild mechanical agitation. ***Do not use pressurized air for agitation.***

Shelf Life: Glenium 3030 NS admixture has a minimum shelf life of 12 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your BASF Construction Chemicals representative regarding suitability for use and dosage recommendations if the shelf life of Glenium 3030 NS admixture has been exceeded.

Packaging

Glenium 3030 NS admixture is supplied in 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Material Safety Data Sheets: Glenium 3030 NS admixture.

Additional Information

For additional information on Glenium 3030 NS admixture or its use in developing concrete mixes with special performance characteristics, contact your BASF Construction Chemicals representative.

The Admixture Systems business of BASF Construction Chemicals is a leading provider of innovative admixtures for specialty concrete used in the ready-mixed, precast, manufactured concrete products, underground construction and paving markets throughout the North American region. The Company's respected Master Builders brand products are used to improve the placing, pumping, finishing, appearance and performance characteristics of concrete.

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Canada 1800 Clark Boulevard, Brampton, Ontario L6T 4M7 ○ Tel: 800 387-5862 ○ Fax: 905 792-0651

Master Builders

BASF

The Chemical Company

February 6, 2014

Project: general
Project location: general

Certificate of Conformance
MasterLife® SRA 20 Admixture
BASF Corporation* Shrinkage-Reducing Admixture for Concrete

*(successor in interest to BASF Construction Chemicals, LLC , which is successor by merger to BASF Admixtures, Inc., formerly known as Degussa Admixtures, Inc., formerly known as Master Builders, Inc.)

I, Richard Hubbard, Sr. Technical Marketing Specialist for BASF Corporation, Cleveland, Ohio,certify:

That MasterLife SRA 20 admixture is a BASF Corporation Shrinkage-Reducing admixture for concrete; and

That no calcium chloride or chloride based ingredient is used in the manufacture of MasterLife SRA 20 admixture; and

That MasterLife SRA 20 admixture, based on the chlorides originating from all the ingredients used in its manufacture, contains less than 0.15% chloride ion by weight of the admixture; and

That MasterLife SRA 20 admixture meets the requirements for a Type S, Specific Performance Admixture as specified in Table 1 of ASTM C 494/C 494 M, the Standard Specifications for Chemical Admixtures for Concrete and AASHTO M194.

Richard Hubbard
Sr. Technical Marketing Specialist, BASF Corporation

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Master Builders
Admixture Solutions

BASF
The Chemical Company

3

03 30 00	Cast-in-Place Concrete
03 40 00	Precast Concrete
03 70 00	Mass Concrete

MasterLife® SRA 20

Shrinkage-Reducing Admixture

Formerly MasterLife SRA 20*

Description

MasterLife SRA 20 shrinkage-reducing admixture was developed specifically to reduce drying shrinkage of concrete and mortar, and the potential for subsequent cracking.

MasterLife SRA 20 admixture functions by reducing capillary tension of pore water, a primary cause of drying shrinkage.

MasterLife SRA 20 admixture meets ASTM C 494/C 494M requirements for Type S, Specific Performance, admixtures.

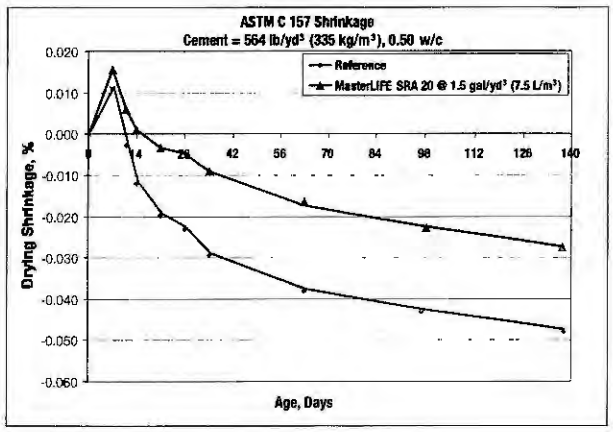
Applications

Recommended for use in:

- Ready-mixed or precast concrete structures requiring shrinkage reduction and long term durability
- Wet mix shotcrete
- Mortars and grouts

Features

- Significantly reduces drying shrinkage by as much as 80% at 28 days, and up to 50% at one year and beyond
- Reduces stresses induced from one-dimensional surface drying in concrete slabs and floors
- Reduces carbonation



Benefits

- Reduces drying shrinkage cracking and microcracking thereby improving aesthetics, watertightness and durability
- Reduction in drying shrinkage minimizes prestress loss
- Minimizes curling

Performance Characteristics

MasterLife SRA 20 admixture does not substantially affect slump. MasterLife SRA 20 admixture may increase bleed time and bleed ratio (10% higher). MasterLife SRA 20 admixture may also delay time of set by 1-2 hours depending upon dosage and temperature. Compressive strength loss is minimal with MasterLife SRA 20 admixture.

All projects requiring MasterLife SRA 20 admixture in concrete applications exposed to freezing and thawing environments must be pre-approved and require field trials prior to use. Therefore, contact your local sales representative when concrete treated with MasterLife SRA 20 admixture is being proposed for applications exposed to freezing and thawing environments.

MASTER® BUILDERS SOLUTIONS

Guidelines for Use

Dosage: Knowledge of the shrinkage characteristics of the concrete mixture proposed for use is required prior to the addition of MasterLife SRA 20 admixture. The dosage of MasterLife SRA 20 admixture will be dependent on the desired drying shrinkage and the reduction in drying shrinkage required. Therefore, it is strongly recommended that drying shrinkage testing be performed to determine the optimum dosage for each application and each set of materials.

The typical dosage range of MasterLife SRA 20 admixture is 0.5 to 1.5 gal/yd^3 (2.5 to 7.5 L/m^3). However, dosages outside of this range may be required depending on the level of shrinkage reduction needed.

Mixing: MasterLife SRA 20 admixture may be added to the concrete mixture during the initial batch sequence or at the jobsite.

The mix water content should be reduced to account for the quantity of MasterLife SRA 20 admixture used.

If the delayed addition method is used, mixing at high speed for 3-5 minutes after the addition of MasterLife SRA 20 admixture will result in mixture uniformity.

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: MasterLife SRA 20 admixture will neither initiate nor promote corrosion of reinforcing steel, prestressing steel or of galvanized steel floor and roof systems. Neither calcium chloride nor other chloride-based ingredients are used in the manufacture of MasterLife SRA 20 admixture.

Compatibility: MasterLife SRA 20 admixture is compatible with all water-reducers, mid-range water-reducers, high-range water-reducers, set retarders, accelerators, silica fume, and corrosion inhibitors. For air-entrained concrete applications, MasterAir® AE 200 admixture is the recommended air-entrainer. The dosage of MasterAir AE 200 admixture should be established through truck trial evaluations. The trials should include a simulated haul time of at least 20 minutes to assess air content stability. MasterLife SRA 20 admixture should be added separately to the concrete mixture to ensure desired results.

Storage and Handling

Storage Temperature: MasterLife SRA 20 admixture is a potentially combustible material with a flash point of 198 °F (92 °C) . This is substantially above the upper limit of 140 °F (60 °C) for classification as a flammable material, and below the limit of 200 °F (93 °C) where DOT requirements would classify this as a combustible material. Nonetheless, this product must be treated with care and protected from excessive heat, open flame or sparks. For more information refer to the Safety Data Sheet.

MasterLife SRA 20 admixture should be stored at ambient temperatures above 35 °F (2 °C), and precautions should be taken to protect the admixture from freezing. If MasterLife SRA 20 admixture freezes, thaw and reconstitute by mild mechanical agitation. Do not use pressurized air for agitation.

Shelf Life: MasterLife SRA 20 admixture has a minimum shelf life of 12 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your local sales representative regarding suitability for use and dosage recommendations if the shelf life of MasterLife SRA 20 admixture has been exceeded.

Packaging

MasterLife SRA 20 admixture is available in 55 gal (208 L) drums and 268 gal (1014 L) totes.

Related Documents

Safety Data Sheets: MasterLife SRA 20 admixture

Additional Information

For additional information on MasterLife SRA 20 admixture or its use in developing concrete mixtures with special performance characteristics contact your local sales representative.

The Admixture Systems business of BASF's Construction Chemicals division is the leading provider of solutions that improve placement, pumping, finishing, appearance and performance characteristics of specialty concrete used in the ready-mixed, precast, manufactured concrete products, underground construction and paving markets. For over 100 years we have offered reliable products and innovative technologies, and through the Master Builders Solutions brand, we are connected globally with experts from many fields to provide sustainable solutions for the construction industry.

Limited Warranty Notice

BASF warrants this product to be free from manufacturing defects and to meet the technical properties on the current Technical Data Guide, if used as directed within shelf life. Satisfactory results depend not only on quality products but also upon many factors beyond our control. BASF MAKES NO OTHER WARRANTY OR GUARANTEE, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO ITS PRODUCTS. The sole and exclusive remedy of Purchaser for any claim concerning this product, including but not limited to, claims alleging breach of warranty, negligence, strict liability or otherwise, is shipment to purchaser of product equal to the amount of product that fails to meet this warranty or refund of the original purchase price of product that fails to meet this warranty, at the sole option of BASF. Any claims concerning this product must be received in writing within one (1) year from the date of shipment and any claims not presented within that period are waived by Purchaser. BASF WILL NOT BE RESPONSIBLE FOR ANY SPECIAL, INCIDENTAL, CONSEQUENTIAL (INCLUDING LOST PROFITS) OR PUNITIVE DAMAGES OF ANY KIND.

Purchaser must determine the suitability of the products for the intended use and assumes all risks and liabilities in connection therewith. This information and all further technical advice are based on BASF's present knowledge and experience. However, BASF assumes no liability for providing such information and advice including the extent to which such information and advice may relate to existing third party intellectual property rights, especially patent rights, nor shall any legal relationship be created by or arise from the provision of such information and advice. BASF reserves the right to make any changes according to technological progress or further developments. The Purchaser of the Product(s) must test the product(s) for suitability for the intended application and purpose before proceeding with a full application of the product(s). Performance of the product described herein should be verified by testing and carried out by qualified experts.

* MasterLife SRA 20 became MasterLife SRA 20 under the Master Builders Solutions brand, effective January 1, 2014.

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