

Geotechnical Engineering Investigation

STD.2900

Scope

This standard was prepared to present Enterprise Product Company (Company) requirements for Geotechnical Engineering Investigation. This standard describes the minimum requirements for a geotechnical engineering investigation by other parties consulted by the Company. Geotechnical Investigation shall comply with all applicable federal, state, and local requirements.

The geotechnical investigation specified herein includes no environmental related investigation or analysis.

TABLE OF CONTENTS

1.0	REFERENCES	3
1.1.	Government Regulations	3
1.2.	American Society for Testing and Materials (ASTM)	3
2.0	DEFINITIONS	3
3.0	GENERAL	3
3.1.	Quality Control	3
3.2.	Permits	4
3.3.	Submittals	4
4.0	DELIVERABLES	4
4.1.	Field Reports	4
4.2.	4.2. Preliminary Report	5
4.3.	Final Report	5
5.0	EXECUTION	5
5.1.	General	5
5.2.	Examination of Site	5
5.3.	Utilities	5
5.4.	Field Work	6
5.5.	Laboratory Testing	6
5.6.	Reporting	6
Attachment	Revision Log	12

1.0 REFERENCES

When adopted in this standard or in the contract, the edition of the following codes, standards and specifications in effect on the date of the contract award shall be used unless otherwise specified. Short titles will be used herein when appropriate.

1.1. Government Regulations

Government regulations shall be followed under the jurisdiction of the Federal Standards and Instructions of the Occupational Safety and Health Administration (OSHA), including any additional requirements by state or local agencies that have jurisdiction where the work is performed.

1.2. American Society for Testing and Materials (ASTM)

D698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort
D1557	Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
D1883	Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils
D2166	Test Method for Unconfined Compressive Strength of Cohesive Soil
D2435	Test Method for One Dimensional Consolidation Properties of Soils Using Incremental Loading
D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2850	Test Method for Unconsolidated- Undrained Compressive Strength of Cohesive Soils in Triaxial Compression
D4253	Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
D4254	Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
D5434	Guide for Field Logging of Subsurface Explorations of Soil and Rock

2.0 DEFINITIONS

Company – Enterprise Products Company and affiliates.

Geotechnical Consultant – The party responsible for performing the geotechnical engineering investigation described in this standard.

Contract – The legal agreement between the Company and the Geotechnical Consultant to perform the work described in this standard.

3.0 GENERAL

3.1. Quality Control

- (1) Final report(s) shall be submitted under the seal and signature of a Geotechnical Engineer who is legally entitled to practice engineering in the state in which the project is located.

- (a) Unless waived by the Company Project Manager, Geotechnical Consultant shall provide an engineer or geologist in the field full time during exploration activities.
- (b) The Engineer/Geologist shall supervise and observe all subsurface exploration operations, classify samples and prepare logs of borings, soundings, pits, etc.

3.2. Permits

Geotechnical Consultant shall obtain all work permits, excavation permits, and other permits or authorizations required by the Company or by governmental or regulatory agencies and/or local jurisdictions for performance of the work.

This includes permits or authorizations for borings, soundings, pits, wells, piezometers, transportation of samples, etc.

3.3. Submittals

The following requirements apply to the Geotechnical Consultant's proposal submitted to the Company Project Manager prior to award of contract.

- (1) When the Company Project Manager provides a required program for field and/or laboratory testing, include either a statement supporting the adequacy of the proposed program or suggested modifications.
- (2) When the Company Project Manager does not provide a required program for field and laboratory testing, include a detailed proposed program of field exploration, field-testing and laboratory testing containing:
 - Plan showing locations and depths of proposed borings and any other proposed exploration
 - Proposed field sampling and testing program, including types and frequency of samples and tests
 - Proposed laboratory testing program, including types and numbers of tests
 - Descriptions of any proposed methods/tests not referenced herein
- (3) Include a schedule of beginning and completion dates of field and laboratory work and dates for submittal of preliminary and final reports.
- (4) Include descriptions of any structures, equipment, utilities, vegetation, or other facilities that will require removal or that will be damaged due to equipment access to boring locations.
- (5) Include resumes, or statement of qualifications and experience, of technical and professional personnel to be assigned to the project, including field personnel. Describe the roles, responsibilities, and degree of involvement of each individual.

4.0 DELIVERABLES

4.1. Field Reports

- (1) Provide field logs of borings, soundings, pits, wells, and other field exploration/testing activities in accordance with ASTM D5434.
- (2) Provide progress reports including:
 - Summary of work completed
 - Description of unusual or unanticipated conditions encountered
 - Assessment of adequacy of work scope and any recommended modifications

- Statement of progress relative to planned schedule

4.2. Preliminary Report

- (1) Preliminary report shall contain findings, conclusions, and recommendations and shall include as a minimum:
 - Logs and location plan of borings, soundings, pits, wells, and other field exploration/testing activities
 - Subsurface cross sections
 - Discussion of groundwater and impact on proposed construction
 - Results and interpretations of field testing
 - Recommended foundation type(s) and design parameters
 - Discussion of foundation settlements
 - Discussion of potential problems that may affect project planning, schedule, cost, design, or construction

4.3. Final Report

- (1) The final report shall respond to the Company Project Manager or designee's comments and questions on the preliminary report.
- (2) Final report shall include all information required in Appendix A.

5.0 EXECUTION

5.1. General

- (1) Furnish all labor, equipment, tools, supervision, supplies, and transportation required to perform the geotechnical investigation, exploration, testing, analyses, and reporting in accordance with ASTM D420 and with this standard, including requirements in Appendix A.
- (2) Comply with the Federal Standards and Instructions of OSHA, including any additional requirements by state or local agencies that have jurisdiction where the work will be performed.
- (3) Comply with all aspects of safety programs and policies of the Company and/or Owner.
- (4) Comply with ASTM procedures referenced in this standard and with other widely accepted standards or specifications when approved by the Company Project Manager.
- (5) If initial fieldwork and/or testing indicate a need for modifications in the work scope, immediately inform the Company Project Manager or designee.

5.2. Examination of Site

Geotechnical Consultant shall examine the site and become familiar with all existing conditions and evaluate the conditions with respect to performance of the work and to the design/construction of the proposed facilities.

5.3. Utilities

- (1) Prior to commencing the fieldwork, the Geotechnical Consultant shall locate all public underground utilities and shall request the Company Project Manager to locate all plant underground utilities.
- (2) The Geotechnical Consultant shall perform all work a sufficient distance away from underground and above ground utilities to protect personnel and utilities.

5.4. Field Work

- (1) Unless specifically made a responsibility by the Company Project Manager in the contract, provide any site modifications, improvements, special equipment, or clearing required to access locations of borings, soundings, pits, etc. Restore site to original condition as possible, or as required by the contract.
- (2) If any indication of soil or groundwater contamination is detected, immediately suspend all work and inform the Company Project Manager or designee. Do not resume work until notification to proceed is received from the Company Project Manager or designee.
- (3) In each test boring, perform soil sampling at intervals of no greater than 2.5 feet (75 cm) in the upper 10 feet (3 m), and thereafter every 5 feet (1.5 m) and at changes in strata.
- (4) Use minimum 3 in (76 mm) diameter tubes for thin walled tube sampling.
- (5) Determine groundwater levels.
- (6) Notify the Company Project Manager or designee at least three days prior to completion of fieldwork and/or removal of equipment from the site.
- (7) Grout all completed boreholes and soundings, from the bottom of the hole up, with a grout mixture of Portland cement and between 4 percent and 15 percent by weight of bentonite. Use potable water or water from a source approved by the Company Project Manager.

5.5. Laboratory Testing

- (1) Perform laboratory testing as required by contract.
 - (a) Classification testing shall be in accordance with ASTM D2487.
 - (b) Other soil properties shall be determined in accordance with:
 - ASTM D698
 - ASTM D1557
 - ASTM D1883
 - ASTM D2166
 - ASTM D2435
 - ASTM D2850
 - ASTM D4253
 - ASTM D4254
- (2) Notify the Company Project Manager or designee immediately of any indicated need for modifications to the testing program.

5.6. Reporting

- (1) Prepare and submit to the Company Project Manager the following reports:
 - Weekly field reports including information contained in Section 4.1, unless waived by the Company Project Manager.
 - Three copies of a preliminary report in accordance with Section 4.2, unless waived by the Company Project Manager.
 - Six copies of Final Report in accordance with Section 4.3, unless otherwise stated in the contract.

Appendix A Geotechnical Engineering Services

The final report of the Geotechnical Consultant shall include information and recommendations on items marked in the following list.

- (1) Introduction
 - (a) Description of proposed construction
 - (b) Purpose and scope of investigation
 - (c) Abstract of findings and recommendations
- (2) Site Conditions
 - (a) Site geology, general description
 - (b) Potential geologic hazards
 - (c) Site surface description
 - (d) Site topography, general description
 - (e) Description of above ground obstructions
- (3) Subsurface Conditions
 - (a) Stratigraphy
 - (b) Subsurface material properties, general description
 - (c) Groundwater elevations and expected variations
 - (d) Description of underground obstructions encountered or otherwise identified
- (4) Field Investigation
 - (a) Summary of operations
 - (b) Description of sampling procedures
 - (c) Description of field-tests
 - (d) Logs of borings, soundings, pits, wells, etc., in accordance with ASTM D5434 and containing:
 - (i) Complete descriptions and thickness of all strata, including near-surface materials such as paving, base course, topsoil, fill, etc.
 - (ii) Locations referenced to plant coordinate system
 - (iii) Ground surface elevations referenced to plant datum, if available; if not, then referenced to MSL (Mean Sea Level)
 - (iv) Standard penetration test values in blows per 6 in increment
 - (v) Results of all field tests
 - (e) Location plan, containing as a minimum:
 - (i) Scale plan with locations of borings, soundings, pits, wells, etc.
 - (ii) Include plant coordinate system
- (5) Laboratory Tests
 - (a) Description of tests
 - (b) Test results
- (6) Hydrology

- (a) Erosion potential
- (b) Surface run-off coefficients
- (c) Percolation
- (7) Seismic Analysis
 - (a) Seismicity based on seismic risk map
 - (b) Soil profile type and site coefficient(s)
 - (c) Site specific seismic risk study
- (8) Foundation Recommendations
 - (a) Type(s) of foundation recommended
 - (b) Basis for selecting recommended foundation type(s)
 - (c) Recommendations for foundation type(s) selected
 - (d) Recommendations for deep foundations regardless of foundation type selected
 - (e) Recommendations for shallow foundations regardless of foundation type selected
 - (f) Soil strength parameters used in determining design capacities
- (9) Shallow Foundation Recommendations
 - (a) Spread footings: Depth below grade, size and shape restrictions
 - (b) Mat foundations: Depth below grade, modulus of subgrade reaction
 - (c) Tank foundations: Recommendations and restrictions, excavation and backfill, ringwall considerations, extended water tests
 - (d) Vibratory equipment foundations: Dynamic shear modulus, Poisson's ratio, and other considerations
 - (i) Based on correlation's from published literature
 - (ii) Based on in-situ testing
 - (e) Ultimate and allowable net soil bearing capacity
 - (i) As a function of the shape and size of foundation, depth of embedment, and soil strength
 - (ii) Any increase in net allowable bearing capacity for hydrotest loads, and short term loads such as wind and earthquake
 - (f) Ultimate and allowable friction strength between foundation base and soil, lateral soil passive pressure for foundation sliding and overturning check
 - (g) Foundation settlement
 - (i) As a function of loading, shape and size of foundations, and compressibility of sub-soils
 - (ii) Immediate settlement during construction
 - (iii) Long term settlement
 - (iv) Time rate of settlement
 - (v) Adjacent foundation settlement
 - (vi) Differential settlement for tanks:
 - Along the perimeter
 - Center of tank to perimeter
 - Slope of tank bottom after anticipated settlement

- Limitations or recommendations for hydrotest procedures to minimize differential settlement
 - Anticipated settlement and rebound during hydrotest and specific measurements during hydrotest
- (10) Deep Foundation Recommendations
- (a) Type of pile or drilled pier and basis for recommendation
 - (b) Ultimate and allowable axial compression capacity through end bearing and skin friction
 - (i) Capacity vs. length
 - (ii) Any increase in capacity for hydrotest loads, or for short-term loads such as wind and earthquake
 - (c) Minimum and maximum tip elevations, when applicable
 - (d) Ultimate and allowable axial uplift capacity
 - (i) Uplift capacity vs. length
 - (ii) Any increase in capacity for hydrotest loads, or for short-term loads such as wind and earthquake
 - (e) Soil parameters for pile analysis under lateral load using LPILE.
 - (f) Down drag considerations
 - (g) Spacing, group action, and use of batter piles
 - (h) Settlement considerations
 - (i) Vibratory equipment foundations, spring constants in each direction for recommended pile type
 - (j) Driven pile installation considerations
 - (i) Driving criteria, including refusal criteria
 - (ii) Wave equation analysis
 - (iii) Pre-drilling requirements/restrictions
 - (iv) Potential problems and recommended solutions
 - (v) Pile installation near existing facilities
 - (k) (Non-driven) drilled pile and pier installation considerations
 - (i) Installation equipment requirements
 - (ii) Casing/slurry considerations
 - (iii) Installation criteria and recommendations
 - (iv) Potential problems and recommended solutions
 - (l) Load test requirements, procedures, and acceptance criteria
- (11) Earth Pressures
- (a) Active earth pressure, at-rest earth pressure
 - (b) Ultimate and allowable passive soil resistance for on-site soils, and recommended fill and backfill material
 - (c) Groundwater considerations
 - (d) Drainage requirements

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- (12) Soil Properties
 - (a) Coefficient of friction or adhesion values between soil and concrete
 - (b) Unit weight of soil
 - (c) Cohesion and angle of internal friction
 - (d) Chemical analysis and other properties of soil and groundwater at depths of proposed structural elements and utilities, as follows:
 - (i) pH value
 - (ii) Electrical conductivity (laboratory determination)
 - (iii) Chloride ion (Cl) concentration
 - (iv) Sulfate ion (SO₄) concentration
 - (v) Electrical resistivity of soil (field determination)
 - (vi) Yearly average moisture content of soil
 - (vii) Thermal resistivity of soil
 - (e) Permeability
 - (i) Laboratory determination
 - (ii) In situ determination
 - (13) Slabs And Pavements
 - (a) Natural soil and fill, subgrade suitability
 - (b) Recommended California bearing ratio value for pavement design
 - (i) Based on correlation's from published literature
 - (ii) Based on laboratory testing
 - (iii) Based on in-situ testing
 - (c) Recommended modulus of subgrade reaction for slab design
 - (d) Treatment for improving subgrade, if required
 - (e) Base course, sub-base courses, and shoulders recommendations
 - (f) Surfacing recommendations
 - (g) Base, sub-base, and subgrade drainage recommendations
 - (h) Complete pavement system design
 - (14) Other Considerations, Discuss And Provide Recommendations For:
 - (a) Frost susceptibility of soils, frost depth
 - (b) Liquefaction potential of soils
 - (c) Swelling potential of soils, including depth of zone of soil moisture content fluctuation
 - (d) Collapsible or dispersive soils
 - (e) Effects of proposed construction on existing facilities or adjacent property
 - (f) Geologic or other potential hazards
 - (15) Excavation Considerations
 - (a) Allowable excavation slope inclinations, temporary and permanent
 - (b) Groundwater control
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- (i) Recommended dewatering method
 - (ii) Temporary and permanent groundwater control
 - (iii) Flow quantities
- (c) Foundation subgrades
 - (i) Heave control
 - (ii) Protection/preserving integrity of subgrade
- (d) Effects on existing facilities
- (e) Potential excavation problems
- (f) Rock excavation
 - (i) Rippability of rock
 - (ii) Definition of rock for contract documents
 - (iii) Rock quantity estimate guidance
- (g) Pressure diagrams for shoring design
- (h) Applicability of specialized shoring/stabilization procedures
- (i) Classification of soil types per OSHA Regulations (Types A, B, C)
- (16) Dikes And Embankments
 - (a) Recommended slope inclination
 - (b) Slope stability analysis
 - (c) Settlement
 - (d) Seepage analysis
 - (e) Erosion protection of slopes
 - (f) Foundation and subgrade preparation
 - (g) Fill material: Type, compaction, and moisture content control
- (17) Railroads
 - (a) Natural soil and fill subgrade preparation
 - (b) Ballasting, with consideration to availability of local materials
- (18) Earthwork
 - (a) Topsoil: Thickness for stripping; definition for contract documents
 - (b) Suitability of on-site material for structural and non-structural fills
 - (c) Special preparations or other requirements for use of on-site material
 - (d) Availability of imported fill
 - (e) Subgrade preparation
 - (f) Recommended compaction criteria and moisture content control
 - (g) Potential compaction difficulties and recommended solution

Attachment Revision Log

Revision 0.0			Publish Date: 24 Jun 11
Location of Change	Type of Change	Reason for Change	
N/A	N/A		
Revision 0.1			Publish Date: 14 Mar 18
Location of Change	Type of Change	Reason for Change	
Section 1.2	Deletion/Update	Deleted reference to withdrawn ASTM standard D420, and updated references to ASTM D2435 and D2487.	
Section 3.2	Update	Corrected spelling "Pieziometers" to "Piezometers."	
Appendix A (9)(f)	Addition	Added "Ultimate and allowable friction strength between foundation base and soil, lateral soil passive pressure for foundation sliding and overturning check".	
Appendix A (10)(e)	Update	Updated section to say "Soil parameters for pile analysis under lateral load using LPILE."	
Various Locations	Revision	Revised responsibility from the Company to the Company Project Manager	