CITY OF SEATTLE

Seattle
Public Utilities

IMPROVEMENT OF: SOUTH PARK PUMP STATION
Project Manual – Volume 3 of 3
Division 31 through Division 43

FUNDED BY: DWF and King County Flood Control District
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SEATTLE, WASHINGTON
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PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes: All excavation, shoring, backfilling, compaction, and grading necessary or required for the construction of the work as covered by these Specifications and indicated on the Drawings. Excavation shall include, without classification, the removal and disposal of all materials of whatever nature encountered, including water and all other obstructions that would interfere with the proper construction and completion of the required work.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.

1.03 DEFINITIONS
A. “Engineer” means a person or entity lawfully entitled to practice engineering, representing the Owner within the limits of his/her delegated authority.
B. “Geotechnical Consultant” means either a licensed Engineer or licensed geologist in the state of which the work is located.
C. “Owner’s Representative” means a person that is a designated official representative of the Owner to oversee the project.

1.04 REFERENCE SPECIFICATIONS
A. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
B. The Contractor shall have at least one copy of the Standard Specifications at the job site.
C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.05 SUBMITTALS
A. Submit the following according to Standard Specification 1-05.3 Submittals.
1. Product Data sheets for products listed in Part 2 Products.
2. Potholing Report, as required.
3. Qualifications of independent testing laboratories used for geotechnical testing of soils.
4. Samples and Test Results
   a. Furnish, without additional cost to Owner, such quantities of imported material as may be required by the Engineer for testing purposes. Cooperate with the Engineer and furnish necessary facilities and testing of all materials and workmanship.
b. Submit supplier name and test results for all imported materials required in this specification, with sufficient lead time for Engineer to review and approve prior to delivery to site.

c. Tests shall be performed by a qualified testing agency. Accompanying documentation shall be prepared by the Contractor and shall indicate that test results comply with these Specifications and are for this Project.

d. All material furnished and all work performed shall be subject to inspection, and no material shall be delivered to the site until it has been approved by the Engineer, or used in the construction work until it has been inspected and approved in the field by the Engineer.

5. Submit a Dewatering Work Plan with drawings and complete design information showing methods and equipment for dewatering necessary to keep excavation and pipe trenches dry during construction.

6. Weigh tickets for soil materials imported from off-site sources.

1.06 QUALITY ASSURANCE

A. Soil Testing:

1. The Owner will engage a Geotechnical Consultant to test soil materials proposed for use and for overseeing quality control testing during excavation and fill operations.

2. Samples of material shall be furnished to the Geotechnical Consultant by the Contractor at least one week before their anticipated use.

3. Contractor shall smooth out areas for density tests and otherwise facilitate testing work as directed.

B. Shoring Systems: Pre-engineered systems, clearly labeled as such, may be used.

1.07 SUBSURFACE INVESTIGATIONS FOR EXISTING CONDITIONS

A. Geotechnical investigations for design purposes for this project are available and other available data may be reviewed by contacting the Owner. Subsurface conditions were investigated by SPU. See the Geotechnical Report, Final South Park Pump Station – Review and Update of Geotechnical Recommendations and Geotechnical Design Parameters dated February 28, 2019.

B. While the records of data obtained may be considered by the Contractor to be correct within the limitations of the subsurface investigation program, any conclusions or recommendations made in the reports are for information only and are not a part of the Contract Documents.

PART 2 - PRODUCTS

2.01 CRUSHED ROCK

A. Crushed rock shall be in accordance with Standard Specification 9-03.7(3).

2.02 CRUSHED SURFACING TOP COURSE

A. Crushed surfacing top course shall be in accordance with Standard Specification 9-03.14.
2.03 **PEA GRAVEL**
A. 3/8” pea gravel (washed) shall be in accordance with the requirements of Standard Specification 9-03.1(3)D AASHTO Grading #8 and be rounded.

2.04 **GRAVEL BORROW**
A. Aggregate for gravel borrow shall be in accordance with Standard Specification 9-03.12.

2.05 **STRUCTURAL FILL**
A. Shall consist of crushed surfacing base course or crushed surfacing top course. If determined suitable by the Geotechnical Consultant, on-site material may be used as structural fill if capable of being compacted as specified under the weather conditions prevailing at the time of construction.

2.06 **NONSTRUCTURAL FILL**
A. Shall be on-site or imported well-graded granular material free of organics and debris. Maximum particle size 4 inches and no more than 30 percent fines (material passing No. 200 sieve). Material shall be capable of being compacted as specified under the weather conditions prevailing at time of construction.

2.07 **BACKFILL FOR FOUNDATIONS**
A. Backfill for foundation shall be in accordance with Standard Specification 9-03.10(1).

2.08 **GRAVEL BACKFILL FOR DRAINS**
A. Gravel backfill for drains shall be in accordance with Standard Specification 9-03.10(4).

2.09 **BACKFILL FOR WALLS**
A. Backfill for walls shall be in accordance with Standard Specification 9-03.10(2).

2.10 **CAPILLARY BREAK**
A. Capillary break material shall consist of 5/8 inch clean crushed gravel. Gravel shall be per Section 2.08 Gravel Backfill for Drains.

2.11 **COMPACTED BACKFILL**
A. On-site soils may be used, if determined suitable by the Geotechnical Consultant and the subgrade is properly prepared. Refer to the geotechnical report for reuse of fill soils as subgrade beneath pavement areas.

2.12 **QUARRY SPALLS**
A. Shall be crushed quarry rock. Quarry spalls shall be hard, sound, durable and unweathered. The quarry spall shall meet the 5 test requirements listed in Standard Specification 9-13.6. Quarry spalls shall meet the following gradation requirements by weight:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-inch</td>
<td>100</td>
</tr>
<tr>
<td>4-inch</td>
<td>40 max.</td>
</tr>
<tr>
<td>2-inch</td>
<td>5 max.</td>
</tr>
</tbody>
</table>
2.13 WATER
A. Water for compaction, dust control, and other uses shall be potable water supplied by the contractor unless approved otherwise by the Engineer.

2.14 WASHED GRAVEL BACKFILL
A. Washed Gravel Backfill shall be type 5 Mineral aggregate in accordance with Standard Specification 9-03.10(6).

2.15 GRAVEL BACKFILL
A. Gravel Backfill shall be in Crushed surfacing top course accordance with Standard Specification 9-03.10.

PART 3 - EXECUTION
3.01 EXCAVATION
A. Unauthorized excavation consists of removal of materials beyond indicated elevations or dimensions without specific direction of the Owner's Representative. Unauthorized excavation, as well as remedial work directed by the Owner's Representative, shall be at no change in contract amount.

1. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending the indicated bottom elevation of the footing or based to the excavation bottom. The bottom of the excavation must be at least as wide as the sum of the depth of the unauthorized excavation and the footing width.

2. Elsewhere, backfill and compact unauthorized excavations with structural fill as specified herein.

B. Overexcavation: In certain areas where soft spots occur in the subgrade, satisfactory subgrade shall be achieved by overexcavation and replacement with structural fill material or lean mix concrete such as controlled density fill per Section 31 23 24.

1. Location of extent of soft spot areas to be verified by Owner's Geotechnical Consultant in the field.

C. Stability of Excavations: Slope the sides of excavations to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavation in a safe condition until completion of backfilling.

D. Shoring and Bracing: Provide shoring and bracing to comply with local codes and authorities having jurisdiction. Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition. Maintain shoring and bracing in excavations regardless of the time period excavations will be open. Shoring and bracing shall be extended as excavation progresses.

E. Dewatering: Provide dewatering per Standard Specification 2-08 to prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area. Also refer to Section 31 23 20, Control of Water.
F. Material Storage: Stockpile excavated materials as required. Place, grade, shape and cover stockpiles for proper drainage and to prevent accumulation of excess moisture.
   1. Locate and retain soil materials away from edge of excavations.
   2. Dispose of excess soil material and waste materials legally off-site.

G. Excavation for Buildings and Retaining Walls
   1. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10-foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction, and inspection.
   2. In excavating for footings and foundations, take care not to disturb the bottom of the excavation. Excavate by hand to final grade just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive concrete. Compact base to the density required and allow testing of compaction prior to constructing concrete forms.
   3. Place footings on native soils, or properly compacted fill material where existing soft materials are encountered below footings, overexcavate as required by the Owner’s Geotechnical Consultant or until dense native soil is encountered and backfill with lean concrete. The minimum lateral limits of the overexcavation and lean concrete backfill beneath footings shall be defined by a line extending downward and out from the outer edge of the footing at an angle of 1H:1V. Maintain side slopes as required by authorities having jurisdiction.

H. Excavation for Pavements: Cut surface under pavements to comply with cross-sections, elevations and grades as shown within a tolerance of plus or minus 0.10-foot.

I. Excavation for Planting Areas: Conform to cross-sections, elevations and dimensions shown, within a tolerance of plus or minus 0.10-foot.

J. Excavation for Trenches: For storm and sewer systems, trench excavations shall be per City of Seattle Standard Plan 284 and per COS standard specifications 2-07 and 7-17. For water lines, trench excavations shall be per City of Seattle Standard Plan 350 and per COS standard specifications 7-11 and 7-17.

K. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F.

3.02 SUBGRADE VERIFICATION

A. Following site preparation and excavation for the building, paved surfaces and roadways, the exposed subgrades shall be observed and approved by the Owner’s Geotechnical Consultant. Testing shall be conducted as directed by the Owner’s Geotechnical Consultant, which includes in place density tests to verify the subgrade has been properly prepared. In place density tests should indicate that the soil is generally within +/- 3 percent of the optimum moisture content and that the soil has been compacted as specified in Section 3.04 COMPACTION and according to the 2017 City of Seattle Standard Specifications Section 2-09, Subgrade Preparation. In lieu of in place density testing, a proof roll of subgrade soil could be performed per the geotechnical report.

B. Overexcavate any soft, loose or disturbed soils identified by the Geotechnical Consultant and replace with compacted structural fill or lean mix concrete per 3.1.B.

C. If required by Geotechnical Consultant, provide equipment and labor for proofrolling.
3.03 BACKFILL AND FILL

A. For backfill of all excavations use material sampled and tested by the Owner’s Geotechnical Consultant.

B. All fill used for the following shall be structural fill:
   1. Fill beneath footings and foundations.
   2. Backfill against footings, foundations and structural walls, except 18 inches of gravel backfill for walls shall be placed immediately adjacent to structures for drainage, unless otherwise shown on the drawings.
   3. Fill beneath building slabs.
   4. Fill within 3 feet vertically of the base of pavements.
   5. Fill beneath concrete sidewalks supporting art work.

C. Fill beneath areas to be landscaped shall be free-draining soils.

D. Backfill excavations as promptly as work permits, but not until completion of the following:
   1. Acceptance by Owner’s Representative of construction below finish grade including, where applicable, foundations, waterproofing, dampproofing, piping, conduits and perimeter insulation.
   2. Inspection, testing, approval and recording locations of underground piping and conduits. Coordinate locations with surveyor for as-built or record drawing survey.
   4. Removal of shoring and bracing and backfilling of voids with satisfactory materials.
   5. Removal of trash and debris.
   6. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

E. Ground Surface/Landscaping Areas Preparation
   1. Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. On existing sloped surfaces, steeper than 1 vertical to 4 horizontal, cut benches into hillsides of 10 feet minimum width and 5 feet maximum height.
   2. When existing ground surface has a density less than that specified under “Compaction” for the particular area classification, break up the ground surface, pulverize, moisture-condition to the optimum moisture content, and compact to required depth and percentage of maximum density.
F. Placement and Compaction: Allowable thickness of fill lifts will depend on the material type and compaction equipment used. In no case place backfill and fill materials in layers more than 8 inches in loose depth for material compacted by heavy compaction equipment, and more than 4 inches in loose depth for material compacted by hand-operated tampers. For fill deeper than 3 feet below the base of pavements, lifts may be 12 inches maximum in loose depth.

1. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content per Section 3-04 Compaction. Moisture content shall be determined for each layer before compaction. Depending on how large the spread area is, more than one sample may be needed to be in compliance. Contractor to sample as directed by the Owner’s Geotechnical Consultant.

2. Compact each layer per Section 3-04 Compaction.

3. Do not place backfill or fill material on surfaces muddy, frozen, or containing frost or ice.

4. Place backfill and fill materials in such a manner as to prevent wedging action of backfill against structures.

3.04 COMPACTION

A. General: Control soil compaction during construction providing minimum percentage of density specified for each area.

B. Percentage of Maximum Density Requirements: Under the following areas, compact soil to not less than the following percentages of maximum dry density determined in accordance with ASTM D1557 (“Modified Proctor”):

1. Structures: Compact top 12 inches of subgrade where exposed, and each layer of backfill or fill material to 95 percent of maximum dry density.

2. Building Slabs and Steps: Compact top 12 inches of subgrade and each layer of backfill or fill material to 95 percent of maximum dry density.

3. Lawn or Unpaved Areas: Compact top 12 inches of subgrade and each layer of backfill or fill material to 85 percent of maximum dry density.

4. Walkways: Compact top 12 inches of subgrade and each layer of backfill or fill material to 95 percent of maximum dry density.

5. Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 95 percent of maximum dry density.

6. Utility Bedding and Backfill: Compact each layer of bedding and backfill to 95 percent of maximum dry density.

7. Granular Fill Placed Against Subgrade Walls: Compact to 90 percent of maximum dry density with small hand-operated equipment to avoid overcompaction.

C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade, or layer of soil material. Prevent free water from appearing on surface during or subsequent to compaction operations.

1. Remove and replace, or scarify and air dry, soil material too wet to permit compaction to specified density.
2. Soil material removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to a satisfactory value.

D. Compaction Testing Frequency. Contractor shall provide compaction testing as determined by the Owner’s Geotechnical Consultant.

3.05 GRADING
A. General: Uniformly grade areas of work including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.
B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding. Finish surfaces shall be free from irregular surface changes.
C. Provide compacted final grades within a tolerance of 1/2-inch when tested with a 10-foot straightedge.
D. Compaction: Compact surfaces to the depth and percentage of maximum density for each area classification.
E. ADA grading: Grading in areas that are ADA routes or areas designated as 5% maximum longitudinal grade as shown on the plans shall have a tolerance of 1/4-inch when tested with a 10-foot straightedge.

3.06 WET WEATHER PROVISIONS
A. Schedule earthwork operations to minimize the potential for erosion, siltation, and disturbance of site soils.
B. Perform earthwork operations in discrete areas as required to minimize the exposure of disturbed soils to wet weather.
C. Compact exposed soil to reduce the infiltration of rain water.
D. Direct surface water away from fills and excavations.
E. Provide temporary pumping equipment to keep excavations and construction free of water.
F. Soils that become too wet for compaction shall be removed and replaced with compacted structural fill.

3.07 DISPOSAL OF EXCESS AND WASTE MATERIALS
A. Remove any unused excess excavated material from the site, and dispose of legally off the Owner’s property, prior to final inspection.
B. Remove waste materials, including unacceptable excavate material, trash and debris, and dispose of legally off the Owner’s property.

3.08 FIELD QUALITY CONTROL
A. Quality Control Testing During Construction: Allow Owner’s Geotechnical Consultant to observe, test, and approve subgrades and fill layers before further construction work is performed.
B. Footings for structures and retaining walls shall be observed by the Geotechnical Consultant for bearing capacity verification prior to concrete placement. Compaction tests shall be performed if in the opinion of the Geotechnical Consultant they are necessary.

C. If subgrades or fills which have been placed do not meet specified density, provide corrective work as specified at no additional expense.

D. Per the Drawings, allow the Owner’s Geotechnical Consultant to conduct an infiltration test of the soils prior to placement of footing concrete forms for the construction of the foundation.

3.09 PROTECTION

A. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

C. Recondition Compacted Areas: Where completed contracted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, compact to required density and provide other corrective work as specified, with retesting, prior to further construction.

END OF SECTION 31 00 00
PART 1 - GENERAL

1.01 SUMMARY

A. This Section specifies earthwork, which consists of excavation, trenching, materials, backfilling, compacting, and grading.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor’s responsibility to perform all the work required by the Contract Documents.

1. Section 01 22 10
2. Section 01 33 10
3. Section 01 56 10
4. Section 01 57 50
5. Section 31 23 20
6. Section 31 41 00
7. Section 31 25 00
8. Section 31 23 24
9. Section 31 32 01

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this Section and the listed documents, the requirements of the Contract Specifications shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D1556</td>
<td>Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method</td>
</tr>
<tr>
<td>ASTM D1557</td>
<td>Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft³(2,700 kN-m/m³))</td>
</tr>
<tr>
<td>ASTM D2216</td>
<td>Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</td>
</tr>
<tr>
<td>ASTM D6938</td>
<td>Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)</td>
</tr>
<tr>
<td>ASTM E329</td>
<td>Standard Specification for Agencies Engaged in Construction Inspection and/or Testing</td>
</tr>
<tr>
<td>ASTM D4632</td>
<td>Standard Test Method for Grab Breaking Load and Elongation of Geotextiles</td>
</tr>
<tr>
<td>Reference</td>
<td>Title</td>
</tr>
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<td>-----------</td>
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</tr>
<tr>
<td>ASTM D4533</td>
<td>Standard Test Method for Trapezoid Tearing Strength of Geotextiles</td>
</tr>
<tr>
<td>ASTM D4355</td>
<td>Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus</td>
</tr>
<tr>
<td>ASTM D4751</td>
<td>Standard Test Method for Determining Apparent Opening Size of a Geotextile</td>
</tr>
<tr>
<td>ASTM D4491</td>
<td>Standard Test Methods for Water Permeability of Geotextiles by Permittivity</td>
</tr>
<tr>
<td>COS</td>
<td>Current Edition City of Seattle Standard Specifications for Road, Bridge and Municipal Construction</td>
</tr>
<tr>
<td>WSDOT</td>
<td>Current Edition Washington State Department of Transportation Standard Specifications for Road, Bridge and Municipal Construction</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

A. Compaction: Degree of compaction is specified as percent compaction. Maximum or relative densities refer to dry soil densities obtainable at optimum moisture content as determined by ASTM D1557.

B. Excavation Slope: An inclined surface formed by removing material from below existing grade.

C. Embankment Slope: An inclined surface formed by placement of material above existing grade.

D. Imported Backfill: Select material which meets the fill class specified and is obtained from a supplier regularly engaged in the business of supplying soil/fill material. It is not material which is obtained from any on-site excavation.

E. Geophysical Materials: Material from designated or recognized sources that have been classified to meet certain stable load bearing under given site conditions.

F. COS: City of Seattle

G. WSDOT: Washington State Department of Transportation

1.04 SUBMITTALS

A. Procedures: **Section 01 33 10.**

B. Samples of all fill materials to be used 30 days in advance of use. Samples shall consist of 0.5 cubic foot of each type of material used.

C. Laboratory test reports and samples of fill materials to be used, certifying:
   1. Moisture-density relationships and gradation test reports and curves.
   2. Gradation tests for non-cohesive materials.
1.05 QUALITY ASSURANCE

A. Engineer will take samples and perform moisture content, gradation, compaction, and density tests during placement of backfill materials to check compliance with the Specifications.

B. Remove surface material at locations designated by the Engineer and provide such assistance as necessary for sampling and testing.

C. Engineer may request that the Contractor construct trenches for inspection in compacted or consolidated backfill to determine per ASTM D6938 that the Contractor has complied with these Specifications.

D. Testing by the Engineer does not relieve the Contractor of its responsibility to determine to its own satisfaction when and if its work meets these Specifications.

E. Tests will be made in accordance with ASTM E329 in accordance with the following:

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>ASTM D6938, ASTM D2216</td>
</tr>
<tr>
<td>Gradation</td>
<td>ASTM C136, ASTM D422</td>
</tr>
<tr>
<td>Density in-place</td>
<td>ASTM D6938, ASTM D1556</td>
</tr>
<tr>
<td>Moisture-density relationships</td>
<td>ASTM D1557 Method C or D</td>
</tr>
</tbody>
</table>

PART 2 - PRODUCTS

2.01 FILL MATERIALS

A. Type A (Pit Run Crushed Rock) COS Mineral Aggregate Type 27:

1. Select granular material free from organic matter.
2. Sand equivalent value of not less than 20.
3. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 inch</td>
<td>100</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>70 to 100</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>25 to 75</td>
</tr>
<tr>
<td>No. 40</td>
<td>0 to 50</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 15 (wet sieving)</td>
</tr>
</tbody>
</table>

4. The material may be an imported quarry waste, clean natural sand or gravel, select trench excavation, or a mixture thereof.
B. Type B (Clean Gravel-Sand): No equivalent:
   1. Clean gravel-sand mixture free from organic matter.
   2. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inch</td>
<td>100</td>
</tr>
<tr>
<td>1-1/2 inch</td>
<td>95 to 100</td>
</tr>
<tr>
<td>No. 4</td>
<td>35 to 100</td>
</tr>
<tr>
<td>No. 10</td>
<td>10 to 100</td>
</tr>
<tr>
<td>No. 40</td>
<td>0 to 60</td>
</tr>
<tr>
<td>No. 100</td>
<td>0 to 30</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>

C. Type C (Unclassified): Not Used.

D. Type E (Drain Rock) COS Mineral Aggregate Type 4:
   1. Clean and washed.
   2. Composed of hard, durable, sound pieces having a specific gravity of not less than 2.65.
   3. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>0 to 2</td>
</tr>
</tbody>
</table>

E. Type F (1-1/2" Crushed Rock) COS Mineral Aggregate Type 21:
   1. Composed of hard, durable, sound pieces having a specific gravity of not less than 2.65.
   2. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>5/8 inch</td>
<td>85 to 100</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>45 to 70</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>0 to 25</td>
</tr>
</tbody>
</table>

F. Type G (2-1/2" Crushed Rock) COS Mineral Aggregate Type 14:
   1. Imported, well-graded sand and gravel, free of organic debris and other deleterious material.
2. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>2 inch</td>
<td>65 to 100</td>
</tr>
<tr>
<td>1 inch</td>
<td>50 to 85</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>30 to 50</td>
</tr>
<tr>
<td>No. 40</td>
<td>0 to 16</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 9</td>
</tr>
</tbody>
</table>

G. Type L (Structural Fill) COS Mineral Aggregate Type 17:

1. Imported, well-graded sand and gravel, free of organic debris and other deleterious material.
2. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inch</td>
<td>95-100</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>25 to 75</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 5 (wet sieving)</td>
</tr>
<tr>
<td>Sand Equivalent</td>
<td>60</td>
</tr>
<tr>
<td>Dust Ratio</td>
<td>2/3 Max.</td>
</tr>
</tbody>
</table>

H. Type M (Foundation Drain Filter) No equivalent:

1. Well-rounded rock.
2. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inch</td>
<td>100</td>
</tr>
<tr>
<td>3 inch</td>
<td>80 to 100</td>
</tr>
<tr>
<td>1-1/2 inch</td>
<td>40 to 90</td>
</tr>
<tr>
<td>1-inch</td>
<td>20 to 65</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>5 to 50</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>0 to 15</td>
</tr>
</tbody>
</table>

I. Type N (Pit Run Sandy Gravel) COS Mineral Aggregate Type 15:

1. Free from clay and organic matter, moisture content that is less than the material's optimum value, and compacts readily.
2. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 inch</td>
<td>100</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>20 to 40</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 10</td>
</tr>
<tr>
<td>LA Abrasion</td>
<td>30% Max</td>
</tr>
</tbody>
</table>

J. Type O (Controlled Density Fill, CDF): Section 31 23 24, Controlled Density Fill (CDF).

K. Type P (Crushed Surfacing Base Course) COS Mineral Aggregate Type 2:

1. The fracture requirement shall be at least one fractured face and will apply to material retained on each specification sieve size U.S. No. 10 and above if that sieve retains more than 5 percent of total sample.

2. The portion retained on a 1/4-inch sieve shall not contain more than 0.15 percent wood waste.

3. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/4 inch</td>
<td>100</td>
</tr>
<tr>
<td>5/8 inch</td>
<td>50 to 80</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>30 to 50</td>
</tr>
<tr>
<td>No. 40</td>
<td>3 to 18</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>

L. Type Q (Quarry Spalls) 4 Inch to 8 Inch Quarry Spalls:

1. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 inch</td>
<td>100</td>
</tr>
<tr>
<td>3 inch</td>
<td>40 max</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>10 max</td>
</tr>
</tbody>
</table>

2. For construction entrances, meet the above requirements with the exception that the percent passing the 3/4-inch screen shall be limited to 5 percent maximum.

M. Type R (Crushed Surfacing Top Course) COS Mineral Aggregate Type 1:

1. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8 inch</td>
<td>100</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>55 to 75</td>
</tr>
<tr>
<td>No. 40</td>
<td>8 to 24</td>
</tr>
<tr>
<td>No. 200</td>
<td>5% max</td>
</tr>
<tr>
<td>% fracture</td>
<td>75 min</td>
</tr>
<tr>
<td>% sand equivalent</td>
<td>40 min</td>
</tr>
</tbody>
</table>
2. The fracture requirement shall be at least one fractured face and applies to material retained on each specified sieve size No. 10 and above if that sieve retains more than 5 percent of the total sample.

3. The portion retained on a 1/4-inch sieve shall not contain more than 0.15 percent wood waste.

N. Type S (Bedding and Pipe Zone Material) COS Mineral Aggregate Type 9:

1. Screened sand, gravel, or other inert Materials clean and washed. The materials shall have hard, strong, durable particles free from adherent coatings. The Materials shall be washed thoroughly to remove clay, load, alkali, organic matter, or other deleterious substances.

2. Conform to the following for grading and quality:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 inch</td>
<td>100</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>80 to 100</td>
</tr>
<tr>
<td>No. 8</td>
<td>0 to 10</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 3</td>
</tr>
</tbody>
</table>

O. Type U (Bedding and Pipe Zone Material) COS Mineral Aggregate Type 22:

1. Clean sand/gravel mixture free from organic matter.

2. The product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious Materials. The crushed screenings shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exist on more than 50 percent of the surface area of any size between successive laboratory sieves. The portion of material retained on all sieves with a ¼ inch opening and larger shall not contain more than 0.1 percent deleterious Materials by weight.

3. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 inch</td>
<td>100</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>75 to 100</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>0 to 25</td>
</tr>
</tbody>
</table>

P. Type V (Rip Rap):

1. The stone for riprap and quarry spalls shall be hard, sound and durable. It shall be free from segregation, seams, cracks, and other defects tending to destroy its resistance to weather.

2. Should the riprap contain insufficient 4" to 8" spalls the Contractor shall furnish and place supplementary spall material from a source approved by the Engineer, at the Contractor’s sole expense.

3. The grading of the riprap will be determined by the Engineer by visual inspection of the load before it is dumped into place, or, if so ordered by the Engineer, by dumping individual loads on a flat surface and sorting and measuring the individual rocks contained in the load.
4. Conform to the following gradation:

<table>
<thead>
<tr>
<th>Minimum Size</th>
<th>Maximum Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>40% to 90%</td>
<td>1 ton (1/2 cubic yard)</td>
</tr>
<tr>
<td>70% to 90%</td>
<td>300 lbs. (2 cubic feet)</td>
</tr>
<tr>
<td>10% to 30%</td>
<td>3 inch 50 lbs. (spalls)</td>
</tr>
</tbody>
</table>

Q. Type W (Rock Facing Material):

1. Rock for constructing new rock facing shall be large, broken pieces of igneous and metamorphic rock types. Each rock shall be rectangular, intact, fracture free, sound and durable Material, resistant to weathering and free of soft weathered Material and seams of soft rock susceptible to deterioration.

2. The size categories for rock shall be as follows:

<table>
<thead>
<tr>
<th>Size</th>
<th>Approx. weight, lbs</th>
<th>Min. approx. dimensions, inches</th>
<th>Approx. volume, cf</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-man rock</td>
<td>200 – 400</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Two-man rock</td>
<td>500-800</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Three-man rock</td>
<td>900-1,200</td>
<td>16</td>
<td>6.6</td>
</tr>
<tr>
<td>Four-man rock</td>
<td>1,300-2,000</td>
<td>18</td>
<td>12.5</td>
</tr>
<tr>
<td>Five-man rock</td>
<td>2,000-4,000</td>
<td>24</td>
<td>18.5</td>
</tr>
<tr>
<td>Six-man rock</td>
<td>4,100-6,000</td>
<td>30</td>
<td>31</td>
</tr>
</tbody>
</table>

3. Rocks less than 1.5 cubic foot (cf) in volume shall not be used.

4. SPU Materials Lab will review materials from known sources. The Contractor shall provide the services of an ASTM or AASHTO accredited testing laboratory approved by the Engineer to sample the rock from sources unknown to the SPU Materials Lab, ensuring that rock samples are representative of the rock anticipated for use on the project, and to perform the following laboratory tests:

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Standard</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>ASTM C 127</td>
<td>Minimum 2.65</td>
</tr>
<tr>
<td>Soundness</td>
<td>AASHTO T 104</td>
<td>Not greater than 5% loss</td>
</tr>
<tr>
<td>(section 5.2.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerated expansion</td>
<td>CRD-C-148</td>
<td>Not greater than 15% breakdown</td>
</tr>
<tr>
<td>Absorption</td>
<td>ASTM C 127</td>
<td>Not greater than 2%</td>
</tr>
<tr>
<td>L. A. Abrasion</td>
<td>ASTM C 131</td>
<td>Maximum 20% loss @ 500 revolutions</td>
</tr>
</tbody>
</table>

5. All rock to be delivered to and incorporated into the project where rock facing is over 6 feet high, shall meet the minimum testing requirements noted above; the rock shall be stockpiled in a separate pile at the quarry prior to delivery to the Project Site and shall be protected from contamination with other, untested rock sources.

R. Type X: Not used.
S. Type Y: Not used.

T. Type Z: Not used.

U. Type AA (Sand) COS Mineral Aggregate Type 7: Not used.

V. Type BB (Clay Cap): Bentonite clay.

W. Type CC (Well Graded Sand) COS Mineral Aggregate Type 6:

1. Sand shall consist of a well-graded inert material.
2. Sources of sand shall be inspected and approved by Puget Sound Energy prior to delivery of material.
3. Conform to the following gradation:

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>95 to 100</td>
</tr>
<tr>
<td>No. 8</td>
<td>68 to 86</td>
</tr>
<tr>
<td>No. 16</td>
<td>47 to 65</td>
</tr>
<tr>
<td>No. 30</td>
<td>27 to 42</td>
</tr>
<tr>
<td>No. 50</td>
<td>9 to 20</td>
</tr>
<tr>
<td>No. 100</td>
<td>0 to 7</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 2</td>
</tr>
</tbody>
</table>

2.02 CONSTRUCTION GEOTEXTILES [COS]

A. Geotextile and Thread for Sewing:

1. The material shall be a geotextile consisting only of long chain polymeric fibers or yarns formed into a stable network such that the fibers or yarns retain their position relative to each other during handling, placement, and design service life. At least 95 percent by weight of the material shall be polyolefins or polyesters. The material shall be free from defects or tears. The geotextile shall also be free of any treatment or coating which might adversely alter its hydraulic or physical properties after installation. The geotextile shall conform to the properties as indicated in Tables 1 through 3 for each use specified in the Contract. Specifically, the geotextile uses included in this Section and their associated tables of properties are as follows:

<table>
<thead>
<tr>
<th>Geotextile Application</th>
<th>Applicable Property Tables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground Drainage, Low Survivability, Classes A, B, and C</td>
<td>Tables 1 and 2</td>
</tr>
<tr>
<td>Underground Drainage, Moderate Survivability, Classes A, B, and C</td>
<td>Tables 1 and 2</td>
</tr>
<tr>
<td>Separation</td>
<td>Table 3</td>
</tr>
<tr>
<td>Soil Stabilization</td>
<td>Table 3</td>
</tr>
</tbody>
</table>
2. Thread used for sewing shall consist of high strength polypropylene, polyester, or polyamide. Nylon threads will not be allowed. The thread used to sew permanent erosion control geotextiles shall be resistant to ultraviolet radiation. The thread shall be of contrasting color to that of the geotextile itself.

B. Geotextile Properties:

Table 1. Geotextile for Underground Drainage Strength Properties for Survivability

<table>
<thead>
<tr>
<th>Geotextile Property</th>
<th>Test Method</th>
<th>Geotextile Property Requirements[^1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab Tensile Strength, min. in machine and x-machine direction</td>
<td>ASTM D 4632</td>
<td>Low Survivability Woven / Nonwoven&lt;br&gt;180 lbs. / 115 lbs. min.&lt;br&gt;250 lbs. / 160 lbs. Min</td>
</tr>
</tbody>
</table>
| Grab Failure Strain, in machine and x-machine direction | ASTM D 4632  | Moderate Survivability Woven / Nonwoven<br>&lt;50% / &lt;50%
| Seam Breaking Strength                          | ASTM D 4632[^3] | &lt;50% / &lt;50%                                |
| Puncture Resistance                             | ASTM D 4833    | 67 lbs. / 40 lbs. min.                             |
| Tear Strength, min. in machine and x-machine direction | ASTM D 4533  | 67 lbs. / 40 lbs. min.                             |
| Ultraviolet (UV) Radiation stability            | ASTM D 4355  | 50% strength retained min., after 500 hrs. in weatherometer |

[^1]: See notes after Table 3 below.

Table 2. Geotextile for Underground Drainage Filtration Properties

<table>
<thead>
<tr>
<th>Geotextile Property</th>
<th>Test Method</th>
<th>Geotextile Property Requirements[^1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOS</td>
<td>ASTM D 4751</td>
<td>Class A: .43 mm max. (No. 40 sieve)&lt;br&gt;Class B: .25 mm max. (No.60 sieve)&lt;br&gt;Class C: .18 mm max. (No.80 sieve)</td>
</tr>
<tr>
<td>Water Permittivity</td>
<td>ASTM D 4491</td>
<td>.5 sec-1 min.&lt;br&gt;.4 sec-1 min.&lt;br&gt;.3 sec-1 min.</td>
</tr>
</tbody>
</table>

[^1]: See Notes after Table 3 below.
Table 3. Geotextile for Separation or Soil Stabilization

<table>
<thead>
<tr>
<th>Geotextile Property</th>
<th>Test Method</th>
<th>Geotextile Property Requirements¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Separation Woven/Nonwoven</td>
</tr>
<tr>
<td>AOS</td>
<td>ASTM D 4751</td>
<td>.60 mm max. (No. 30 sieve)</td>
</tr>
<tr>
<td>Water Permittivity</td>
<td>ASTM D 4491</td>
<td>.02 sec-1 min.</td>
</tr>
<tr>
<td>Grab Tensile Strength, min. in machine and x-machine direction</td>
<td>ASTM D 4632</td>
<td>250 lbs. / 160 lbs. min.</td>
</tr>
<tr>
<td>Grab Failure Strain, in machine and x-machine direction</td>
<td>ASTM D 4632</td>
<td>&lt;50% / 50%</td>
</tr>
<tr>
<td>Seam Breaking Strength</td>
<td>ASTM D 4632</td>
<td>220 lbs. / 140 lbs. min.</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>ASTM D 4833</td>
<td>80 lbs. / 50 lbs. min.</td>
</tr>
<tr>
<td>Tear Strength, min. in machine and x-machine direction</td>
<td>ASTM D 4533</td>
<td>80 lbs. / 50 lbs. min.</td>
</tr>
<tr>
<td>Ultraviolet (UV) Radiation stability</td>
<td>ASTM D 4355</td>
<td>50% strength retained min., after 500 hrs. in weatherometer</td>
</tr>
</tbody>
</table>

Notes for Tables 1, 2, and 3:
1. All geotextile properties in Tables 1 through 3 are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).
2. The test procedures used are essentially in conformance with the most recently approved ASTM geotextile test procedures, except for geotextile sampling and specimen conditioning, which are in accordance with WSDOT Test Methods 914 and 915, respectively.
3. With seam located in the center of 8-inch long specimen oriented parallel to grip faces.

C. Geotextile Approval and Acceptance:

1. Source Approval:
   a. For each geotextile application, the Contractor shall submit to the Engineer for approval, the manufacturer’s name, address, the geotextile full product name, and the geotextile structure including fiber/yarn type.
   b. If the geotextile source has not been previously evaluated, a sample of each proposed geotextile shall be submitted to the Engineer for evaluation. After the sample and required information for each geotextile type has been received by the Engineer, a maximum of 14 calendar Days will be required for this testing. Source approval will be based on conformance to the applicable values from Tables 1 through 3.
   c. Source approval shall not be the basis of acceptance of specific lots of Material unless the lot sampled can be clearly identified and the number of samples tested and approved meet the requirements of WSDOT Test Method 914.
2. Geotextile Samples for Source Approval and Engineer Testing:
   a. Each sample shall have minimum dimensions of 5 feet by the full roll width and shall be a minimum 6 square yards. The machine direction shall be marked clearly on each sample and is defined as the direction perpendicular to the axis of the geotextile roll. Source approval for temporary silt fences will be by Manufacturer’s Certificate of Compliance.
   b. Samples shall be cut from the geotextile roll by a suitable method that produces a smooth geotextile edge without edge ripping or tearing. The samples shall not be taken from the outer wrap of the roll nor the inner wrap of the core.

3. Acceptance Samples:
   a. Samples will be taken by the Engineer at the Project Site to confirm the geotextile meets the specified properties.
   b. Approval will be based on testing of samples from each lot. A “lot” shall be defined for the purposes of this Specification as all geotextile rolls within the consignment (i.e., all rolls sent to the Project Site) which were produced by the same manufacturer during a continuous period of production at the same manufacturing plant and have the same product name. After receipt of the samples by the Engineer, a maximum of 14 calendar Days will be required for testing. If the results of the testing show that a geotextile lot, as defined, does not meet the properties required for the specified use as indicated in Tables 1 through 6 in Section 9-37.2, the roll or rolls which were sampled will be rejected. Two additional rolls for each roll found defective from the lot tested will then be sampled at random by the Engineer for retesting. If retesting shows that any of the additional rolls tested do not meet the required properties, the entire lot will be rejected. If the test results from all the rolls retested meet the required properties, the entire lot minus the roll(s) which failed will be accepted. All geotextile with defects, deterioration, or damage will be rejected and shall be replaced shall be replaced at no expense to the Owner.

4. Acceptance by Certificate of Compliance:
   a. When the quantities of geotextile proposed for use in each geotextile application are less than or equal to the following amounts, acceptance shall be by Manufacturer’s Certificate of Compliance:

<table>
<thead>
<tr>
<th>Application</th>
<th>Geotextile Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground Drainage</td>
<td>600 sq. yards</td>
</tr>
<tr>
<td>Soil Stabilization and Separation</td>
<td>1,800 sq. yards</td>
</tr>
<tr>
<td>Permanent Erosion Control</td>
<td>1,200 sq. yards</td>
</tr>
<tr>
<td>Temporary Silt Fence</td>
<td>All quantities</td>
</tr>
</tbody>
</table>

   b. The Manufacturer’s Certificate of Compliance shall include the manufacturer’s name, current address, full product name, geotextile structure including fiber/yarn type, geotextile roll number, proposed use(s), and certified test results.
5. Approval of Seams:
   a. If the geotextile seams are to be sewn in the field, the Contractor shall provide a section of sewn seam which can be sampled by the Engineer before the geotextile is installed.
   b. The seam sewn for sampling shall be sewn using the same equipment and procedures as are to be used to sew the production seams. If production seams are to be sewn in both the machine and cross-machine directions, the Contractor shall provide sewn seams for sampling which are oriented in both the machine and cross-machine directions. The seams sewn for sampling shall be at least 2 yards in length in each geotextile direction. If the seams are sewn in the factory, the Engineer will obtain samples of the factory seam at random from any of the rolls to be used. The seam assembly description shall be submitted by the Contractor to the Engineer and are to be included with the seam sample obtained for testing. This description shall include the seam type, stitch type, sewing thread type(s), and stitch density.

PART 3 - EXECUTION

3.01 GENERAL

A. Control of Water:
   1. Keep excavations free from water during construction.
   2. Control and disposal of water: Per Sections 01 56 10, Site Water Discharge, 31 23 20, Control of Water, and 31 25 00, Erosion and Sedimentation Controls.

B. Overexcavation of Unstable Foundation Material:
   1. Where the undisturbed condition of natural soils is inadequate for support of the planned construction, the Engineer will direct the Contractor to overexcavate to adequate supporting soils.
   2. Fill the excavated space to the specified elevation with class backfill shown on the Drawings or per Table A if not shown.
   3. Unless otherwise indicated, the overexcavated space under footings and structures shall be filled with Material Type L.
   4. The quantity of overexcavation and backfill will be paid per Section 01 22 10, Measurement and Payment.

C. Excavated Material:
   1. Excavated materials shall be considered unsuitable and shall be disposed of off-site.
   2. Dispose of excavated material off-site in accordance with applicable ordinances and environmental requirements.
D. Trenching:

1. All material excavated from trenches and piled adjacent to the trench shall be piled and maintained so that the toe of the slope is at least 2 feet from the edge of the trench. This material shall be piled to cause a minimum of inconvenience to public travel, and provision shall be made for traffic where necessary. [COS]

2. The Contractor shall provide clear access to all fire hydrants, water valves, and meters and shall leave clearance to enable the free flow of storm water in all gutters, conduits and natural watercourses.

3. Remove all ledge rock, boulders and stones four inches and larger to provide a minimum clearance of 12 inches under and around the pipe. The maximum size of aggregate within 12 inch of the pipe shall not exceed 1 inch per foot of pipe diameter and in no case shall exceed 3 inch. [COS]

4. Replace all excavated material with fill material that meets the requirements of Table A.

5. In loose or soft soils, perform the excavation at the bottom of the trench by equipment that does not have digging teeth. Should the natural or fill foundation soils at the trench bottom be disturbed or loosened because of the Contractor's operations, recompact or remove. If material is removed, refill the area with material as specified in Table A.

E. Finish Grading:

1. Finished surfaces shall be smooth, compacted, and free from irregularities. The degree of finish shall be that normally obtainable with a blade-grader.

2. Finished grade shall be as specified by the spot elevations +0.10 foot, except where a local change in elevation is required to match sidewalks, curbs, manholes, and catch basins, or to ensure proper drainage.

3. When the work is an intermediate stage of completion, the lines and grades shall be as specified +0.5 foot to provide adequate drainage.

F. Control of Erosion: Maintain earthwork surfaces true and smooth, and protected from erosion. Where erosion occurs, provide fill or excavate as necessary to return earthwork surfaces to the grade and finish specified.

3.02 CLASSIFICATION OF FILL

A. Fill material shall be placed in horizontal layers and compacted with power operated tampers, rollers, idlers, or vibratory equipment.

B. Material type, maximum layer depth, relative compaction, and general application are specified in Table A below.

C. Unless otherwise indicated, fill classes shall be used where specified in Table A under general application.
<table>
<thead>
<tr>
<th>Fill Class</th>
<th>Material Type</th>
<th>Maximum Uncompacted Layer Thickness, Inches</th>
<th>Minimum Compaction, Percent</th>
<th>General Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>L</td>
<td>8</td>
<td>95</td>
<td>Slabs on grade, basement fill.</td>
</tr>
<tr>
<td>A2</td>
<td>A</td>
<td>8</td>
<td>95</td>
<td>Subsequent pipeline backfill in roadways, embankments, and roadway shoulders.</td>
</tr>
<tr>
<td>B</td>
<td>L</td>
<td>8</td>
<td>95</td>
<td>Structure backfill.</td>
</tr>
<tr>
<td>C2</td>
<td>A</td>
<td>8</td>
<td>95</td>
<td>Site fill and embankments.</td>
</tr>
<tr>
<td>E</td>
<td>E</td>
<td>8</td>
<td>-</td>
<td>Bedding and backfill around foundation drain pipes and directly under slabs for structures and tanks.</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>6</td>
<td>95</td>
<td>Drainage blanket.</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
<td>6</td>
<td>95</td>
<td>Compacted fill or embankment below and adjoining pavement base course.</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>8</td>
<td>95</td>
<td>Fill under slabs or structures.</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>8</td>
<td>95</td>
<td>Alternative foundation drain pipe bedding and backfill and for stone filter</td>
</tr>
<tr>
<td>N</td>
<td>N</td>
<td>8</td>
<td>90</td>
<td>Imported trench backfill to replace excavated materials.</td>
</tr>
<tr>
<td>O</td>
<td>O</td>
<td>–</td>
<td>–</td>
<td>Alternative pipe bedding and trench backfill</td>
</tr>
<tr>
<td>P</td>
<td>P</td>
<td>8</td>
<td>90</td>
<td>Roadway base course.</td>
</tr>
<tr>
<td>Q</td>
<td>Q</td>
<td>12</td>
<td>–</td>
<td>Construction entrance, temporary road base.</td>
</tr>
<tr>
<td>R</td>
<td>R</td>
<td>6</td>
<td>95</td>
<td>Roadway top course.</td>
</tr>
<tr>
<td>S</td>
<td>S</td>
<td>6</td>
<td>–</td>
<td>Bedding and pipe zone backfill for pipe systems other than Class U.</td>
</tr>
<tr>
<td>U</td>
<td>U</td>
<td>6</td>
<td>95</td>
<td>Bedding and pipe zone backfill for plastic and HDPE pipe systems.</td>
</tr>
<tr>
<td>BB</td>
<td>BB</td>
<td>8</td>
<td>–</td>
<td>Clay cap</td>
</tr>
</tbody>
</table>
### 3.03 EARTHWORK FOR STRUCTURES

#### A. Structure Excavation:

1. The last 3 inches from the finished subgrade shall be removed without disturbing the subgrade.

2. The bottom shall not be more than 0.15 foot above or below the lines and grades specified. If the elevation of structure excavation is not specified, the excavation shall be not more than 0.15 foot above or below the elevation specified for fill material below the structure. slopes shall vary no more than 0.5 foot from specified grade unless the excavation is in rock where the maximum variation shall be 2 feet.

3. Should the excavation be carried below the lines and grades specified on the Drawings, or should the bottom of the excavation be disturbed because of the Contractor's operations and require overexcavation and backfill, refill such excavated space to the proper elevation in accordance with the procedure specified for backfill.

4. Unless otherwise indicated, excavations shall extend a sufficient distance from walls and footings to allow for placing and removal of forms, and installation of services, except where concrete is specified to be placed directly against excavated surfaces.

#### B. Structure Backfill:

1. Unless otherwise indicated, placement of fill materials shall be in accordance with Table A.

2. After completion of construction below the elevation of the final grade, and prior to backfilling, concrete forms shall be removed and the excavation shall be cleaned of debris.

3. Do not place backfill until the subgrade portions of the structure have been inspected by the Engineer.

4. No backfill material shall be deposited against concrete structures until the concrete has reached its 28-day specified strength unless approved by the Engineer of Record.

5. Backfill material shall be placed in uniform layers, and shall be brought up uniformly on all sides of the structure.

6. Accomplish compaction by using power-operated tampers, rollers, or vibratory equipment. Perform compaction within 2 feet of walls with hand-operated vibratory compactors.

7. Unless otherwise indicated, backfill around and above pipelines within the excavation line of any structure shall be the same as that specified for structures.

### 3.04 EARTHWORK FOR PIPELINES AND CONDUITS

#### A. Trenching

1. Trenching methods shall meet requirements of Section 31 23 20, Control of Water and 31 41 00, Shoring.
2. Excavate all storm drain and sewer trenches in accordance with the lines and grades shown on the Drawings. Refer to the Drawings for the typical storm drain trench section.

3. Excavate all water service trenches in accordance with the lines and grades shown on the Drawings. Refer to the Drawings for the typical watermain trench section.

B. Pipe Foundations:

1. Inadequate Soils:
   a. Where the undisturbed condition of the natural soil material is inadequate for support of the planned pipeline, the Engineer will direct the Contractor to overexcavate to adequate supporting soils.
   b. Fill the excavated space to the specified grade with backfill per Table A.
   c. All costs involved in the excavation and disposal of the inadequate soil material and placement of the fill shall be considered over-excavation.
   d. Should the excavation be carried below the lines and grades indicated on the Drawings because of the Contractor's operations, refill such excavated space to the proper elevation at no additional cost.
   e. The quantity of extra excavation of inadequate soil material and backfill will be paid per Section 01 22 10, Measurement and Payment.

2. Foundation Preparation:
   a. Properly prepare the foundation or place and compact the foundation material prior to installation of all pipe bedding and pipe.
   b. This shall include the necessary preparation of the native trench bottom and/or the top of the foundation material to a uniform grade so that the entire length of pipe rests firmly on a suitable properly compacted material.
   c. Place bedding and backfill material around the pipe in a manner to meet requirements specified in the respective section for the type of pipe being installed.

C. Pipe Bedding: Placement of bedding material in the pipe zone shall be Class B as indicated on City of Seattle Standard Plan no 285 for rigid and flexible pipe.

D. Backfilling

1. Complete pipe bedding and pipe zone backfill as indicated on the City of Seattle Standard Plan 285 before subsequent backfilling operations are started.

2. Take all necessary precautions to protect the pipe from any damage, movement or shifting. In general, perform backfilling by placing the material so as not to damage the pipe.

3. Provide for the proper maintenance of traffic flow and accessibility as may be necessary, and make adequate provisions for the safety of property and persons.
4. Unless specifically authorized in writing by the Engineer, remove temporary cribbing, sheeting or other timbering in accordance with Section 31 41 00, Shoring. The Contractor shall remove any support system or shield system or related system in such a manner as to not disturb bedding or backfill or damage the pipe. Where bedding or backfill is disturbed, the Contractor shall reconsolidate these materials to specified requirements at no cost to Seattle Public Utilities. Where pipe damage occurs, the Contractor shall repair the pipe at no cost to Seattle Public Utilities. [COS]

5. Keep pipe placed below the water table from floating by keeping the excavation dry in accordance with Section 31 23 20, Control of Water.

6. Remove all brush, stumps, logs, planking, disconnected drains, boulders, etc., from the material to be used for backfilling the trench.

E. General Compaction Requirements:

1. Equipment:
   a. Provide the proper size and type of compaction equipment and select the proper method of utilizing said equipment to attain the required compaction density.
   b. In all cases, select and use equipment so as to not damage the pipe or other utilities and structures.
   c. Truck-mounted drop hammers or truck-mounted impact hammers, impact pavement breakers, and similar types of mobile equipment will not be permitted for compacting backfill placed around or above pipes.

2. Water settling methods of compaction shall not be permitted.

3. In-place compaction tests may be made by the Engineer. Remove and recompact material that does not meet specified requirements.

3.05 SITE FILL

A. Unless otherwise indicated, site fill shall be Fill Class C2. If the existing slope in an area to be filled is greater than 5:1, bench the area prior to filling.

3.06 FINISH

A. Areas covered by the work, including excavated and filled sections and transition areas, shall be graded uniformly to the elevations shown.

B. The finished surface shall be reasonably smooth, compacted, and free from irregular surface changes.

C. The degree of finish shall be that ordinarily obtainable from a blade-grader operation.

D. The finish surface shall be not more than 0.05 foot above or below the established grade.

E. The surface of areas to be paved on which a base course is to be placed shall not vary more than 0.05 foot from established grade and cross section.

END OF SECTION 31 05 00
PART 1 - GENERAL

1.01 SUMMARY

A. This Section specifies the qualifications, installation, monitoring, maintenance and reporting requirements for settlement and vibration monitoring.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor’s responsibility to perform all the work required by the Contract Documents.

1. Section 01 33 10
2. Section 01 71 23
3. Section 03 30 00
4. Section 31 05 00
5. Section 31 23 20

C. Purpose

1. Settlement Monitoring:
   a. The settlement indicator points will provide reference points for monitoring vertical and horizontal ground movement and to establish a baseline record of such movement.
   b. Measurements of ground movement will provide the basis for the implementation of remedial measures to prevent possible damage to structures and utilities.
   c. Remedial measures, if necessary, include modifications of construction procedures, repair or replacement of damaged facilities and restoration to original conditions of any disturbed property, structure or utility.

2. Vibration Monitoring
   a. The vibration monitoring will determine if the equipment and methods used to complete the work cause vibrations which equal or exceed a specific standard which could cause damage to existing facilities.
   b. The data gathered will provide on-site feedback of the effects of specific operations and procedures which may, over an extended period, cause damage.
   c. Operations that are found to cause vibration damage shall be modified to prevent damage from vibration.
1.02 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the following documents. It is a part of this Section as specified and modified. In case of conflict between the requirements of this Section and that of the listed document, the requirements of this Section shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO H-20</td>
<td>Standard Specification for Highway Bridges – H-20 Truck Load</td>
</tr>
<tr>
<td>Chapter 173-160 WAC</td>
<td>Minimum Standards for Construction and Maintenance of Wells</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

A. Instrumentation Wells: All holes drilled below the groundwater table for the purpose of installing geotechnical instruments.

B. Geotechnical Instruments: Instruments used to measure settlement, depth to groundwater table and vibrations. Includes settlement monitoring points, groundwater observation wells and vibration monitors.

C. Optical Survey Monitoring: Precise field measurements using survey techniques for determination of elevations, coordinates and distances for performing geotechnical instrumentation monitoring.

D. Settlement Monitoring Points:
   1. Fixed markers placed on structures and utilities for monitoring changes in elevations of new and existing structures and existing utilities.
   2. Monitored by optical survey methods to determine vertical or horizontal displacements.
   3. Include structure and utility settlement points.

E. Action Level: Specified amount of measured movement at which point action shall be taken to adjust the excavation and construction operations.

F. Vibratory Monitors: Seismographs used to measure vibration levels in velocity and frequency.

1.04 SUBMITTALS

A. Procedures: Section 01 33 10.

B. Qualifications of the individual(s) responsible for the installation and monitoring of the vibration and settlement.

C. Settlement and Vibration Instrumentation Installation and Monitoring Plan, including:
   1. Schedule and timing for instrument installation and performance of monitoring, including summary table for all instrument installations by number and location
      a. Timing of each instrument installation.
      b. Initial baseline monitoring schedule.
c. Timing of monitoring commencement and schedule of monitoring for each instrument.

2. Individuals responsible for all monitoring, report writing and format of reporting

3. Operating manuals, specifications and installation procedures for each type of instrumentation.

4. Documentation of calibration checks on individual instruments and readouts for the vibration monitors, including recalibration after any damage or disturbance.

5. Procedure to confirm that instruments are working correctly following installation.

6. Outline of procedures detailing how monitoring will be conducted.

7. Data review process for comparison to indicated Action Levels.

8. Corrective Action Plan
   a. Details of actions to be taken in the case of settlement or vibrations exceeding the specified Action Levels.
   b. Include operational changes to reduce the rate of settlement.

9. Detailed plan of instrumentation locations.

10. Sample data forms and data output files in MS Excel format for settlement monitoring.

11. An updated list and testing is required when equipment is brought to the site which has not been previously tested for this Contract.

D. Daily reports of the work monitored and completed including a printout recording peak wave data every minute during construction operations. The Contractor shall include observations that will help in describing the monitoring results of that day.

E. Reports of settlement monitoring data.

F. Survey report every two weeks for tie-in check of all settlement monitoring points relative to project survey control.

1.05 QUALITY ASSURANCE

A. The Settlement and Vibration Instrumentation Installation and Monitoring Plan shall be approved and monitoring points shall be established prior to the beginning of the sheet pile installation and shall remain in place and monitored through all ground improvement activities, structure installation and pipeline excavation.

B. Qualifications:

1. Surveyor: Section 01 71 23, Field Engineering

2. Instrumentation Specialist that will manage/oversee acquisition, installation, data collection and analyze/interpret instrumentation:
   a. At least five (5) years experience in installation, monitoring and analyzing similar types of settlement monitoring in urban environments.
   b. Employed by a firm regularly engaged in settlement and vibration instrumentation and monitoring.
   c. Not employed directly by the Contractor.
C. Installation and decommissioning of all instrumentation wells shall be performed by a Washington State licensed well contractor.

1.06 EMERGENCY MEASURES
A. Whenever there is a condition which is likely to endanger the stability of the excavation or adjacent structures and utilities, as indicated by the periodic collection of data or by visual observations, operate a full crew for 24 hours a day, including weekends and holidays, without interruption, until those conditions are controlled and no longer jeopardize the stability of the work or adjacent structures.

1.07 AS-BUILT DRAWINGS
A. Settlement Points and Vibration Monitoring Devices on a maximum scale of 1 inch equals 20 feet and elevation using the City of Seattle Datum and Easting and Northing coordinates

1.08 SETTLEMENT MONITORING DATA
A. Instrumentation Specialist shall upload settlement monitoring data to MS Excel within eight hours of the readings being taken.
B. Present settlement monitoring data using City of Seattle Datum.
C. Prepare settlement monitoring data plots using MS Excel, review plots for accuracy and completeness and submit electronic copies of data reports and plots to the Engineer.

1.09 MEASUREMENT REQUIREMENTS FOR SETTLEMENT MONITORING
A. Establish the initial elevations of settlement monitoring points to 0.01 foot.
B. Record the subsequent elevations of settlement monitoring points to 0.01 foot.
C. Achieve level circuit closure with an error of closure of 0.017 N-feet or less, where N is the circuit distance in miles.
D. Establish the initial horizontal coordinates of monitoring points to 0.01 foot.

1.10 AVAILABILITY OF DATA
A. Do not disclose data reports and all other unprocessed data, readings and observations to third parties.

1.11 RIGHT OF ENTRY
A. Right of entry to private property to be provided by the City.

1.12 PRE-AND POST-CONSTRUCTION SURVEYS
A. Pre- and post-construction surveys of the existing structures indicated in the Contract Documents to be performed by a surveyor contracted by the Contractor's independent testing service. The same surveyor shall conduct both the pre- and post-construction surveys.
PART 2 - PRODUCTS

2.01 GENERAL

A. Provide instrumentation reading devices, fixtures, cables and necessary software for the various monitoring systems.

B. Type S fill: Section 31 05 00, Common Work Results for Earth Work.

C. Access covers for utility settlement points

1. Frame: Heavy duty steel or cast iron construction.

2. Lid: Solid steel or cast iron, gasketed and locking (requiring a flush surface entry).

3. Dimensions: Appropriate to borehole diameter and instrumentation requirements.


5. Acceptable access cover manufacturers: Morris Products, Inc., Olympic Foundry Inc., or approved equal.

D. Pavement repair: Four (4) temporary pavement patch materials products approved by the Engineer for use include:

1. Unique Paving Material (UPM) Alpine Products
   Phone: (253) 351-9828
   E-mail: Skip@alpinetrafficproducts.com
   Web-site: www.upm.com

2. Qualified Patch Material (QPR)
   a. E Z Street Lakeside Industries
      PO Box 7016
      Issaquah, WA 98027
      Phone: (425) 313-2681
      Fax: (425) 313-2622
      Web-site: www.lakesideind.com

   b. U.S. Cold Patch Phone: (425) 244-5000
      Fax: (425) 423-9120
      Web-site: www.uscoldpatch.com

   c. Other temporary patching products may be submitted to the Engineer for approval.

2.02 SETTLEMENT POINTS

A. Structure Settlement Points:

1. Structure settlement points installed in walls or vertical surfaces shall consist of fixed or reflector targets or ½-inch diameter steel expansion bolts drilled and anchored in or bonded to the surface as shown on the Drawings.

2. Bolts shall be embedded a minimum of 2 inches and project ½-inch from the vertical surface.
3. Optical or laser surveying methods will be used for monitoring settlement.

B. Utility Settlement Points:

1. Fixed end fiberglass rod extensometer and manual read mechanical reference head.
2. Install by digging a pit or vacuuming a hole above the utility or buried structure to be measured.
3. For excavated pits, the final 3 feet shall be dug by hand.
4. Utility shall be cleaned in the area of the elevation rod installation
5. Fiberglass rod shall then be grease packed to the top of the utility.
6. Casing shall be centered over the rod using centralizers.
7. Casing shall be cut to form a tight fit over the utility.
8. Backfilling around the casing shall be with the removed material or Type S fill per Section 31 05 00, Common Work Results for Earth Work.

2.03 VIBRATION MONITORING DEVICE

A. The Contractor shall provide at least two portable seismographs for monitoring the velocities of ground vibrations resulting from construction activities. The number of seismographs provided shall be:

1. Sufficient to monitor the utilities and structures shown in the Drawings.
2. Determined by the Contractor based on the Contractor’s selected means and methods and construction sequencing.

B. The furnished seismographs shall be Model Blastmate III, as manufactured by Instantel Inc. or approved equal having the following features:

1. External triaxial geophone and air overpressure microphone.
2. Three channels for vibration monitoring plus a fourth channel for air overpressure monitoring.
3. Two power sources: internal rechargeable battery and charger and 115 volts AC. Battery shall be capable of supplying power to monitor vibrations continuously for up to 30 days.
4. Self-triggering waveform capture mode that provides the following information: plot of wave forms, peak particle velocities, peak overpressure, frequencies of peaks.
5. Continuous monitoring mode shall be capable of recording single-component peak particle velocities, and frequency of peaks with an interval of one minute or less.
6. Computer software for performing continuous monitoring, data downloading, analysis and producing reports.
C. The portable seismographs shall meet the following measurement requirements:
   1. Seismic range: 0.005 to 10 inches per second.
   2. Seismic accuracy: +/- 3 percent of the measured peak particle velocity or better at frequencies between 3 Hertz and 250 Hertz.
   3. Seismic resolution: 0.005 inches per second or less.
   4. Acoustic range: 88 to 148 dB (referenced to 20 micro-Pascals) with an accuracy and resolution of +/-0.3 dB.
   5. Acoustic frequency response: 2 to 250 Hertz.
   6. Capable of internal dynamic calibration.

PART 3 - EXECUTION

3.01 GENERAL

A. Install the utility and building settlement monitoring points as indicated on the Drawings and as close as practical to the locations indicated on the Drawings. Adjust for actual conditions in the field.

B. Exact locations of instrumentation shall be field-determined and shall be approved by the Engineer prior to installation.

C. Verify location of buried utilities before installation of instrumentation.

D. Provide all necessary power for the monitoring equipment.

E. Provide as-built of instrumentation locations within five days of installation.

3.02 SETTLEMENT MONITORING

A. General:
   1. Unless otherwise directed by the Engineer, perform monitoring at those locations shown on the Drawings.
   2. Record the readings prior to, during and after Substantial Completion of deep soil mix column construction.
   3. These readings shall be submitted daily on forms acceptable to the Engineer.
   4. The readings shall be, at a minimum, at the following frequency intervals:

<table>
<thead>
<tr>
<th>When</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to construction activity being monitored</td>
<td>For two weeks, every seven days</td>
</tr>
<tr>
<td>During construction within 200 feet of construction activity</td>
<td>Daily</td>
</tr>
<tr>
<td>After substantial completion of construction activity being monitored</td>
<td>For one month, every seven days</td>
</tr>
</tbody>
</table>

B. Limit construction activities to control structure or utility settlement to a maximum of 1.0 inch.
C. Action Level: When monitoring produces readings over 0.5 inch, alter operations to assure that the action level is not exceeded and notify the Engineer.

D. Settlement monitoring points shall be installed, monitored, protected, maintained and removed and the area restored to a minimum of preconstruction condition.

3.03 INSTRUMENT INSTALLATION

A. Structure settlement monitoring points:
   1. Structure settlement points installed in walls or vertical surfaces shall consist of fixed reflector targets or ½-inch diameter steel expansion bolts drilled and anchored in or bonded to the surface as shown on the Drawings.
   2. Bolts shall be embedded a minimum of 2 inches and project ½-inch from the vertical surface.
   3. Optical or laser surveying methods will be used for monitoring settlement.

B. Utility settlement monitoring points:
   1. Install by digging a pit or vacuuming a hole above the utility or buried structure to be measured.
   2. For excavated pits, the final three feet shall be dug by hand.
   3. Utility shall be cleaned in the area of the elevation rod installation.
   4. Fiberglass rod shall then be grease packed to the top of the utility.
   5. Casing shall be centered over the rod using centralizers.
   6. Casing shall be cut to form a tight fit over the utility.
   7. Backfilling around the casing shall be with the removed material or Type S fill per Section 31 05 00, Common Work Results for Earth Work.
   8. Complete by installing access covers and patching pavement.

C. Vibration monitors:
   1. For monitoring in the vicinity of nearby structures or utilities, vibration sensors shall be located on the ground surface near the structures or utilities.
   2. Geophones shall be installed in accordance with the manufacturer’s recommendations.
   3. Geophones shall be oriented toward the construction activity.

3.04 SETTLEMENT BASELINE READINGS AND CALIBRATION

A. Make initial readings on all settlement monitoring points, in accordance with 1.10:
   1. Three complete sets of baseline measurements and readings shall be taken at all of the settlement monitoring points.
   2. Baseline readings shall be comparable and equal within the rated instrument accuracy.
B. Instrument calibration:
   1. The optical survey monitoring and vibration monitoring systems shall, at all times
during the monitoring program, meet the manufacturer’s minimum calibration
requirements.
   2. Correlate readings from any new replacement instrumentation with the
previously acceptable data.
   3. Settlement monitoring points shall be measured relative to a survey bench mark
located at least 500 feet from the site.

3.05 PROTECTION AND MAINTENANCE
A. Protect and provide access as necessary to all settlement monitoring points and
geotechnical instruments installed by others.
B. Keep protective access covers in place at all times other than during manual monitoring
and maintenance and keep access cover enclosures free of water and soil.
C. Replacement instruments, components and readout units shall be available within 24
hours for repair and replacement of existing installed instrumentation.
D. In the event of abnormal monitoring data or instrument damage, repair or replace the
affected instrument or components within 48 hours of detection at no additional cost to
Seattle Public Utilities.

3.06 VIBRATION MONITORING
A. Limit construction activities to the extent of controlling any vibrations transmitted through
the soil to any nearby houses, buildings, structures or adjacent utilities.
B. Unless otherwise directed by the Engineer, the Contractor’s independent testing service
shall monitor vibration in the areas shown on the Drawings daily during construction
activities, including, but not limited to, sheet pile installation, deep soil mix column
installation and any other shoring installation and removal.
C. The locations of vibration monitors shown on the Drawings are approximate. The
Contractor shall install the instruments as close as practicable to the locations shown.
The Contractor shall adjust locations for actual conditions in the field. The exact
locations of the instruments shall be field-determined and shall be approved by the
Engineer prior to installation.
D. The maximum allowable particle velocity at the nearest structure shall be limited to a
Peak Particle Velocity of 0.5-inch per second. Demonstrate that vibration levels are not
being exceeded for each construction activity.
E. If the Peak Particle Velocity limit is exceeded, the Contractor shall immediately cease the construction operation that is causing the vibration and notify the Engineer. The Contractor shall develop and submit a plan, to the Engineer, that describes how the work can proceed without exceeding the Peak Particle Velocity limit. Allow 48 hours for the review of the plan by the Engineer. The Contractor shall not resume the work that exceeded the Peak Particle Velocity threshold until receiving the Engineer’s approval of the revised work plan. The Contractor shall be responsible for the delay associated with the exceedance of the Peak Particle Velocity limit and developing the work plan. If the approved revised work plan does not reduce the Peak Particle Velocity to below the allowable limit, the Contractor shall cease all related operations contributing to the vibrations and repeat the process of developing a revised work plan and obtaining the Engineer’s approval. The Engineer’s approval of the revised work plan shall not alleviate the Contractor of the responsibility for conducting the work in a manner such that displacements or vibrations do not exceed the allowable limit.

3.07 PRE-CONSTRUCTION CONDITION

A. In addition to videotape and photographs, prior to starting work in the area, complete a detailed examination of each structure, which is required to have structure settlement points, as noted on the Drawings.

B. The detailed examination of each structure shall be performed by a Professional Engineer registered in the state of Washington.

C. Include in the survey, scale drawings showing all existing cracks, sticking doors and windows and structural distress.

D. Measure and record all initial existing crack widths.

E. In the survey, place 2-dimensional plastic crack measuring templates, such as Avongard or similar, at critical and representative locations.

F. Document and submit the results of the pre-construction inspection in a bound volume with the seal of the responsible Professional Engineer on the title page.

G. The measurements of pre-existing cracks and settlements shall also be taken during and after construction.

END OF SECTION 31 09 13
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes: This section includes information related to site clearing and grubbing.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.
C. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
D. The Contractor shall have at least one copy of the Standard Specifications at the job site.
E. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.03 DEFINITIONS
(NOT USED)

1.04 EXISTING CONDITIONS
A. The Contractor shall determine actual site conditions as it affects this portion of work.

PART 2 - PRODUCTS
(NOT USED)

PART 3 - EXECUTION

3.01 CLEARING AND GRUBBING
A. Clearing and Grubbing activities shall conform to Standard Specification 2-01.

3.02 CLEARING AND GRUBBING DISPOSAL
A. Clearing and Grubbing Disposal shall conform to Standard Specification 2-01.2.

3.03 CONSTRUCTION REQUIREMENTS
A. Clearing shall conform to Standard Specification 2-01.3(1).
B. Grubbing shall conform to Standard Specification 2-01.3(2).
C. Limits of Clearing and Grubbing shall conform to Standard Specification 2-01.3(3), and as shown on the Plans.
D. Roadside Cleanup shall conform to Standard Specification 2-01.3(4).
E. Protection of Existing Improvements shall conform to Standard Specification 2-01.3(5).

END OF SECTION 31 10 00
PART 1 - GENERAL

1.01 SUMMARY

A. This Section specifies the definition for the control of water on site and the requirements for designing, installing, maintaining and operating temporary systems to control water on site. On-site water includes groundwater, surface water and all other water that may be encountered accumulating on the ground surface and seeping from the ground during the performance of the work.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 01 33 10: Submittals.
2. Section 01 56 10: Site Water Discharge
3. Section 01 57 50: Temporary Environmental Pollution Control.
4. Section 01 76 00: Protection of Existing Facilities.
5. Section 31 05 00: Common Work Results for Earthwork.
7. Section 31 41 00: Shoring.

C. Dewatering systems include, but are not limited to, any dewatering wells, well points, recharge or injection wells, pumps, vacuum lines, discharge lines, and other equipment, appurtenances, and related earthwork necessary to perform dewatering.

D. Dewatering shall be used to maintain all excavations in a substantially dry condition, with stable subgrade and sidewalls for the execution of surveying and backfilling. The dewatering shall be used to lower the groundwater level to at least 2 feet below the bottom level of the excavation, for the duration of the excavation.

E. During installation of pipeline and placement of bedding and trench backfill, excavations shall be kept free of water. The Contractor shall control surface run-off so as to prevent entry or collection of water in excavations.

F. The Contractor is solely responsible for the proper design, installation, operation, maintenance, performance, failure, or damage resulting from any component of the dewatering system for this Contract.

G. Dewatering shall not be performed outside the sheet pile excavation support.

1.02 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the following documents. These references are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and that of the listed document, the requirements of this Section shall prevail, provided that all regulatory requirements are met.
1.03 SUBMITTALS

A. Procedures: **Section 01 33 10, Submittals.**

B. Control of Water Plan: The Contractor shall submit to the Engineer, a plan outlining the methods and installation, including details of the water control system.

C. System Design: Submit a dewatering system design plan that includes:

1. Dewatering and hydrostatic pressure relief methods.
2. Dewatering equipment.
3. Number, location, and depth of all existing and additional dewatering wells, well points, monitoring wells, piezometers, and recharge/injection wells.
4. Location and dimensions of discharge piping, discharge points, valves, flow meters, settlement tanks, and other dewatering equipment.
5. Water discharge shall be directly into the Duwamish Waterway. The discharge location should be indicated.
6. Water may need treatment prior to discharge to the Duwamish Waterway to meet state surface water quality standards. The treatment system should be designed to manage a minimum of 200 gallons per minute.
7. Calculations used to design the system.
8. Projected water level drawdown and elevation in all existing and additional dewatering wells, well points, monitoring wells, piezometers, and recharge/injection wells.
9. Plan view drawing showing the estimated zone of influence and resulting groundwater elevations for aquifer during dewatering.
10. Estimated dewatering system discharge flow rates.
11. Estimated recharge/injection system flow rates, if used.
12. Systems for control of inflow into excavations. Sheet pile shoring will be used in pipe installation areas and for the pump station wet well. If other watertight barriers, concrete tremie seals or grouted soil masses are planned, these shall be described.
13. The plan shall include methods for control and removal of surface water flow across the site and prevention of surface water flow from entering the excavations.
D. Drilling Logs and Well Diagrams:

1. Submit drilling logs that include:
   a. Drilling method(s).
   b. Location.
   c. Surface elevation.
   d. Drilling conditions.
   e. Soil descriptions.
   f. Groundwater conditions.
   g. Borehole depth.

2. Submit dewatering well, well point, and recharge/injection well diagrams that include:
   a. Total well depth.
   b. Well material and diameter.
   c. Screen material, length, slot size, and depth interval.
   d. Filter pack material and depth interval.
   e. Seal material and depth interval.

E. Filter pack descriptions used in dewatering wells, well points, and recharge/injection wells that include:

1. Calculations used to select filter pack gradation.
2. Gradation curve: ASTM D 422.
3. Manufacture’s or supplier’s statement that material is free of clay, silt, dirt, organic or other foreign matter.

F. Pump descriptions that include:

1. Manufacturer.
2. Capacity.
3. Rating curve.

G. Flow meter descriptions that include:

1. Manufacturer.
2. Calibration documentation.

H. Submit daily: Location and number of dewatering and recharge wells in operation; water levels in all dewatering wells, well points, monitoring wells, piezometers, and recharge/injection wells; instantaneous flow and discharge rates; total flow and discharge volumes; and a description of any problems with the dewatering system and any remedial actions implemented.

I. Submit weekly: Measurements of sand content in all dewatering wells, well points, monitoring wells, piezometers, recharge/injection wells, and discharge points.
J. Contact information shall be provided for a designated emergency contact. The contact shall be a responsible individual available 24 hours per day, 7 days per week.

K. Well decommissioning documentation.

1.04 DESIGN REQUIREMENTS

A. Use an approved Washington State licensed hydrogeologist to design the dewatering system. The designer shall have a minimum of 10 years of experience in the design of dewatering systems. Use accepted and professional design and engineering methods consistent with standard of practice.

B. Reduce the hydrostatic pressure in the aquifer to prevent basal instability in deep excavations.

C. Protect and avoid damage to all existing facilities, utilities, roadways, and improvements from dewatering induced land settlement.

D. Install monitoring wells to evaluate performance of the dewatering system.

E. Drawdown outside the sheet pile excavation support shall not exceed 2 feet at a distance of 50 feet from the edge of the excavation.

F. Comply with Chapter 173-160 WAC for the drilling, installation, construction, and decommissioning of all dewatering wells, well points, monitoring wells, and piezometers.

G. Comply with Chapter 173-218 WAC and Chapter 173-200 WAC for the drilling, installation, construction, development, operation, and decommissioning of all recharge/injection wells.

PART 2 - PRODUCTS

2.01 CONTROL OF WATER SYSTEM COMPONENTS

A. Temporary pumping systems:

1. All pumps used shall be fully automatic, self-priming units that do not require the use of foot-valves or vacuum pumps in the priming system. The pumps may be electric or diesel powered. All pumps used must be constructed to allow dry running for periods of time to accommodate the cyclical nature of effluent flows.

2. The Contractor shall provide the necessary stop/start controls for each pump.

3. All temporary discharge piping shall be constructed of rigid pipe with positive, restrained joints. Aluminum irrigation piping or glued PVC will not be allowed. Discharge hose will only be allowed in short sections and by the direction of the Engineer.
PART 3 - EXECUTION

3.01 GENERAL

A. Keep excavations free of water during construction.

B. The primary Control of Water for the excavations shall be by the use of excavation methods and watertight ground support systems that minimize the flow of groundwater into the excavations.

C. Provide and operate the machinery and equipment necessary to keep excavations free of water.

D. Dewater and dispose of the water so as not to cause injury to public, private, or other property, or to cause a nuisance or a hazard to the public or the environment.

E. Dispose of all water in a manner that complies with all permitting and regulatory requirements.

F. Provide on site sufficient pumping equipment and machinery in good working condition for emergencies, including power outages and flooding.

G. Provide on site workers needed for the operation of the dewatering system.

H. Maintain electric power service connections to the dewatering system.

I. Do not shut down the dewatering system between shifts, on holidays, on weekends, or during work stoppage without written permission from the Project Representative.

J. Maintain groundwater levels a minimum of two feet below the bottom of all excavations at all times and under all conditions and as necessary to maintain the undisturbed state of natural soil.

K. Control groundwater to prevent the softening of excavation bottoms or the formation of “quick” conditions or “boils.”

L. Prevent the removal of native soils during dewatering.

M. Control surface water runoff and prevent the entry or collection of surface water in excavations.

N. The static groundwater level, within the excavation, shall be controlled so as to maintain the undisturbed state of the foundation soils and allow acceptable placement of any bedding or backfill to the required density.

O. Do not use sumps for excavations deeper than 3 feet below the static groundwater level.

P. Immediate measures shall be taken, including but not limited to the modification of excavation and ground support procedures and ground permeability modifications, to reduce the inflow of water entering an excavation, where the volume or inflow rate is at risk of causing;

1. Damage or the potential of causing loss or damage to adjacent property or structures.

2. Loss of ground be the entrainment of fines.

3. Adverse effects on the performance of the site work.
3.02 DEWATERING DISCHARGE

A. Discharge locations, rates and water quality requirements shall be indicated on the Control of Water plan. Water treatment methods shall be indicated to achieve the water quality requirements for discharge. Discharge shall be directly to the Duwamish Waterway.

B. Provide in-line flowmeters or approved equal on all discharge pipes.
   1. Install and operate per manufacturer’s specifications.
   2. Use meters that provide instantaneous flow rate and total flow volume.
   3. Submit calibration documentation.

3.03 DRILLING

A. Mud rotary drilling is not permitted to install dewatering wells, well points, or recharge/injection wells.

3.04 WELL MATERIALS

A. Casing:
   1. Dewatering wells, well points, and recharge/injection wells: Polyvinyl chloride (PVC) or approved equal.

B. Screen:
   1. Dewatering wells, well points, and recharge/injection wells:
      a. Same diameter as the casing material.
      b. Machine-slotted PVC or approved equal.
      c. Slot-size: Engineered to minimize the movement of native soil into the well and maximize the flow of water into the well.

C. Centralizers:
   1. Dewatering wells and recharge/injection wells: Install at the bottom of the screen and one foot above the top of the screen.
   2. Well points: Install immediately above the top of the screen.

D. Filter Pack:
   1. Dewatering wells, well points, and recharge/injection wells:
      a. Quality: Clean, well rounded, washed silica sand and gravel free from silt, clay, and other deleterious material.
      b. Grain size: 70 percent of the native soil’s retained grain size multiplied by 4, 5, or 6 (the less uniform the native soil, the higher the multiplier).
      c. Uniformity coefficient: Less than 2.5 (determined by dividing the sieve size that retains 40 percent of the filter pack material by the sieve size that retains 90 percent of the filter pack material).
      d. Gradation: Produces a smooth and gradual grain size distribution curve when plotted.
E. Seals:
   1. Dewatering wells, well points, and recharge/injection wells: Chapter 173-160 WAC.

3.05 WELL DEVELOPMENT
A. Dewatering Wells, Well Points, and Recharge/Injection Wells:
   1. Remove fine soil from newly installed dewatering wells, well points, monitoring wells, and recharge wells to enhance the hydraulic connection between the screened interval and the surrounding soil.
   2. Untreated development water may not be disposed under the discharge permit.

3.06 SUMPS
A. Do not use open sumps.
B. Provide slotted or perforated casing with approved filter pack material.

3.07 ELECTRICAL SERVICE
A. Provide electrical service dedicated solely to the operation of the dewatering system on a circuit separate from all other electric uses.
B. Provide a backup electric power supply that can deliver 100 percent of the demand needed for the dewatering system.
C. Provide an automatic system to switch from primary electrical service to backup service in the event of primary service failure.
D. Provide an alarm system to notify site personnel in the event of an electrical service failure.

3.08 SYSTEM PROTECTION
A. Take all reasonable and necessary precautions to provide continuous and successful system operation.
B. Clearly mark all wells, pumps, vacuum headers, discharge lines, and other system components to prevent damage from vehicles or equipment.
C. Provide protective measures capable of supporting the heaviest equipment on site where vehicles or equipment cross the dewatering system.
D. Provide valves on headers and discharge lines on either side access ramps.

3.09 SOIL PROTECTION
A. Operate the system so that fines are not removed from native and engineered foundation soils during dewatering.
B. Monitor sand content in all dewatering wells, well points, recharge/injection well, and at all discharge points on a weekly basis:
3.10 BACKUP EQUIPMENT

A. Maintain on site sufficient backup equipment and materials to provide continuous and
effective operation of the dewatering system. Equipment and materials include, but are
not limited to, pumps, motors, generators, header pipe, discharge pipe, valves, tees,
ebrows, tools, and parts or other system hardware needed to immediately repair or
modify any part of the system.

B. Provide backup pumps, motors, and generators whose performance capacity is equal to
or greater than the primary components.

C. Keep standby equipment fueled and operational at all times.

3.11 MONITORING SYSTEM

A. Ensure that an accurate and continuous record of all pumped water flow information is
maintained:

1. Monitoring wells may not be used as dewatering wells.

B. Data Collection:

1. Collect daily water levels in all dewatering wells, monitoring wells, piezometers,
and recharge/injection wells.

2. Collect daily instantaneous flow rates from all dewatering wells and well points,
and to all recharge/injection wells.

3. Collect daily instantaneous and total flow rates at all discharge points.

4. Collect data during system operation and continue to collect data after the
completion of dewatering until the groundwater system has recovered to 90
percent of pre-dewatering levels.

3.12 DAMAGES

A. Repair any damage to work in place that may result from inadequate or improper
Control of Water System installation, maintenance and operation and any mechanical or
electrical failure of the system. Work in place is including, but not limited to

1. Structures.

2. Other Contractor’s equipment

3. The excavations, including damage to the bottom due to heave and removal of
material and pumping out of the excavated area.

B. Immediately support any footings, foundations, basement walls, concrete driveways,
utilities or other structures that become unstable and vulnerable to settlement due to
removal or disturbance of groundwater. Support shall include, but not be limited to
shoring, sheeting, bracing, grouting, underpinning, driving piles, excavation, backfilling,
placing new structural concrete beneath or adjacent to the unstable structure or other
means necessary to rectify the particular problem involved.

C. Be responsible for all loss or damage arising from removal or disturbance of
groundwater including, but not limited to, claims for impacts to groundwater remediation
operations by others, subsidence damage or the loss of structural support that may
occur in the prosecution of the work.
D. For the resolution of claims resulting from the failure of the Contractor to repair damage arising from the removal or disturbance of groundwater, refer to Section 01 76 00, Protection of Existing Facilities.

3.13 SOIL DATA

A. Per Section 00 31 10, Owner-Furnished Project Information.

B. Use of available information, in no way, relieves the Contractor from the responsibility for the operation of a properly functioning Control of Water system.

3.14 SYSTEM REMOVAL

A. Well Decommissioning: Chapter 173-160 WAC.

END OF SECTION 31 23 20
PART 1 - GENERAL

1.01 SUMMARY

A. When specified in the Contract or when approved by the Engineer, the Contractor shall supply controlled density fill (CDF) as backfill Material.

B. CDF Materials shall meet the requirements of the following sections of the 2017 City of Seattle (COS) Standard Specifications for Road, Bridge and Municipal Construction

1. Portland and Hydraulic Cement, Section 9-01
2. Aggregates for Portland Cement Concrete, Section 9-03.1
3. Curing Materials and Admixtures, Section 9-23
4. Fly Ash, Section 9-23.6
5. Common Ground Granulated Blast Furnace Slag, Section 9-23.7
6. Water, Section 9-25

1.02 REFERENCES

(NOT USED)

1.03 DEFINITIONS

(NOT USED)

1.04 CONTROLLED DENSITY FILL FOR PIPE BEDDING

A. For pipe bedding, the following CDF mix design shall be used

<table>
<thead>
<tr>
<th>Pipe Bedding CDF</th>
<th>Material</th>
<th>Quantity/Cubic Yard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Portland Cement Type I-II</td>
<td>94 pounds</td>
</tr>
<tr>
<td></td>
<td>Fly Ash Cl. F</td>
<td>2.2 cubic feet</td>
</tr>
<tr>
<td></td>
<td>Fly Ash Cl. C</td>
<td>1.1 cubic feet</td>
</tr>
<tr>
<td></td>
<td>Mineral Aggregate Type 7 w/Cl F Fly Ash</td>
<td>16.8 cubic feet</td>
</tr>
<tr>
<td></td>
<td>Mineral Aggregate Type 7 w/Cl C Fly Ash</td>
<td>17.9 cubic feet</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>4.8 cubic feet</td>
</tr>
<tr>
<td></td>
<td>Air Entrainment</td>
<td>2.7 cubic feet</td>
</tr>
</tbody>
</table>

1. Slump shall not exceed 7 inches
1.05  CONTROLLED DENSITY FILL FOR TRENCH BACKFILL

A. For trench backfill, the following CDF mix design shall be used

<table>
<thead>
<tr>
<th>Trench Backfill CDF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Quantity/Cubic Yard</td>
</tr>
<tr>
<td>Portland Cement Type I-II</td>
<td>30 pounds</td>
</tr>
<tr>
<td>Fly Ash Cl. F</td>
<td>2.2 cubic feet</td>
</tr>
<tr>
<td>Fly Ash Cl. C</td>
<td>1.1 cubic feet</td>
</tr>
<tr>
<td>Mineral Aggregate Type 7 w/Cl F Fly Ash</td>
<td>17.1 cubic feet</td>
</tr>
<tr>
<td>Mineral Aggregate Type 7 w/Cl C Fly Ash</td>
<td>18.2 cubic feet</td>
</tr>
<tr>
<td>Water</td>
<td>4.8 cubic feet</td>
</tr>
<tr>
<td>Air Entrainment</td>
<td>2.7 cubic feet</td>
</tr>
</tbody>
</table>

1. Slump shall not exceed 7 inches

B. Alternate CDF formulation: The Contractor may propose an alternate formulation and shall make a submittal on the alternate formulation in accordance with the 2017 COS Standard Specifications Section 1-05.3(5). This submittal shall include the following information:

1. Reason for alternate formulation on application;
2. Mix design components and component quantities for a 1 cubic yard batch;
3. Strength data at 24 hours, 7 days and 28 days. The strength at 24 hours shall not be less than 15 psi, when tested in accordance with ASTM D 4832.
4. Slump shall not exceed 7 inches;
5. The mixture shall not produce excessive bleed water; and
6. The 28 day strength shall be a minimum 50 psi and a maximum 100 psi, when tested in accordance with ASTM D4832.

C. An exception to one or more of items 3, 4, 5 and 6, immediately above, may be allowed if the reason provided in item 1 confirms no harm may result from the use of the alternate CDF mix formulation. Use of such alternate CDF formulation will not be allowed unless the Engineer provides written acceptance of the alternate formulation submittal.

1.06  CONTROLLED DENSITY FILL FOR STRUCTURE BACKFILL

A. For structure backfill, the following CDF mix design shall be used

<table>
<thead>
<tr>
<th>Structure Backfill CDF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Quantity/Cubic Yard</td>
</tr>
<tr>
<td>Portland Cement Type I-II</td>
<td>50 pounds</td>
</tr>
<tr>
<td>Fly Ash Cl. F</td>
<td>2.2 cubic feet</td>
</tr>
<tr>
<td>Fly Ash Cl. C</td>
<td>1.1 cubic feet</td>
</tr>
<tr>
<td>Mineral Aggregate Type 7 w/Cl F Fly Ash</td>
<td>17.2 cubic feet</td>
</tr>
</tbody>
</table>
**1.07 CONTROLLED DENSITY FILL MANUFACTURER’S CERTIFICATE OF COMPLIANCE**

A. For all CDF materials, the producer shall provide a Manufacturer’s Certificate of Compliance for each truckload of controlled density fill. The Manufacturer’s Certificate of Compliance shall verify that the delivered Material is in compliance with the mix design and shall include:

1. Project Contract number,
2. Date,
3. Truck number,
4. Batched weights of each ingredient and
5. Signature of the Supplier affirming the accuracy of the information provided

**PART 2 - PRODUCTS**

(NOT USED)

**PART 3 - EXECUTION**

**3.01 GENERAL REQUIREMENTS**

A. During all phases of the backfilling operations and testing, as outlined herein, the Contractor shall protect infrastructure, provide for the maintenance of traffic as may be necessary and provide for the safety of property and person.

B. If water is present and prevents the Contractor from properly placing and compacting backfill, as determined by the Engineer, it shall be removed in accordance with Section 2-08 of the 2017 COS Standard Specifications.

C. Excavations shall be backfill as soon as possible. Backfill shall not be placed against any concrete Structure until the concrete has attained 90 percent of its design strength and has cured for at least 14 days. However, the Contractor may backfill footings and columns as soon as forms have been removed, so long as the backfill is brought up evenly on all sides.

D. Prior to backfilling, all form lumber and debris shall be removed. The protective system used by the Contractor shall be systematically removed to allow for acceptable backfilling.

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity/Cubic Yard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral Aggregate Type 7 w/C Fly Ash</td>
<td>18.1 cubic feet</td>
</tr>
<tr>
<td>Water</td>
<td>4.8 cubic feet</td>
</tr>
<tr>
<td>Air Entrainment</td>
<td>2.7 cubic feet</td>
</tr>
</tbody>
</table>

1. Slump shall not exceed 7 inches
3.02 CONTROLLED DENSITY FILL

A. Compaction of controlled density fill will not be required. If water is present and prevents the Contractor from properly placing controlled density fill, as determined by the Engineer, it shall be removed by pumping or other means.

B. Special precautions shall be taken to prevent any wedging action against abutments and wing walls. If the excavation has sloping sides, the slopes shall be broken up by stepping or serrating to prevent wedge action before backfill is placed. Fill placed around culverts, piers or underground utilities shall be deposited on both sides to approximately the same elevation, at the same time.

END OF SECTION 31 23 24
PART 1 - GENERAL

1.01 SUMMARY
A. This Section specifies the design, installation, operation, and maintenance of the systems to bypass stormwater. The Contractor shall provide Stormwater bypass to divert the existing stormwater flow around the work area for the duration required to install the diversion structure and maintenance hole 3.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.
C. This Section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this Section and the listed documents, the requirements of the Contract Specifications shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008 Geotechnical Report, South Park Pump Station, prepared by Seattle Public Utilities Materials Lab</td>
</tr>
<tr>
<td></td>
<td>Draft South Park Pump Station – Review and Update of Geotechnical Recommendations and Geotechnical Design Parameters dated September 17, 2015</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS
A. Stormwater Bypass: General term referring to the process of removing stormwater in the 72” drain pipe and transporting it around the construction site.
B. Stormwater Bypass System: System to convey the stormwater runoff in the existing drainage system.

1.04 REFERENCE SPECIFICATIONS
A. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2014 Edition.
B. The Contractor shall have at least one copy of the Standard Specifications at the job site.
C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.
1.05 SUBMITTALS

A. Submit the following according to Section 01 33 10.

B. Stormwater Bypass Plan: The Contractor shall submit to the Engineer a plan outlining the method, installation and details of the stormwater bypass system. This plan must be specific to the Project and complete, including such items as schedules, locations, elevations, capacities of equipment, materials and all other incidental items necessary and/or required to insure proper protection of the facilities, including protection of the access and bypass pumping locations from damage due to the discharge flows, and compliance with the requirements and permit conditions specified in Section 01 56 10. The plan shall include the following:

1. Staging area for pumps
2. Storm drain plugging method and types of plugs
3. Number, size, material, location and method of installation of suction piping
4. Number, size, material and method of installation and location of installation of discharging pipe
5. Bypass pump sizes, capacity, number of each size to be on site and primary and backup power requirements.
6. Calculations of static lift, friction losses, and flow velocity. Provide pump curves showing pump operating range.
7. Standby power generator size and location
8. Downstream discharge plan
9. Method of protecting discharge manhole and pipe from erosion and damage
10. Method of sealing around installed stop log and measures for removing water from the tide gate vault.
11. Thrust and restraint block sizes and locations
12. Any temporary pipe supports and anchoring required
13. Design plans and computation for access to bypass pumping locations indicated on the Drawings
14. Calculations for selection of bypass pumping pipe size
15. Schedule for installation of and maintenance of bypass pumping lines
16. Plan indicating location of bypass pumping line locations.
17. Sequence and durations of work during the operation of the Bypass System.
18. Method for monitoring and recording water levels at the bypass intake and discharge points.
19. Flood detection alarm system and response plan with two emergency contacts.
C. Contact information and Reporting: The contractor shall submit:
   1. Contact information for a designated emergency contact. The contact shall be a responsible individual available 24/7.
   2. Weekly Reports: Daily records of water levels.

D. The Contractor shall resubmit components of the drawings and design data if the systems or any part thereof is significantly modified during installation or operation.

1.06 QUALIFICATIONS
A. The Stormwater Bypass System designer with a minimum of 10 years’ experience in the design of bypass systems and currently licensed in the state of Washington as licensed professional engineer.

1.07 STORMWATER BYPASS SYSTEM DESIGN REQUIREMENTS
A. The Stormwater Bypass system shall meet the requirements of all codes and regulatory agencies having jurisdiction.

B. Use an approved Washington State licensed engineer to design the stormwater bypass system. Use accepted and professional design and engineering methods consistent with standard of practice.

C. A Stormwater Bypass Pumping System shall be designed to satisfy these separate performance criteria:
   1. Dry weather pumping system performance (for work on the 72-inch drain pipe from May 1st to September 30th):
      a. Pass an estimated base flowrate of 0.5 cfs.
      b. Maintain a maximum water level in existing MH #D071-108 of El = 3.5 ft.
      c. Pass the maximum flow rate during the highest NOAA predicted tide for Seattle, WA during the duration of the dry weather work.
      d. Provide 100 percent standby pumping capacity for the dry weather system.
   2. Wet weather pumping system performance (for work on the 72-inch drain pipe from October 1st to April 31st):
      a. Pass a maximum flowrate of 72 cfs.
      b. Maintain a maximum water level in existing MH #D071-108 of El = 6.5 ft, which is the equivalent of 3 ft surcharge on the existing 72” storm drain.
      c. Pass the maximum flow rate during the highest NOAA predicted tide for Seattle, WA during the duration of the wet weather work.
      d. Provide 100 percent standby pumping capacity for the wet weather system.
   3. Both the wet weather and dry weather pump systems shall include level alarms, auto level pump start control, and sound attenuation.
   4. Stormwater bypass system shall conform to the local noise ordinance associated with project site.
PART 2 - PRODUCTS

2.01 CONTROL OF WATER SYSTEM COMPONENTS

A. See Section 01 56 10.

B. Temporary pumping systems:
   1. All pump used shall be fully automatic self-priming units that do not require the use of foot-valves or vacuum pumps in the priming system. The pumps may be electric or diesel powered. All pumps used must be constructed to allow dry running for periods of time to accommodate the cyclical nature of effluent flows.
   2. The Contractor shall provide the necessary stop/start controls for each pump.
   3. All temporary discharge piping shall be constructed of rigid pipe with positive, restrained joints. Aluminum irrigation piping or glued PVC will not be allowed. Discharge hose will only be allowed in short sections and by direction of the Engineer.

PART 3 - EXECUTION

3.01 GENERAL

A. At all times the Contractor shall have on hand sufficient pumping equipment in good working condition for the continuous operation of the stormwater bypass and pump monitoring systems.

B. Standby pumps are to be fueled and on-line, isolated from the primary system by a valve at all times.

C. Test daily all standby centrifugal pumps and generators to ensure their immediate availability.

D. Systems shall not be shut down between shifts, on holidays, or weekends, or during work stoppages.

E. The Contractor shall be solely responsible for installation, protection, operation, and maintenance for components of the stormwater bypass system.

3.02 STORMWATER BYPASS SYSTEM OPERATION

A. The Contractor shall maintain stormwater flow around the work area in a manner that will not cause surcharging of storm drains, damage to storm drains and that will protect public and private property from damage and flooding.

B. The Contractor may core existing storm drains/manholes or remove manhole lids or sections to make connections to the existing storm manhole as may be required to provide adequate room for the bypass system suction conduit.

C. Plugging or blocking of the storm drain flow shall incorporate primary and secondary plugging devices. When plugging or blocking is no longer needed for performance and acceptance of work, it is to be removed in a manner that permits the storm drain flow to slowly return to normal without surge.

D. The Contractor shall perform leakage and pressure tests of the bypass pumping discharge piping to ensure zero-leakage prior to actual operation. The Contractor shall give the Engineer 24 hours notice prior to testing.
E. Stormwater Bypass Discharge Point: The permitted discharge point is the existing downstream tideflex valve vault and maintenance hole 3. No other discharge points are allowed.

F. Upon completion of the bypass pumping operations, and after the receipt of written permission from the Engineer, the Contractor shall remove all of the pumps, piping and generators, repair all core taps, replace manhole lids/sections and restore all property to pre-construction conditions or as indicated in the Drawings.

3.03 ELECTRICAL SUPPLY FOR CONTROL OF WATER SYSTEM

A. Supply a separate electrical service to be dedicated for stormwater bypass. This service shall be separate from all other Contractor electrical requirements.

3.04 STORMWATER BYPASS SYSTEM PROTECTION

A. Take all reasonable precautions necessary to ensure continuous operation of the system.

B. Mark and signpost all pump and pipeline locations.

C. Wherever vacuum headers or discharge lines are to be crossed for access and egress, use physical bridging devices such as a ramp to protect and separate the system from vehicular traffic.

D. Bridges shall be capable of supporting the heaviest equipment on site and shall provide at least one foot of clearance between the stormwater bypass system element and the underside of the barrier.

E. Clearly identify with brightly colored or flagged 8 foot-high poles on each side of the access point, all vehicular access points across the stormwater bypass system.

F. All pipelines with vehicular crossing bridges, such as ramps, shall be valved on both sides of the ramp.

3.05 MONITORING AND RESPONSE SYSTEM

A. Ensure that an accurate and continuous record of level information is maintained.

B. At a minimum, the Contractor shall execute the following protocol at all times while the bypass system is active.

1. Set up temporary monitoring and alarm equipment prior to installing bypass equipment. Alarm setpoints shall be at or below the maximum water level of 3.5' existing MH #D071-108.

2. If an alarm is triggered, the Contractor shall resolve the issue while notifying the Engineer.

3. If storage levels continue to rise more than 1' above the alarm level, the Contractor shall notify the SPU Operations Control Center of the situation and request SPU support response, if appropriate. The Control Center will dispatch a response team if needed.

4. In the event of an overflow or backup, the Contractor shall immediately implement the approved Spill Prevention Plan. The Contractor shall immediately notify the SPU Operations Control Center and the Engineer of any overflows or backup.
3.06 DAMAGES

A. Repair any damage to work in place that may result from inadequate or improper stormwater bypass system installation, maintenance and operation of the system, and any mechanical or electrical failure of the system. Work in place including but not limited to:

1. Structures.
2. Other contractors’ equipment.

END OF SECTION 31 23 30
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes

1. This Section includes specifications for excavating, trenching, and backfilling for utilities and related structures, as indicated, including underground piping for water supply, storm drainage, underground electrical conduits and duct banks, and utility boxes, catch basins, manholes, and vaults.

1.02 REFERENCES

A. This Section incorporates by reference the following documents.

1. City of Seattle (COS):

2. Seattle City Light Material Standards

3. Seattle Department of Transportation:
   a. SDOT Director’s Rule 01-2017, Right of Way Opening and Restoration Rule.

   a. WAC 296-155 Part N: Safety Standards for Construction Work, Excavation, Trenching and Shoring

1.03 DEFINITIONS

1.04 SUBMITTALS

A. Procedures: Section 01 33 10

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.

C. Material source, and all tests and certifications necessary to approve material, including moisture/density relation test results. If on-site material is proposed for use as any of the materials specified in construction, provide test results certifying suitability of said material.

1.05 ENVISION

A. The Owner has elected to pursue Envision verification for this project. The Contractor’s Envision Point of Contact shall coordinate with the Envision team to provide documentation as needed by the Project. Related Owner-identified credits for achievement include, but are not limited to:

1. RA1.3 Use recycled materials.

2. RA1.4 Use regional materials.
B. Contractor shall provide any documentation for these credits as identified in the Envision Guidance Manual that is related to the Contractor Scope of Work. If contractor is not able to meet the criteria and documentation requirements, Contractor to advise Owner for direction. Refer to Section 01 81 13 for additional information on Envision requirements.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Bedding and Backfilling Materials:

1. Water line bedding: Class B bedding in accordance with COS Standard Plan 350. Mineral Aggregate Type 6 or 7 in accordance with COS Specification Section 9-03 for all water mains.

2. Storm Drainage rigid piping bedding: Class B bedding in accordance with COS Standard Plan 285. Mineral Aggregate Type 9 in accordance with COS Specification Section 9-03.

3. Bedding for underground electrical conduits and duct banks shall conform to the Seattle City Light Material Standards 0222.02.

4. Compacted Base for Pre-cast utility vault shall be Mineral Aggregate Type 9 with Portland cement in accordance with COS Standard Specification Section 9-03.

5. Trench Backfill: Mineral Aggregate Type 17 from an on-site or imported source conforming to COS Specification 9-03.14 or Controlled Density Fill (CDF), in accordance with Section 31 23 24.

6. Controlled Density Fill (CDF): In accordance with Section 31 23 24.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. Staking and Grades:

1. Refer to Section 01 71 23.

B. Protection of Persons and Property:

1. Erect and maintain temporary bracing, shoring, lights, barricades, signs, and other measures as necessary to protect the public, workers, and adjoining improvements from damage during trenching work in accordance with applicable codes and regulations.

2. Protect utilities, pavements, and facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by the trenching operations.

3. Protect open trenches outside of secured fence areas with steel plates with non-slip surfaces or water filled barriers during non-working hours. Provide barriers to block pedestrians or vehicles from entering the work area and approaching trenches during working hours.
C. Dewatering
1. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.
2. Where water is encountered in the trench, dewater as specified in Section 31 23 19.
3. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
4. Establish and maintain temporary drainage ditches and other diversions outside excavation to convey water. Do not use trench excavations as temporary drainage ditches.

D. Trenching and Excavating:
1. Perform work in accordance with the requirements of WAC 296-155, Part N, Excavation, Trenching and Shoring.
2. Do not undermine or disturb sidewalks, pavements, appurtenant structures, adjacent improvements or underground installations adjacent to and beyond the trench.
3. Excavate to the depth, line, and grade indicated on the Contract Drawings or as referenced in a Standard Plan.
4. Excavate using open cut methods.
5. Keep the length of trench excavation in advance of pipe installation operations to a minimum.
6. The maximum trench width in the Right of Way shall not exceed the neat line trench width as shown or indicated in the Contract Drawings.
7. Outside the Right of Way and in unimproved areas, trench width above the top of pipe may at the Contractor’s option exceed the neat line trench width indicated on the Contract Drawings by sloping or benching. All requirements for excavating, handling and disposing of excavated material, and placing and compacting additional suitable backfill, outside of the neat line trench limits shall be at the sole expense of the Contractor.
8. Excavate to the inverts indicated on the drawings plus any additional excavation as necessary to accommodate the Contract specified class of bedding. Provide over-excavation for the pipe bells such that pipe barrels and bells along the pipe are uniformly supported full length.
9. Grade surrounding areas or utilize alternative controls to prevent surface water from flowing in to the excavations.
10. Maintain at least 3 feet of separation from the toe of the slope of any stockpiled excavated material from the trench edge.
11. For utility structures, provide a minimum of 12 inches between the exterior surfaces of utility structures and the sides of the excavation.
12. All ledgerock, boulders, stones, and any object larger than 3 inch in any dimension shall be removed within 6 inches in any direction from the pipe.
13. Remove trench protective systems in such a manner as to not disturb bedding or backfill. Where bedding or backfill is disturbed, reconsolidate the material as specified.

14. Ensure excavations for structures conform to the applicable requirements of Section 31 10 00.

E. Bedding:

1. For Water Mains:
   a. Place bedding in accordance with the dimensions indicated on the Contract Drawings or as referenced in a COS Standard Plan.
   b. Provide uniform support along the entire pipe barrel, without load concentration at joint collars or bells. Provide over-excavation for the pipe bells such that pipe barrels and bells along the pipe are uniformly supported full length.
   c. Do not use blocking to adjust pipe to grade.
   d. Reconsolidate bedding disturbed by pipe movement or by removal of trench protection prior to backfill.
   e. Take special care to provide adequate bedding support at wye or tee connections and adjacent manholes or other structures to avoid bending or shearing stresses at these critical points.

2. Pipe Bedding for Storm Drains as specified in the City of Seattle Specifications Section 7-17.3(1)B and in accordance with COS Standard Plan 284 and 285.

3. Bed duct banks on 2 inches of compacted washed sand as indicated.


5. Pre-cast utility vault: Prepare compacted base as shown in the drawings.

F. Backfilling: Backfill with material indicated. Take all necessary precautions to protect the pipe, duct bank or vault from any damage or shifting.

1. Pipe and duct bank Backfilling: Backfill from the side of the trench to a uniform depth of 1 foot above ductile iron pipe before starting compaction, and to a uniform depth of 2 feet above concrete pipe and duct banks before starting compaction.

2. Electrical Vault backfill in accordance with Seattle City Light Construction Guideline U2-15.1.

3. Pre-cast utility vault: Backfill for precast utility vault shall be shall be Mineral Aggregate Type 17 in accordance with COS Standard Specification Section 9-03.

G. Compaction: Refer to Section 31 10 00. The requirement for compaction is Class II Compaction in improved areas such as parking lots or sidewalks. The compaction requirement in unimproved areas or landscaped areas is Class I Compaction.
H. Restoration:

1. Comply with surface restoration requirements as indicated in the Contract Drawings, Contract Specifications, or as referenced in a COS Standard Plan.

2. In City of Seattle Right-Of-Way, comply with SDOT Director's Rule 01-2017, Right of Way Opening and Restoration Rule.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 31 10 00 for requirements.
PART 1 - GENERAL

1.01 DESCRIPTION

A. The intent of the Soil Mixing program, specified herein, is to provide ground improvement within the limits indicated on the project plans and to achieve the required degree of improvement detailed in these specifications. The objective of the ground improvement is to reduce the liquefaction potential and increase the static allowable bearing capacity of the loose silty sand and sand soils underlying the pump station, the electrical building and associated structures and utilities and to improve post-liquefaction stability of these features.

B. Wet Soil Mixing is the mechanical homogenization of soil with a wet cementitious binder “grout slurry” to produce “soilcrete.” Grout slurry is a wet, cementitious binder. This can be a variety of materials including cement, fly ash, slag and an assortment of additives. A grout slurry delivery system pumps grout slurry through a hose from the storage tank to the mixing tool. The mixing tool is the mechanical stirring and shearing tool used to homogenize the soil and binder.

1.02 MATERIALS

A. The Soil Mixing Contractor shall provide all materials required to accomplish the soil mixing program and meet project objectives.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C150</td>
<td>Low alkali Type II PCC for cement binder materials</td>
</tr>
<tr>
<td>ASTM C1157</td>
<td>For conformance of slag cement</td>
</tr>
</tbody>
</table>

1. Grout Slurry:
   a. The Soil Mixing Contractor shall produce evidence that the material to be used meets or exceeds the design requirements. The binder/grout is delivered in a slurry form (i.e. combined with water). Depending on the in situ soil, the volume of grout slurry necessary ranges from 20 to 40 percent by volume. The grout slurry is typically composed of a variety of binder materials including: portland cement, fly ash, and ground, granulated blast furnace slag.
   b. The purpose of the grout slurry is to assist in loosening the soil for penetration and mixing and to lower permeability, aid in structural support and treat in situ soils. The grout slurry will be premixed in batch plants which combine materials in predetermined proportions or via continuous mixing with its quality controlled by specific gravity.
Binder slurry should be a stable homogeneous mixture of approved binder, approved admixtures, and water. The ratios of various components may be proposed for modifications by the contractor but should not be implemented until reviewed and accepted by SPU. Any proposed deviations from the submitted and approved mix design should be resubmitted for SPU's approval. Revalidation through laboratory or field testing is necessary for changes that exceed 10 percent of previously approved mix designs. Regardless of such changes, the contractor is responsible for satisfying the acceptance criteria.

2. Water: Fresh water, free of excessive amounts of deleterious substances, that adversely affect the properties of the grout, shall be used to produce the grout. It is the responsibility of the Soil Mixing Contractor that the grout, resulting from the water, shall always meet the standard of this specification.

3. Additives: Admixtures of softening agents, dispersants, retarders or plugging or bridging agents will not be allowed to be added to the water, unless the Contractor submits documentation demonstrating the effects of the admixture and the admixture is approved by the engineer. Admixtures are typically proposed to be added to the grout slurry to permit efficient use of materials and increased workability of the grout slurry.

4. Binders: Cement used in preparing grout slurry shall conform to ASTM Designation C-150 “Requirements for Portland Type I-II Cement.” Ground granulated blast furnace slag (GGBFS) used as a binder shall conform to ASTM C 989 or ACI 233R. The slag shall be adequately protected from moisture contamination while in transit to and in storage at the project site. Reclaimed cement or cement containing lumps or deleterious matter shall not be used.

5. Soil-binder mixture should be a stable mixture of binder slurry and in situ soil. The contractor should propose the ratios and quantities of various components.

6. The contractor should measure, handle, transport, and store bulk binder in accordance with the manufacturer’s recommendations.

7. Material that has become caked due to moisture absorption should not be used. Binder materials containing lumps or foreign matter of a nature and in amounts that may be deleterious to the injection operation should not be used. In each instance in which the binder source is changed, the batch plant silos should be completely emptied before storing binder from the new source. Mixing binders from different sources in the same silos is not permitted.

**PART 2 - PRODUCTS**

(Not used)
PART 3 - EXECUTION

3.01 GENERAL
A. The work shall consist of Wet Soil Mixing for ground improvement, within the limits indicated on the project plans to meet the acceptance criteria presented in these specifications. In connection with the Soil Mixing program, as shown on the plans, the Soil Mixing Contractor shall provide all labor, materials and equipment to accomplish the following items of work: disposal/stockpiling of all spoils, construction of the Soil Mix columns to the lines and grades on the construction plans, all quality control inspections and tests.

3.02 STANDARDS AND REFERENCES
A. The most recent version of the following testing method shall be employed: ASTM C39 Unconfined Compressive Strength Testing.
B. Reference documents as provided to the Soil Mixing Contractor shall include
   1. This specification.
   3. Project geotechnical report.

3.03 SITE EXAMINATION AND SURVEY
A. Prior to bidding, the contractor should review the available subsurface information and visit the site to assess the site geometry, equipment access conditions, location of existing structures, and above-ground utilities and facilities.
B. Prior to commencing Soil Mixing, the Soil Mixing Contractor shall conduct a site investigation suitable for the scope of work. The contractor should field locate and verify the locations of all utilities prior to starting work. The contractor should maintain uninterrupted service for those utilities designated to remain in service throughout the work. The contractor should notify the engineer of any utility locations different from those shown in the plans that may require relocation of deep mixed elements or structure design modifications.
C. In areas where existing underground utilities are within 20 feet of the Soil Mixing work area, a detailed utility survey shall be performed prior to initiating work. The underground utilities must also be monitored daily, during work within 20 feet of the utilities. The work shall be stopped and the engineer notified if 1/8 inch movement is measured in any direction on the utility lines. Any damage to existing utilities shall be repaired at the Soil Mixing Contractor’s own expense.

3.04 PRE-PRODUCTION LAB TESTING
A. The target soil to be improved by the Soil Mixing work is loose to medium dense black and gray sand with varying amounts of silt (with occasional layers of very soft brown or gray silt), between depths of approximately 5 and 50 feet. Bulk samples of this soil have not yet been retained by the Owner and are therefore not available, at this time.
B. Prior to production work, mix design laboratory testing shall be performed by the ground improvement contractor to verify that the specified results can be achieved. The Soil Mixing Contractor shall drill borings or excavate test pits to obtain samples of the target soil for the lab testing. The mix energy and slurry proportions shall replicate expected field installation procedures.

C. If the pre-production lab testing indicates that the required strength has not been achieved, the Soil Mixing Contractor shall revise the work procedure plan and re-test.

D. The contractor should construct a test section prior to production to verify that the contractor’s proposed equipment, procedures, and mix design can uniformly mix the onsite soils and achieve the product requirements in the acceptance criteria outlined in Section 3.11. If the contractor constructs a test section, they shall obtain full-depth core samples from the test elements in accordance with the QC requirements outlined in Section 3.10. The contractor may propose other sampling techniques to obtain continuous samples of the deep mixed material which, if approved by the engineer could be submitted as further evidence of compliance with the acceptance requirements.

3.05 PUMP STATION AND ELECTRICAL BUILDING FOOTING SUBGRADE PREPARATION

A. The depth of the pump station excavation will be approximately 22 feet below existing grade. The Soil Mixing area will extend across the entire footprint of the pump station structure. The foundation excavations for the pump station shall reach the top of the Soil Mix columns. The electrical building will be constructed within approximately 5 feet of existing grade. The foundation excavations for the electrical building shall extend to the top of the Soil Mix columns. Any areas requiring overexcavation (below planned bottom of foundation elevations) should be backfilled with Aggregate Base Course (City of Seattle Standard Type 2), as shown on the drawings. The material should be compacted in accordance with the 2017 City of Seattle Standard Specifications for Road, Bridge and Municipal Construction. Overexcavation and backfill compaction shall be performed such that no degradation of the bearing surface occurs.

3.06 EQUIPMENT

A. The Soil Mixing Contractor shall supply all equipment required to accomplish the soil mixing program and meet the project objectives.

1. Deep mixing equipment should be of sufficient size, capacity, and torque to perform the required deep mixing to the desired depths.

2. This grout slurry delivery system shall consist of temporary storage and a binder delivery station.

3. An adequate communications system shall be maintained between the drilling operator and the grout slurry delivery operator.
4. All equipment shall have computerized controls to permit accurate and continuous monitoring and recording of: mixing tool depth, binder volume flow rates and factors, binder injection pressures and quantities, tool rotational speeds, tool down pressure, tool advancement and withdrawal rates and other operations required to install soilcrete columns. Soil stabilization equipment shall be of sufficient size, capacity and torque to perform the required soil stabilization operations to the desired depths. The equipment shall be capable of advancing through previously installed and cured soilcrete. The equipment shall use sufficient mixing and injecting equipment to adequately blend binder with the in situ soils to produce a distribution of binder throughout the mixed in situ soils, sufficient to provide the required minimum strength. The owner/engineer should have access to monitoring equipment.

5. The mixing rig is the system used to provide power to the mixing tool. Size varies from conventional hydraulic drill heads to dual-motor, crane mounted turntables. Torque requirements range from 30,000 ft-lbs to 300,000 ft-lbs. The power source for driving the mixing shaft shall be sufficient to maintain the required RPM and penetration rate from a stopped position at the depth specified. The Soil Mixing Contractor shall note whether there are any overhead power lines in their selection of the mixing rig.

6. The mixing tool can be a combination of partial flighting, mix blades, injection ports and nozzles and shear blades. Size ranges from 1 to 12 feet in diameter. The mixing tools should be adequately marked to allow the engineer to confirm the penetration depth to within 1 foot during construction. If rigs with varying mixing tool lengths are used, the shortest tool should extend to the lowest element termination elevations indicated in the plans.

7. Batching Equipment
   a. The batch plan shall consist of purpose-built mixers, volumetric screw feeders and flow controllers. Dry materials shall be stored in silos and fed by screw feeders to the mixers for agitation and circulation. The resulting grout will be transferred to supply the soil mixing rig.
   b. The precise arrangement and sequence of mixing shall be based on the results of the design mix program. Commercial grade clays (i.e. bentonite and/or attapulgite) may be premixed with water (hydrated) in a separate mixer and the slurry stored in a tank. The clay-water slurry shall be transferred to a second mixer (only if premixing is necessary where cement and/or other materials will be added and mixed into the grout).
   c. Clay-water slurry proportions shall be controlled by weight or volumetric batching methods.
   d. Dry ingredient proportions shall be batch mixed by weight or continuously by means of a jet valve to a predetermined final density. A minimum mixing time of three minutes and a maximum holding time of three hours (depending on binders used) will be enforced for the grout.

B. Calibration of mixing components shall be done at the beginning of the project and monthly thereafter. The screw feeders shall be calibrated against time to deliver a predetermined weight. Water shall be controlled by flow meter and/or by volume level indicators in the colloidal mixer. The specific gravity of the grout shall be determined during the design mix program for double checking grout proportions.
3.07 INSTALLATION

A. The soil mix columns shall extend from approximate elevation -38 feet to approximate elevation 7 feet, however, the columns may need to be adjusted within the footprint of the pump station to accommodate the 22 feet deep excavation for the installation. If excavating the soil mix columns is determined to be impractical, the columns, within the pump station footprint shall be adjusted to extend from approximate elevation -38 feet to approximate elevation -10 feet. The current ground surface elevation is approximately 12 feet. Fill and other obstructions may exist near the ground surface. It is the Soil Mixing Contractor’s responsibility to determine if pre-drilling is needed to assist the mixing tool to reach the depth of top of the columns and perform soil mixing.

B. The minimum area replacement ratio of the Soil Mixing shall be 70 percent under the pump station, generator pad and electrical building and surrounding areas within the ground improvement area.

C. The soil mix columns shall be installed continuously in the direction of the structure long dimension (for the pump station and electrical building) to form shear walls within the ground improvement area.

D. The presence of any live underground utility lines will necessitate forming a “gap” in the soil mix shear walls. The Soil Mixing Contractor shall determine the clearance from the utility lines to prevent damages to them. The Soil Mixing Contractor shall use appropriate ground to fill the “gap” in the shear walls that would result in similar strength properties as adjacent soil mix columns and form continuous shear walls.

E. As the Soil Mixing tool is drilled into the ground, cement-based slurry shall be pumped through the hollow stem of the shaft and injected into the soil through jets located on the backside of the leading rotating mixing blades. The mixing blades on the tool will mix the soil with the slurry. Injection and mixing will continue to the design depth. When the design depth is reached, the mixing tool is withdrawn, leaving behind stabilized Soil Mix Columns.

1. Horizontal Alignment: The Soil Mix columns shall be carefully staked out prior to beginning construction. The columns shall be constructed within 4 inches of the locations shown on the Drawings.

2. Vertical Alignment: Vertical alignment of the auger stroke will be controlled by the equipment operator. The columns shall have a vertical variation of not more than ¼ inch per foot.

3. Mixing Shaft Speed: The mixing shaft speed (RPM) shall be adjusted to accommodate a constant rate of mixing shaft penetration based on the degree of drilling difficulty. Mixing shaft speed can be adjusted according to drilling difficulty, and to aid mixing of the soil mix column when needed. Mixing shaft speed may also be adjusted to assist penetration in hard drilling.

4. Penetration Rate: In order to ensure adequate mixing, the penetration rate of the mixing shaft shall be maintained in the range of one to eight vertical feet/minute during both penetration and withdrawal. The bottom of the columns may be double mixed by raising the mixing shafts three feet off the bottom and then reinserting them for remixing. The penetration rate and maximum depth of each stroke shall be recorded on the Daily QC form.
5. Grout Take: The grout take (or injection rate) per vertical foot of column will be adjusted to the requirements of the design mix. Positive displacement pumps will be used to transfer the grout from the mix plant to the Soil Mixing rig. A flow monitoring device will be installed in the grout line to aid in quality control. Inevitably, variations of the grout take will occasionally occur due to field conditions. However, the overall application rate to each stroke shall be monitored, calculated and controlled. Additional mixing shall be used, when necessary, to evenly distribute the grout through the entire column. The injection of grout to each stroke shall be monitored, checked by calculation and recorded.

6. Column Depth: Unless otherwise directed, the Soil Mixed columns shall extend from approximate elevation -38 feet to approximate elevation 7 feet. The final depth and penetration of the columns shall be reassured from shaft penetration and checked by the Contractor and approved by the Engineer immediately following penetration.

7. Obstructions/Mixing Shaft Refusal: If obstructions that reduce the rate of penetration to one foot per minute for five minutes are encountered, the stroke shall be completed in accordance with the specifications and remedial measures will be taken. It is the responsibility of the Soil Mixing Contractor to determine if pre-drilling is needed to install the Soil Mixed columns between the specified elevations.

8. Monitoring: The preset data in the on-board computer shall be verified as correct for each column and, if necessary, adjusted (e.g. installation depth, grout slurry amount ratio, withdrawal rate). The operator shall monitor and adjust, as necessary, during the column installation, the feeding of material, the injection rate and the rates of rotation and rise. All metering equipment shall be calibrated at the beginning of the column installation work and again at the 50 percent project completion point for the Soil Mixing. The Soil Mixing Contractor shall submit the calibration results to the Contracting Officer at the end of each day. The injection of grout slurry shall be greater than or equal to the target per foot anticipated.

9. Column Top: The top of each column shall be established and identified on the construction Drawings. The Soil Mixing Contractor shall bail out any completed column immediately after completion to the designated elevation, prior to initial set.

10. The contractor should control and dispose of all waste materials produced as a result of the mixing operation in accordance with the project requirements. The areas designated in the plans should be used for containing and processing the spoils.

3.08 SUBMITTALS

A. The following shall be submitted to the Owner’s representative by the Soil Mixing Contractor; a list of at least five previously completed projects within the past three years of similar scope and purpose for approval by the Owner’s representative. The list shall include a description of the project, relative size and contact person with phone number.
B. The following shall be submitted to the Owner’s representative by the Soil Mixing Contractor prior to the start of work:

1. Resumes of the management, supervisory and key personnel, for approval by the Owner’s representative.

2. Bench-scale testing report: The contractor must submit results from bench-scale tests conducted. The report should provide all data collected, including at a minimum, descriptions of sampling techniques used, boring logs, classification of all major soil strata to be mixed, site groundwater conditions, binder materials used, mixed design proportions, laboratory mixing techniques used, and curing curves for unconfined compressive strength versus time for each major soil type. Discussion of test results should be provided, including proposed mix designs for use in the field.

3. A soil mix design for the project including sources and type of binder material, with volumetric proportions. If the Soil Mixing Contractor intends to deviate from this submittal, it shall submit evidence of satisfactory use of the proposed material from past projects with similar soil conditions or complete satisfactory laboratory testing specific to these site conditions.

4. A general Work Procedures Plan, outlining means and methods to achieve the specified criteria detailed in this specification. The plan should include the following items:
   a. Detailed descriptions of sequence of construction and all construction procedures, equipment, and ancillary equipment to be used to penetrate the ground, proportion and mix binders, and inject and mix the site soils.
   b. Proposed mix design(s), including binder types, additives, fillers, reagents, and their relative proportions, and the required mixing time, water-to-binder ratio of the slurry, binder factor, and volume ratio for a deep mixed element.
   c. Proposed injection and mixing parameters, including mixing slurry rates, slurry pumping rates, air injection pressure and volume flow rates, mixing tool rotational speeds, and penetration and withdrawal rates.
   d. Methods for controlling and recording the verticality and the top and bottom elevation of each element.
   e. The necessary procedure and measurement to confirm the end-bearing when DMM elements are required to penetrate into a bearing layer.

5. A shop drawing for review, indicating the spacing, location and depth of the Soil Mix columns to achieve the criteria outlined in this specification. The shop drawing shall also include:
   a. Sequence and time schedule of all soil stabilization operations.
   b. Plan locations of all proposed Soil Mix columns to show the details of the layout necessary to satisfy the required geometries.
c. The center of each proposed Soil Mix column location numbered and shown on the plan and dimensioned to the Soil Mixing Contractor’s established site specific coordinate system and other survey baselines, which the Soil Mixing Contractor intends to use for layout and location. The contractor should indicate the identification number of every element if a multi-shaft mixing tool is used and every column if a single-auger mixing tool is used. Calculations and drawings should demonstrate that the element layout, depth, and quantity meet the specification requirements.

6. A schedule of work tasks and time for completion.

7. A description of the Quality Assurance/Quality Control (QA/QC) Program Plan including:
   a. A detailed outline of the QA/QC Program to be undertaken each day during production to confirm the Soil Mix columns achieve specified performance requirements.
   b. Details of procedures to make the required test columns and the test equipment to be used.
   c. Measures to be implemented each day during Soil Mix column installation to monitor, modify, record and control binder ratios, and injection pressures and quantities, auger rotational speeds, auger/mixing tool penetration and withdrawal rates and other related aspects of the Soil Mix column installation process.
   d. Example formats of Daily Production Reports meeting the requirements stated herein.

C. The following shall be submitted to the Owner’s representative by the Soil Mixing Contractor during the work:

1. Production records: By the end of the next business day following each deep mixing shift, the contractor should submit a daily production report in the approved format. The report should be completed and signed by the contractor’s project superintendent. The report should contain at a minimum accurate daily records of the work, including:
   a. Area mixed and element number, diameter, and location (by station, offset, etc.) as shown on construction layout drawing(s) for each container of grout slurry.
   b. Working grade
   c. Mixing depth and reference drawing number
   d. Start time
   e. Finish time
   f. Mixing duration (include start and finish time)
   g. Slurry mix details (% by weight)
   h. Slurry specific gravity measurements
   i. Slurry injection rate
   j. Total slurry weight injected
k. Tool rpm on penetration versus depth
l. Tool rpm on withdrawal versus depth
m. Penetration and withdrawal rates of the mixing tool
n. Description of obstructions or other interruptions of lime-cement injections and their resolution
o. Type of mixing tool.
p. Location of each completed column/element installed during the work shift and all zones completed to date on a plan of suitable scale to clearly show the location of the elements.
q. Other pertinent observations including but not limited to binder escapes, ground settlement or heave, collapses of the treatment zone, and any unusual behavior of any equipment during the mixing process.
r. For both wet grab samples and coring, provide collection date, time, plan location, elevation, and identification numbers of all deep mixed samples, including unsuccessful attempts to retrieve samples.
s. For coring operations, provide the coring method, equipment, and personnel; recovery percentage and percentage treatment (percent of run length that is treated) for each core run; sample collection, handling, and storage details; and name of person responsible for logging and collecting cores and samples to be tested.
t. Quantities of all binder materials delivered to the site plus a reconciliation showing the amount actually injected
u. Summary of any down time or other unproductive time including time, duration, and reason
v. Detailed results of all testing.

2. Any change in the predetermined Soil Mixing program necessitated by a change in the subsurface conditions.

3. Material certifications: Certificates of compliance must be submitted as proof of conformance to materials standards and requirements for each truckload of binder, admixtures, and steel, as needed.

D. The following shall be submitted to the Owner’s representative by the Soil Mixing Contractor after the work: a report documenting the observations, results of all tests, QA/QC records, and as-built field measurement data.

3.09 QUALITY ASSURANCE

A. The Soil Mixing program shall be performed by a specialist Soil Mixing Contractor with at least five continuous years of documented experience in Soil Mixing.

B. The Soil Mixing Contractor shall provide experienced management, supervisory and key personnel, as required, to implement the Soil Mixing program, as follows:

1. The Project Manager shall have at least five years of continuous experience in Soil Mixing with at least two years in the full-time employment of the Soil Mixing Contractor.

2. The superintendent shall have at least two years of experience in Soil Mixing.
3. The Soil Mixing Contractor shall provide detailed information on the training and experience of any operators with less than 5 years of experience for approval by the Contracting Officer; but in no case shall any operator have less than 4 years of experience in the installation of Soil Mix columns.

4. As noted in Section 3.8 B. 1., of these specifications, the Soil Mixing Contractor shall provide evidence of previous Soil Mixing project experience and evidence of management, supervisory and key personnel experience.

C. The Owner’s representative will ensure that procedures and documentation conform to these specifications.

3.10 QUALITY CONTROL

A. The Field Quality Control Representative (FQCR) is the individual given specific inspection tasks identified in this specification. All Soil Mixing operations shall be performed under the inspection of the FQCR. Monitoring and logging of Soil Mixing operations production work shall be done by the FQCR. Layout of the Soil Mix column locations shall be by the Soil Mixing Contractor and checked by the FQCR. As detailed above, daily records shall be maintained by the Soil Mixing Contractor and submitted to the Owner’s representative.

B. The contractor should provide all personnel and equipment necessary to implement the QA/QC requirements of the project. The engineer will review daily production reports and QA/QC test reports to verify that the QA/QC procedures are being properly implemented.

C. The contractors deep mixing work plan should include descriptions of all QA/QC activities and reporting as outlined in Section 3.8. After field validation program is conducted, the contractor may revise the QA/QC procedures, if approved by the engineer. The contractor should maintain the established and approved QA/QC procedures throughout production to ensure consistency in the approved working drawings.

D. Daily production records should be submitted as outlined in Section 3.8.

E. The contractor should measure the specific gravity of the binder slurry at least twice per shift per slurry plant using the methods outlined in ASTM D4380. The specific gravity of the binder slurry measured during production may not deviate by more than 3 percent from the established specific gravity. If the slurry density deviates by more than 3 percent, the contractor should recalibrate monitoring equipment and perform additional testing is required by the engineer at no additional cost to SPU. The contractor may also adjust binder or water quantities appropriately and retest at no additional cost to SPU.

F. The contractor should make simple routine checks of material quantities such as counting the number of bags or truckloads of binder materials that have been used. These quantities should be recorded in the daily production report.

G. Wet samples shall be collected and tested in accordance with Section 3.11.
H. Coring:

1. The contractor should determine the time interval between element installation and coring except that the interval should be no longer than required to conduct 28-day strength testing.

2. The full-depth samples should be obtained along a vertical alignment located one-fourth of a column diameter from the column center. If it is difficult to avoid drilling out of the column at this coring location, the contractor may drill one-fourth of a column diameter along the centerline of an element or shear wall so the core enters the adjacent column in the same element.

3. Core samples should be retrieved using standard triple-tube or equivalent continuous coring techniques.

4. Samples should have a diameter of at least 2.5 inches (65 mm), and each core run should be at least 3 ft (1 m) in length.

5. For each field validation test section, the contractor should collect at least one full-depth core for each mix design at locations defined by the owner/engineer.

6. The contractor should collect one full-depth core from 3 percent of the elements or 860 ft2 of treated area, whichever produced a larger number of cored elements. The cores should be drilled at locations defined by SPU. An element is defined as the treated soil produced by one setup of either a single- or multiple-axis machine.

7. The contractor should photograph each core run.

8. Upon retrieval, the contractor should provide cores to the engineer for logging and test specimen selection.

9. Following logging, the engineer will select at least five specimens from each full-depth continuous core for strength testing. Each test specimen should have a length-to-diameter ratio of 2 or greater.

10. Immediately following logging and test specimen selection by the engineer, the contractor should seal the entire full-depth sample, including the designated test specimens, in plastic wrap to prevent drying and transport the sealed sample to the laboratory. The samples should be protected against drying and mechanical damage prior to and during transport.

11. The samples should be stored in a moist room in accordance with ASTM C192 until the test date.

12. Samples must not be submerged in water during curing unless they are sealed in a watertight plastic bag (e.g., a Ziploc® bag) with as much air removed as possible prior to sealing to void swelling.

13. The contractor should retain portions of the samples that are not tested until completion and acceptance of all DMM work for possible future inspection and confirmation testing by the engineer. If a large volume of samples cannot be reasonably stored on the job site, cores from columns deemed satisfactory may be disposed of prior to project completion if approved by the engineer.

14. All core holes should be filled with cement grout that will obtain a 28-day unconfined compressive strength equal to or greater than the 28-day unconfined compressive strength of the deep mixed materials.
I. Uniformity criteria:

1. The engineer should make the sole determination as to whether the test results satisfy the uniformity acceptance criteria.

2. Full-depth continuous core samples retrieved by the contractor from the DMM element should be used to evaluate uniformity.

3. Core recovery (expressed as a percentage) should be reported for each run and is equal to the total length of recovered core divided by the total core run length. Length of recovered core includes lengths of treated and untreated soil.

4. Percent treatment is calculated as the total length of recovered core minus the sum of the lengths of unmixed or poorly mixed soil regions or lumps that extend across the entire diameter of the core divided by the total core run length expressed as a percentage. Percent treatment must be at least 80 percent for every 5 ft (1.5 m) core run. If 80 percent treatment cannot be confirmed by coring in coarse sandy or gravelly soil, optical televiewer logs can be used to confirm uniformity.

5. If the contractor uses core runs shorter than 5 ft, then the recovery and percent treatment can be calculated taking into equal amounts of core run length on either side of the short core run length to make up a total 5-ft run length for calculation purposes.

3.11 TESTING AND INSPECTION

A. All testing to determine specification compliance will be provided by a qualified independent testing laboratory, retained by the Soil Mixing Contractor.

B. Pre-production laboratory testing shall be conducted by the Soil Mixing Contractor to verify the performance of the treatment under the mix methodology, energy and grout slurry system proposed by the Soil Mixing Contractor.

C. Verticality shall be checked as deemed necessary by the FQCR.

D. Performance testing shall include testing of deep soil mixed columns during ground improvement work by a qualified independent testing laboratory, retained by the deep soil mixing subcontractor. Wet samples shall be retrieved and cast into molds for strength testing immediately upon completion of mixing. This shall be done for every 250 CY of mixing performed and shall consist of no fewer than 10 test elements/samples. These samples shall be taken by a special sampling tool at mid-depth of the column immediately following installation. The soil mix shall be placed in suitable molds, rodded to remove trapped air pockets and then sealed. Particles >10% of the mold opening shall be screened off. The samples will be stored in a damp environment for curing until initial set has been achieved. After initial set, a dead weight load may be imposed on the sample to model the stress from earth pressures. The samples will be transported to a laboratory for testing, once they have sufficient strength gain so that the transporting will not adversely affect the properties. Unconfined compression testing shall be performed in pairs of samples at ages of 3, 7, 28 and 56 days.

E. Monitoring and logging of Soil Mixing operations, in the test areas, and for production work, shall be done by the Soil Mixing Contractor.
F. The unconfined compressive strength of the wet samples shall:

1. Be conducted in accordance with ASTM D2166, except that the loading should continue on all specimens until the cylinders break sufficiently to examine the interior of the specimen.

2. The broken specimen should be photographed so that the engineer may document any apparent segregation, lenses, and pockets in the specimen.

3. Achieve an average 56 day compressive strength of at least 300 psi.

4. Have no more than 10% of the compressive strength values, at 56 days, cure to be less than the minimum design value of 150 psi.

5. If test values are deemed unacceptable from wet sample testing, core sampling and testing of retrieved samples may be used to justify acceptance.

6. If core sampling is performed, the contractor should provide the continuous core samples to the engineer for logging and assessing uniformity.

7. If, after core sampling and testing, the criteria of a. and b. above are still not met, the Soil Mixing Contractor shall select and replace constructed columns, as needed, at no cost to the owner, so that these criteria will be met.
   a. To prove acceptability of the failed element, the contractor may core elements on both sides of the failed element. If those two cores meet the criteria, then the element should be accepted. If the additional cores fail, then the contractor can propose additional investigations and remedial measures, which the engineer will review and have the option to accept or reject depending on whether the proposed remedial measures meet the design intent.

3.12 RESTRICTIONS

A. Soil Mix column construction is typically performed under the site permit. The General Contractor shall be ultimately responsible for obtaining any state and local permits (if required) and conforming to all state and local regulations.

B. The Soil Mixing Contractor shall be responsible for the precise delineation of all above and below ground utilities and obstructions.

C. The General Contractor shall provide all necessary containment to restrict the materials to the work area.

D. The following shall also be listed within this section when applicable: environmental restrictions, work boundaries, hours for construction.

3.13 CLEANUP

A. Work will not be considered complete, nor will final payment be made, until all rubbish, unused material, excess soils and equipment have been removed from the site. The site shall be left in a condition satisfactory to the Owner’s representative.
3.14 Restoration

A. If the Soil Mixing Contractor elected to import fill to construct working pads for heavy equipment, then the Soil Mixing Contractor shall excavate, haul off-site and dispose of the fill in a legal manner, as directed by the Owner’s representative, at the conclusion of the work. The Soil Mixing Contractor shall then smooth-grade the site, as directed by the Owner’s representative.

3.15 Measurement and Payment

A. See Section 01 22 10 – Measurement and Payment.

END OF SECTION 31 32 01
PART 1 - GENERAL

1.01 SUMMARY

A. This Section specifies requirements for Contractor designed excavation support systems of trenches and open excavations greater than four feet in depth. Where sheet piling, shoring, sheeting, bracing, or other supports are necessary, remove all, except as shown or specified otherwise.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor’s responsibility to perform all the work required by the Contract Documents.

1. Section 01 33 10
2. Section 31 23 20

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this Section and the listed documents, the requirements of the Contract Specifications shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS D1.1</td>
<td>Structural Welding Code</td>
</tr>
<tr>
<td>WAC 296-155</td>
<td>Washington Safety Standards for Construction Work</td>
</tr>
<tr>
<td>WAC 296-155 Part N</td>
<td>Excavation, Trenching, and Shoring</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

(NOT USED)

1.04 SUBMITTALS

A. Procedures: Section 01 33 10, Submittals.

B. Qualifications of Shoring Contractor, Professional Engineer and welders.

C. Design documents, including detailed excavation support drawings, calculations, and installation and removal plan and sequencing stamped and sealed by Registered Professional Engineer in the state of Washington. Provide information required by WAC Chapter 296-155 Part N. Engineer will only review Contractor’s shoring submittal for completeness, without reviewing or approving means and methods.

1.05 DESIGN REQUIREMENTS

A. The design, planning, installation, and removal, of all sheeting, shoring, sheet piling, lagging, and bracing shall be accomplished in such a manner as to maintain the required excavation or trench section and to maintain the undisturbed state of the soils below and adjacent to the excavation.
B. Design excavation support systems in accordance with WAC 296-155 Part N and the recommendations presented in “Geotechnical Report South Park Pump Station, Seattle, Washington” prepared by Seattle Public Utilities Materials Laboratory, dated November 2008. Take note of report section 5.1.3 “Shoring” and Figure 3 “Temporary Shoring Wall Design Criteria”.

C. Horizontal strutting below the barrel of a pipe and the use of pipe as support are not acceptable.

D. Meet requirements for groundwater seepage limitations per Section 31 23 20, Control of Water.

E. The Contractor’s proposed procedure and corrective measures to be used should horizontal movement or settlements occur adjacent to the shored excavation or trench.

1.06 QUALIFICATIONS

A. Designer: Registered Professional Engineer in the state of Washington with a minimum of five years experience in the design of earth retaining structures for temporary construction of similar type and depth proposed.

B. Welder: Current certified by the AWS.

1.07 SUPPORT SYSTEM REQUIREMENTS

A. Comply with applicable requirements of the WAC and rules of the WISHA Department of Labor and Industries with respect to excavation and construction.

B. Submit design calculations and method of installation and removal of all sheeting, sheet piling, shoring, and bracing. Information to be provided shall include the following:

1. All calculations, methods, and installation and removal procedures shall be stamped, dated and signed by a currently registered Professional Engineer in the state of Washington.

2. When the construction sequence of structures requires the transfer of bracing to portions of any new structure or to any existing structure, provide a complete design analysis of the expected impact of that bracing on the structure. This action shall in no way absolve the Contractor of responsibility of damage resulting from said bracing.

C. No excavation support systems shall be installed using impact techniques such as hammer driven sheet piles.

D. Submittal to the Engineer will be to assure the Owner of the Contractor’s general compliance with the references and shall not be construed as a detailed review and analysis for adequacy of the support system, nor shall any provisions of the above requirements be construed as relieving the Contractor of its overall responsibility and liability for the work.
E. Local Jurisdictional Authority Approval: For excavation work in a public right-of-way and on private property:

1. Submit plans to the City of Seattle review agency for review and approval prior to submittal to the Engineer. Coordinate with the appropriate review agency prior to submittal of proposed excavation support systems and during the review period as required.

2. Be responsible for City of Seattle permit and plan check fees.
   a. Fees are based on percentage valuation of the excavation support system total value.
   b. Plan check fees shall be due at the time of excavation support system submittals to City of Seattle.
   c. Calculate total value of excavation support system to be permitted and provide to the City of Seattle.

3. Be responsible for independent consultant (used by the City of Seattle) fees for review of the excavation support system.

1.08 CITY OF SEATTLE EXCAVATION SUPPORT SYSTEM/CONTRACTOR-OBTAINED SHORING PERMIT REVISION APPROVAL AND PRE-CONSTRUCTION MEETINGS WITH CITY OF SEATTLE

A. Be responsible for obtaining and securing approved excavation support system (shoring) post-permit revision(s) from the City of Seattle Department of Construction and Inspection (SDCI) for the excavation support systems required to complete the Work.

B. Conduct pre-construction meetings with City of Seattle after issuance of permit revision(s) and prior to the start of excavation work for which the shoring design in needed. Meetings may not be scheduled with the City prior to the City’s issuance of the approved post-permit revision.

1. City of Seattle will determine number of pre-construction meetings required.

2. SDOT shoring review and inspection requires a separate and standalone pre-construction meeting prior to the start of any excavations adjacent to the public right of way. At a minimum attendee shall include representatives of the project representative, contractor, subcontractors performing the work, shoring designer, and SDOT review and inspection personnel.

C. Post-permit revision may also be referred to as deferred permit submittal.

D. Comply with the design and submittal requirements of the City of Seattle and as indicated in this Section.

E. Submit the Contractor proposed designs to the Project Representative for a limited specific purpose review (preliminary review) prior to submittal to the City of Seattle.

1. Include dewatering submittals, as required by Section 01 33 10, and contaminated soil handling and disposal submittals, as required by Section 01 35 30, in the submittal package for shoring as required by this specification.
2. This preliminary review is only for the Geotechnical Engineer of Record to review the submittal to provide a Letter of Concurrence, as required by the City of Seattle that the design of the excavation support system has been developed consistent with the soil parameters and loading criteria per the Geotechnical Report and this Specification.

3. Make modifications to the design as required by the Project Representative to enable the Letter of Concurrence to be completed.

4. Ten (10) days for review of the submittal by the Project Representative.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01 GENERAL

A. Provide excavation support systems to safely retain excavations, minimize inflow of groundwater into excavation, and control ground movements and deformations in accordance with the specified requirements.

B. Control water in accordance with Section 31 23 20, Control of Water.

C. Notify Engineer immediately upon encountering deformations larger than predicted, distress, or damage to the excavation support system.

D. Notify Engineer immediately if any excavation support element is not in accordance with the requirements of the design.

E. Suspend excavation and perform additional measures as required to meet requirements of the excavation support system designer and to meet groundwater seepage requirements per Section 31 23 20, Control of Water.

F. Construct the excavation support systems in such a manner so as to not disturb the state of soil adjacent to the trench or excavation and below the excavation bottom.

G. Unless otherwise indicated, remove excavation support systems after placement and compaction of backfill.

3.02 SHORING

A. Shoring shall be continuous, such that if comprised of individual elements, these element interlock. Vibrated shoring elements may be used where vibrations will not impact adjacent utilities, structures, sidewalls, pavements and existing subsurface conditions. Contractor shall not exceed vibration thresholds set forth in the Specifications or Contract Plans. The Contractor is liable for any damage to adjacent structures. The chosen sites shall be suitable for installation of the shoring to the full depth of penetration required, and to proper alignment and plumb, specified herein, without damage to the shoring elements or rupture of its interlocks. The use of steel sheet piling will not be permitted where sheeting would be required to penetrate boulders, rock or other materials which may prevent the proper installation of such a system.
B. Shoring shall be installed in plumb position, for the system’s entire length to form a continuous diaphragm throughout the length of each run of wall, bearing tightly against original ground. Install shoring elements to depth required for design. Exercise care during installation so that interlocking members can be extracted, if required, without injury to adjacent ground. The installation equipment shall be suitable to the type and nature of the subsurface materials anticipated to be encountered. The equipment and methods of installation, cutting, and splicing shall conform to the approved Shop Drawings.

C. A sufficient quantity of material shall be on hand for shoring, bracing, and other operations for protection of work and use in case of accident or emergency.

3.03 INTERNAL BRACING SUPPORT

A. All bracing support members shall be installed and maintained in tight continuous contact with each other and with the surface being supported.

B. Bracing members shall be preloaded by jacking the struts and shores in accordance with loads, methods, procedures, and sequence as described on the approved Shop Drawings. Coordinate excavation work with bracing installation and preloading. Use steel shims and steel wedges welded or bolted in place to maintain the preloading force in the bracing after release of the jacking equipment pressure. Use procedures to produce uniform bracing member loading without appreciable eccentricities, overstressing, or support member distortion.

C. Struts shall be provided with intermediate bracing as needed to enable them to carry their maximum design load without distortion or buckling. Provide diagonal bracing as necessary to maintain the stability of the system. Web stiffeners, plates, or angles shall be provided as needed to prevent rotation, crippling, or buckling of connectors at points of bearing between structural steel members. Allow for eccentricities resulting from field fabrication and assembly.

D. Excavations shall be a depth no more than 2 feet below the elevation of the support member about to be placed unless designed to span a greater depth. The support member shall be installed and preloaded immediately after installation and prior to continuing excavation.

3.04 REMOVAL OF SUPPORT SYSTEM

A. The method of pulling shoring elements shall be approved. If piling is used, pulling holes shall be provided in pilings as required. Extractors shall be of suitable type and size. Care shall be exercised during pulling of shoring elements to avoid damaging interlocks and adjacent construction. If the Construction Manager determines that adjacent permanent construction has been damaged during pulling, the Contractor will be required to repair this construction at no cost to Seattle Public Utilities.

B. Shoring elements shall be pulled one section at a time. Elements fused together shall be separated prior to pulling unless the Contractor demonstrates, to the satisfaction of the Construction Manager, that the shoring elements cannot be separated.

END OF SECTION 31 41 00
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes: This section includes information related to asphalt concrete pavement.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.

1.03 CITY OF SEATTLE, STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION, 2017 EDITION.
A. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
B. The Contractor shall have at least one copy of the Standard Specifications at the job site.
C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.04 DEFINITIONS
HMA: Hot Mix Asphalt

1.05 ADMINISTRATIVE REQUIREMENTS
(NOT USED)

1.06 SUBMITTALS
A. Submit the following according to Standard Specification 1-05.3 Submittals.
   1. HMA Mix Design conforming to Standard Specification 5-04.3(6)B.
   2. Compaction results conforming to Standard Specification 5-04.3(9).

PART 2 - PRODUCTS

2.01 HOT MIX ASPHALT (HMA)
A. HMA shall be Class ½-inch and Class 1-inch with aggregate conforming to Standard Specification 9-03.6 and asphalt PG 64-22 conforming to Standard Specification 9-02.1(4)B. Asphalt percentage of the total mixture shall be 5.0 to 7.5 percent.
B. Mineral Aggregate shall be as specified in Section 9-03-Aggregates of the Standard Specification.
C. Asphalt Binder: Performance grade for this project shall be shown on the Drawings and comply with the applicable requirements of Section 9-02 – Bituminous Materials of the Standard Specifications
D. Anti-stripping Additive shall be as specified in Section 9-02.4 of the Standard Specifications
2.02 TACK COAT
A. Tack coat shall be emulsified asphalt conforming to Standard Specification 5-04.3(4)B4A.

PART 3 - EXECUTION
3.01 PAVEMENT
A. Pavement construction shall be in conformance with Standard Specification 5-04.
B. HMA compaction tests will be performed by SPU Materials Laboratory. HMA shall be compacted to at least 92 percent of the reference maximum density in accordance with Standard Specification 5-04.3(9)B1.

END OF SECTION 32 10 00
PART 1 - GENERAL

1.01 SUMMARY
A. Section includes: This section includes information related to cement concrete pavement.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.
C. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
D. The Contractor shall have at least one copy of the Standard Specifications at the job site.
E. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.03 DEFINITIONS
(NOT USED)

1.04 ADMINISTRATIVE REQUIREMENTS
(NOT USED)

1.05 SUBMITTALS
A. Submit the following according to Standard Specification 1-05.3 Submittals.
   1. Concrete Mix Design conforming to Standard Specification 5-05.3(1).
   2. Compaction results conforming to Standard Specification 5-04.3(9).

PART 2 - PRODUCTS

2.01 MATERIALS
A. Portland Cement and Blended Hydraulic Cement shall be as specified in Section 9-01 of the Standard Specifications
B. Fine, Coarse and Combined aggregate shall be as specified in Section 9-03 of the Standard Specifications.
C. Premolded Joint Filler shall be as specified in Section 9-04.1 of the Standard Specifications
D. Joint Sealants shall be as specified in Section 9-04.2 of the Standard Specifications
E. Deformed Steel Bars shall be as specified in Section 9-07.2, Dowel Bars shall be as specified in Section 9-07.5, Tie Bars shall be as specified in Section 9-07.6 of the Standard Specifications.

F. Wire Mesh shall be as specified in Section 9-07.7 of the Standard Specifications. Rebar shall be installed as specified in Specification Section 03 20 00.

G. Concrete Patching Material shall be as specified in Section 9-20, Curing Materials and Admixtures shall be as specified in Section 9-23, Water shall be as specified in Section 9-25 and Epoxy Resins shall be as specified in Section 9-26 of the Standard Specifications.

2.02 MIXES

A. Concrete mix design for this project shall comply with the applicable requirements of Section 5-05 and Section 9-01 of the Seattle Standard Specifications.

PART 3 - EXECUTION

3.01 PAVEMENT

A. Pavement construction shall be in conformance with Standard Specification 5-05.3.

B. Prior to paving, adjust all existing maintenance hole rims, drainage structure lids, valve boxes, and utility access structures, within the paving area, to finished grade.

END OF SECTION 32 13 13
PART 1 - GENERAL

1.01 SUMMARY

A. The work includes furnishing all labor, materials, equipment, and transportation and performing all work required to finish the concrete work shown on the Drawings. Work in this Section shall include:

1. Integral coloring of concrete flatwork and walls.
2. Special finishing of concrete flatwork and walls, including: seeded exposed aggregate, and medium sandblast exposed aggregate.
3. Construction of concrete joints, including tooled joints.

1.02 REFERENCES

A. PCA PA124 - Finishing Concrete Slabs with Color and Texture.
B. PCA SP021 – Color and Texture in Architectural Concrete.
C. American Concrete Institute:
   1. ACI 305 - Hot Weather Concreting.
   2. ACI 306 - Cold Weather Concreting.
   3. ACI 316 - Recommendations for Construction of Concrete Pavements and Bases.
D. American Society for Testing and Materials:
   1. ASTM C309 - Liquid Membrane-Forming Compounds for Curing Concrete.
   2. ASTM C979 - Pigments for Integrally Colored Concrete.
E. The 2017 City of Seattle Standard Plans and Specifications for Road, Bridge and Municipal Construction (most recent edition).

1.03 DEFINITIONS

A. “Special Finishes”: includes those concrete elements exposed on the Project formed of special mixes, integral colors, finishes, joints, treatments or all of them where the concrete forms the finish of the element.

1.04 ADMINISTRATIVE REQUIREMENTS

(NOT USED)

1.05 SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.
B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials.
C. Colored Concrete: Provide a 12” x 12” colored concrete sample to Consultant showing broom finish and sand blast finishes.
1.06 QUALITY ASSURANCE
A. Installer Qualifications: Concrete work shall be performed by firm with five years experience with work of similar scope and quality

1.07 DELIVERY, STORAGE AND HANDLING
A. Color Additives: Comply with manufacturer's instructions. Deliver color additives in original, unopened packaging. Store in dry conditions.

1.08 PROJECT CONDITIONS
A. Colored Concrete Environmental Requirements:
   1. Schedule 1: Schedule placement to minimize exposure to wind and hot sun before curing materials are applied.
   2. Schedule 2: Avoid placing concrete if rain, snow, or frost is forecast within 24 hours. Protect fresh concrete from moisture and freezing.

B. Schedule delivery of concrete to provide consistent mix times from batching until discharge.

PART 2 - PRODUCTS
2.01 CONCRETE PAVING
A. As specified in COS herein.
   1. Cement color shall be Davis Color light gray.

2.02 SAND
A. Color shall be locally available natural sand.

2.03 COLOR PIGMENTS
A. Davis Colors manufactured by Davis Colors; phone 800-356-4848, www.daviscolors.com or approved equivalent. The following colors are indicated.
   1. “Light Gray”, 0.5 lb (per 94 lb. sack of cement) Supra-Instant Black #8084, specially treated carbon black (lamp black).

2.04 RELATED MATERIALS
A. Curing Compound for Colored Concrete: Curing compound shall comply with ASTM C309. Suitable substances include the flowing:
   1. W-1000 Clear Cure & Seal manufactured by Davis Colors or equivalent.

B. Chemical Retardants
   1. Grace Top-Cast Grade 05
   2. 2. Grace Top-Cast Grade 25
PART 3 - EXECUTION

3.01 PAVEMENT JOINTS
A. Saw Control Joints into hardened concrete using power saws equipped with shatterproof abrasive or diamond rimmed blades. Cut joints into concrete as soon as surface will not be torn, abraded, or otherwise damaged by cutting action.

3.02 FINISHING OF CONCRETE
A. Medium Sandblast Finish: Allow concrete to cure to according to instructions from manufacturer of retardant. Use chemical retardant and expose aggregate per the following:
   1. Topcast Grade 05 partially exposes aggregate in concrete
B. Exposed Aggregate
   1. Use Grace Top-Case Grade 25 to partially expose aggregate.

3.03 CONCRETE PROTECTION AND CURING
A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.
B. Curing Compound: Apply curing compound in accordance with manufacturer's instructions. Apply curing compound at consistent time for each pour to maintain close color consistency.

3.04 TOLERANCES
A. Minor variations in appearance of colored concrete, which are similar to natural variations in color and appearance of uncolored concrete, are acceptable.

END OF SECTION 32 13 16
PART 1 - GENERAL

1.01 SUMMARY
A. Site stonework shall be approved and located on site by the Consultant.

1.02 REFERENCES
(NOT USED)

1.03 DEFINITIONS
(NOT USED)

1.04 PERFORMANCE REQUIREMENTS
A. General: Provide to the site and hand set stonework in conformance with the Drawings and under the direction of the Consultant.

1.05 SUBMITTALS
A. Submit the following in accordance with Division One.
   1. Product data for each type of stone, Samples for verification purposes of stone in form for each color, grade, finish, type, and variety of stone required and consisting of stones not less than 12 inches square. Include 2 or more stones in each set of samples showing the full range of variations in appearance characteristics to be expected in the completed work. Deliver samples to site for review.

1.06 QUALITY ASSURANCE
A. Single-Source Responsibility for Stone: Obtain stone from a single quarry with resources to provide materials of consistent quality in appearance and physical properties, including the capacity to cut and finish the material without delaying the progress of the work.

B. Information on the Drawings and in the Specifications establishes the requirements for both aesthetic effects and performance of the stone. Aesthetic effects relative to the formal characteristics are indicated by dimensions, arrangement, alignment, and profiles of components and assemblies as they relate to sight lines and relationships to one another and to adjoining construction; performance is indicated by criteria subject to verification either by preconstruction or field test, if applicable, or by in-service experience.

C. Do not modify intended aesthetic effects, except with the Consultant's approval, and only to the extent exclusively needed to comply with the performance requirements. Where modifications are proposed, submit comprehensive explanatory data for review.

D. Installer Qualifications: Installer shall be a licensed mason in the state of Washington. The installer shall have a minimum of 10 years of experience in stone masonry.

1.07 DELIVERY, STORAGE AND HANDLING
A. Deliver materials to the project site in undamaged condition.

B. Store and handle the stone and related materials to prevent their deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breakage, chipping, or other causes.
C. Do not use pinch or wrecking bars.
D. Lift with wide-belt-type slings where possible; do not use wire rope or ropes containing tar or other substances that might cause staining.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL
A. Provide matched blocks from a single quarry from a single bed of quarry stratum unless the stones from randomly selected blocks are acceptable to the Consultant for aesthetic effects.
B. Stones shall be free from cracks, flaking and deterioration.

2.02 STONE
A. Boulders: Weathered Salt and Pepper Granite
1. Supplier: Marenakos Rock Center, Ph. (425) 392-3313, or approved equal.
2. Finish: Natural weathered smooth finish.
4. Boulders must be smooth and free of cracking and flaking.
B. Sawn Boulders: Weathered Salt and Pepper Granite
1. Supplier: Marenakos Rock Center, Ph. (425) 392-3313, or approved equal.
2. Finish: Saw-cut top and bottom, thermal finish top, natural sides.
C. Sawn Boulder Markers: Weathered Salt and Pepper Granite
1. Supplier: Marenakos Rock Center, Ph. (425) 392-3313, or approved equal.
2. Finish: Saw-cut top and bottom, thermal finish top, natural sides.
   a. Finish: Letter Size (TBD), Letter Style (TBD), grout color (TBD)
   b. Notes: Owner to provide text for engraving. Contractor to submit shop drawings for design and text approval. Installation per detail drawings and manufacturer instructions.
D. Stone Slabs: Hardy Island Granite Blocks
2. Finish: Thermal Top, Saw-cut bottom, Split sides
E. Stone Treads: Salt and Pepper Granite
   2. Finish: Thermal Top, Saw-cut bottom, Split sides

PART 3 - EXECUTION

3.01 EXAMINATION
A. Examine the surfaces to receive the stonework, and the conditions under which the stonework will be installed, with the Installer present, for compliance with the requirements for installation and other conditions affecting the performance of the stonework. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION
A. Protect the stonework during setting as follows:
B. Prevent staining of the stone from caulking or paving materials. Immediately remove such materials from the stone without damage to the latter.
C. Protect boulders from damage from construction machines and materials.
D. Clean stone surfaces that have become dirty and stained prior to setting. Remove soil, stains, and foreign materials. Clean stones by thoroughly scrubbing stones with fiber brushes followed by a thorough drenching with clear water. Use only mild cleaning compounds that contain no caustic or harsh filler or abrasives.

3.03 SETTING STONE, GENERAL
A. Execute the stonework by skilled mechanics and employ skilled stone fitters at the site to do the necessary field cutting as stones are set.
B. Set the stones to comply with the requirements indicated on the Drawings and the final shop drawings. Shim and adjust the anchors, supports, and accessories to set the stones accurately and plumb in the locations noted on the drawings. Set to widths indicated and with edges and faces aligned according to the established relationships.
C. Broken, chipped, stained, or otherwise damaged stones:
D. Broken, chipped, stained, or otherwise damaged stone shall be replaced until the methods and results are acceptable to the Consultant.
E. Stones and joints not matching the approved samples.
F. Stonework not complying with other requirements indicated.
G. Replace in a manner the results in the stonework matching the approved samples, complying with other requirements, and showing no evidence of replacement.
H. Clean the stonework not less than 2 days after completion of the work, using clean water and stiff-bristle fiber brushes. Do not use wire brushes, acid-type cleaning agents, cleaning compounds with caustic or harsh fillers, or other materials or methods that could damage the stone.
3.04 PROTECTION

A. Provide final protection and maintain conditions to ensure that no damage occurs to the stonework at the time of Substantial Completion.

END OF SECTION 32 14 40
PART 1 - GENERAL

1.01 SUMMARY
A. Specification Section Includes:
   1. This work shall consist of cement concrete sidewalks.
B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Specification Section 01 33 10.
   4. Specification Section 31 00 00.

1.02 REFERENCES
A. Referenced Standards:
   3. 2010 ADA Standards for Accessible Design.
B. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
C. The Contractor shall have at least one copy of the Standard Specifications at the job site.
D. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.03 DEFINITIONS
A. ADA: Americans with Disabilities Act
B. COS: City of Seattle

1.04 ADMINISTRATIVE REQUIREMENTS
(NOT USED)

1.05 SUBMITTALS
A. Refer to Standard Specification 1-05.3 for submittal requirements and procedures.
B. Submit as necessary to demonstrate conformance with the requirements for all products and execution in Sections 5-05, 8-14 and Division 9 of the Standard Specifications.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Non-Roadway Cement Concrete, W/25% pozzolans, High Strength:
   1. As specified in Section 5-05 of the Standard Specifications.

B. Exposed Aggregate Cement Concrete Treatment:
   1. As specified in Section 5-05.3(21) of the Standard Specifications.

C. Refer to Specification Section 32 13 16 for special concrete finishes

2.02 MIXES

A. Concrete mix design for this project shall be shown on the Drawings and comply with the applicable requirements of Sections 8-14, 5-05, and 9-01 of the Standard Specifications.

PART 3 - EXECUTION

3.01 GENERAL

A. Construct to line, grade and section as shown on Drawings.

B. Sidewalk along ADA routes shall be installed to not exceed the maximum allowable 5% longitudinal slope and a minimum of 2% longitudinal slope per the COS ADA requirements and as indicated on the plans.

C. Prior to paving, adjust all existing maintenance hole rims, drainage structure lids, valve boxes, and utility access structures, within the paving area, to finished grade.

D. Construct in accordance with Section 8-04.3 and Section 8-14 of the Standard Specifications.

E. Prior to paving, adjust all existing maintenance hole rims, drainage structure lids, valve boxes, and utility access structures, and other utilities within the paving area, to finished grade.

END OF SECTION 32 16 23
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes: This section includes information related to pavement markings for the site improvements.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.

1.03 DEFINITIONS
(NOT USED)

1.04 ADMINISTRATIVE REQUIREMENTS
A. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
B. The Contractor shall have at least one copy of the Standard Specifications at the job site.
C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.05 SUBMITTALS
A. Submit the following according to Standard Specification 1-05.3 Submittals.
   1. Material cut sheets for each of the products listed in Part 2 Products.

PART 2 - PRODUCTS

2.01 PAINT
A. Paint for pavement markings shall comply with Standard Specification 9-29.2. The paint shall be factory mixed, quick drying and non-bleeding. Colors shall be as indicated on the Drawings.

PART 3 - EXECUTION

3.01 PAVEMENT MARKINGS
A. Pavement markings installation shall conform to Standard Specification 8-22.3, except that the Contractor shall be responsible for all layout and control points. Striping shall not deviate more than 1/4-inch in 10 feet from a straight line and striping shall not be more than 1-inch from the specified locations. Paint striping shall only be applied after the pavement has been allowed to cure 14 days minimum, when the pavement is clean and dry and when the temperature is above 50 degrees F. Prior to painting the pavement, the Engineer shall review all chalking of pavement lines.

END OF SECTION 32 17 23
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes: Custom fabricated decorative fencing, custom fabricated decorative guardrails, and custom fabricated decorative gates. Handrails and pipe steel railings are not included in this Section.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A36</td>
<td>Carbon Structural Steel</td>
</tr>
<tr>
<td>ASTM A307</td>
<td>Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength</td>
</tr>
<tr>
<td>ASTM A563</td>
<td>Standard Specification for Carbon Steel Nuts</td>
</tr>
<tr>
<td>ASTM A588</td>
<td>High-strength, low-alloy structural steel shapes, plates and bars.</td>
</tr>
<tr>
<td>ASTM F884</td>
<td>Standard Specification for Washers, Steel, Plain (Flat) Unhardened for General Use</td>
</tr>
<tr>
<td>ASTM F1554</td>
<td>Standard Specification for Anchor Bolts, Steel, 36, 55, and 150 ksi Yield Strength</td>
</tr>
<tr>
<td>AWS D1.1</td>
<td>Structural Welding Code, Steel</td>
</tr>
<tr>
<td>OSHA</td>
<td>U.S. Dept. of Labor, Occupational Safety and Health Administration</td>
</tr>
<tr>
<td>IBC</td>
<td>International Building Code with local amendments</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

(NOT USED)

1.04 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 01 73 24.
2. Section 03 30 00.
3. Section 08 71 01.
4. Section 05 50 00.
5. Section 05 52 20.
1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 10.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (□) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Layout, installation and detail shop drawings for fabricated fences and gates including baseplate mounting templates.
   5. Design calculations stamped and signed by a licensed professional engineer in the State of Washington. Railing and base support connections to be designed by the Contractor incorporating specified criteria and provisions in the current building code with local governing amendments.

B. Informational Submittals:
   1. Provide material certification for compliance with this specification for steel materials.

1.06 QUALITY ASSURANCE

A. General:
   1. Fencing within this Section used as guardrails shall conform to the standards of the Occupational Safety and Health Administration (OSHA) and International Building Code.

1.07 DELIVERY, STORAGE AND HANDLING

A. Cushion wrap complete sections, modules and components to prevent scratching and denting during shipment, storage, and installation.

B. Leave wrap intact, insofar as possible.

C. Protect materials from dents, dings, bends, marks and aesthetic damage that would create a permanently disfigured surface.
PART 2 - PRODUCTS

2.01 PERFORMANCE/DESIGN CRITERIA

A. Custom Fabricated Decorative Guardrails. Guardrails shall be designed to meet the performance requirements of Section 05 52 20. Contractor’s supplier and engineer are responsible for designing the guardrail system along with its base support and anchor bolt size and embedment depth into concrete to resist the above loading condition taking into account anchor edge distances and concrete strengths at the point of attachment. Contractor shall submit calculations signed and sealed by a professional engineer in the State of Washington responsible for their preparation where the Contractor is responsible for the design as previously noted.

B. Custom Fabricated Decorative Gates. Decorative gate assemblies shall be designed to meet the performance requirements of Section 01 73 24 and as indicated on drawings. Gates shall be designed to withstand a load of 300-lbs, with less than 10 lbs of force required to open. Contractor’s supplier and engineer are responsible for designing the gates along with its base support and anchor bolt size and embedment depth into concrete to resist the above loading condition taking into account anchor edge distances and concrete strengths at the point of attachment. Contractor shall submit calculations signed and sealed by a professional engineer in the State of Washington responsible for their preparation where the Contractor is responsible for the design as previously noted.

1. Coordinate the work of this section with Section 08 71 01 Finish Hardware. Gates shall be secure and use tamperproof, vandal resistant hardware. Heavy-duty hinges, vandal-proof strike plates, and electrified for low-voltage keycard or touch-pad access.

C. Thermal Movements: Provide fencing and guardrail sections that allow for thermal movements resulting from the project site maximum range in ambient and surface temperatures. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.

D. Contractor shall design the decorative fence and gates such that the clear gap between the decorative fence and decorative gate is not more than 2-inches from the security fence and gate.

2.02 MATERIALS

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat shapes</td>
<td>ASTM A558, Weathering Steel</td>
</tr>
<tr>
<td>Tube shapes</td>
<td>ASTM A847, Weathering Steel</td>
</tr>
<tr>
<td>Steel Angles</td>
<td>ASTM A558, Weathering Steel</td>
</tr>
<tr>
<td>Carbon steel threaded rods at</td>
<td>ASTM A36, galvanized or ASTM F1554</td>
</tr>
<tr>
<td>adhesive anchors</td>
<td>(Grade 36), galvanized</td>
</tr>
</tbody>
</table>
2.03 CONFIGURATION, COMPONENTS

A. Custom Fabricated Decorative Guardrails:

1. Material: Weathering steel, final fabrication including welds shall be pre-weathered to rusticated appearance using saline/salt spray solution and rinsed with clean water. Coat with Anti-Graffiti product as indicated in Section 09 91 00 Painting.

2. Vertical pickets: Flat bar rectangular shape weathering steel, size as indicated on the drawings.

3. Posts: None.

4. Intermediate rails: None.

5. Mounting plate: Plate weathering steel, size as indicated on drawings.

6. Complete, installed components shall not exceed maximum building code sphere clearance requirements for guardrails, or as noted here, whichever is more stringent: 4-inch maximum clearance between pickets.

7. Components shall be welded, without the use of bolted connections. Include appropriate slip joints for expansion & contraction of intermediate rails.

B. Custom Fabricated Decorative Fencing:

1. Material: Weathering steel, final fabrication including welds shall be pre-weathered to rusticated appearance using saline/salt spray solution and rinsed with clean water. Coat with Anti-Graffiti product as indicated in Section 09 91 00 Painting.

2. Vertical pickets: Flat bar rectangular shape weathering steel, size and spacing as indicated on the drawings.

3. Posts: None.

4. Intermediate rails: None.

5. Embedment: Embed vertical pickets within concrete foundation to meet the performance requirements of this Section.

2.04 ASSEMBLY/FABRICATION

A. Material cuts shall be clean, straight, square and accurate for minimum joint gap. Work shall be done in conformance with the guardrail and handrail manufacturer's instructions. Work shall be free from blemishes, defects, and misfits of any type which can affect durability, strength, or appearance.

B. Connect guardrail by welding to plates, supports, and embedments.

C. Supply components required for anchorage of fabrications.

D. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints tight and flush. Round exposed edges to small, uniform radius.
PART 3 - EXECUTION

3.01 EXAMINATION
A. Examine and accept existing conditions before beginning work.
B. Field verify measurements for railings before fabrication.

3.02 INSTALLATION
A. Protect adjacent materials areas during the pre-weather process to prevent staining and rusticated metal drips.
B. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators.
C. Where recesses or blockouts are formed in the concrete, the metalwork shall be grouted in place after concrete has attained its design strength in accordance with Section 03 30 00.
D. Field welding of components is allowed, maintain appropriate working conditions in order to fabricate work free from defects.

3.03 FIELD QUALITY CONTROL
A. Maximum variance from plumb: 1/4 inch in 36-inches.
B. Maximum offset from true alignment: 1/4 inch in 36-inches.

END OF SECTION 32 31 00
PART 1 - GENERAL

1.01 SUMMARY
A. The extent and location of “High Security Chain Link Fence and Gates” Work is shown in the Contract Documents. This Section includes the requirements for furnishing and installing all items and components of a completed fence system in conformance with these specifications and the dimensions and sections indicated on the drawings or as established by the Engineer. The section includes materials applicable for high security chain link fence and gates.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.
1. ASTM A121 Standard Specification for Metallic-Coated Carbon Steel Barbed Wire
2. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
3. ASTM F552 Standard Terminology Relating to Chain Link Fencing
4. ASTM F567 Standard Practice for Installation of Chain Link Fence
5. ASTM F626 Specification for Fence Fittings
6. ASTM F668 Standard Specification for Polyvinyl Chloride (PVC), Polyolefin and Other Polymer-Coated Steel Chain Link Fence Fabric
7. ASTM F934 Specification for Standard Colors for Polymer-Coated Chain Link
8. ASTM F1043 Specification for Strength and Protective Coatings of Metal Industrial Chain Link Fence Framework
9. ASTM F1083 Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
10. ASTM F1664 Specification for Poly (Vinyl Chloride) (PVC) and Other Conforming
11. Organic Polymer-Coated Steel Tension Wire Used with Chain-Link Fence
12. ASTM F1665 Specification for Poly (Vinyl Chloride) (PVC) and Other Conforming Organic Polymer-Coated Steel Barbed Wire Used with Chain-Link Fence

1.03 DEFINITIONS
A. O.D: Outer Diameter

1.04 ADMINISTRATIVE REQUIREMENTS
(NOT USED)

1.05 SUBMITTALS
A. Submit materials data in accordance with of Section 01 33 10. Furnish manufacturers’ technical literature, standard details, product specifications, and installation instructions for all products.
B. Submittals shall include the following:

1. Shop and erection drawings shall show Site plan with layout of fence location with dimensions, location, elevation of fence, details of attachment and footings.
2. Manufacturers material certifications in compliance with current ASTM specifications.
3. Calculations that posts are adequately sized for the expected loads.

1.06 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing chain link fence products with at least 5 years’ experience. Obtain chain link fences and gates, including accessories, fittings, and fastenings, from a single source.

B. Fence contractor: Company with demonstrated successful experience installing similar projects in accordance with ASTM F567 at least 5 years’ experience.


D. Moisture Resistance and Thermal Compatibility: Provide materials that will resist degradation and failure of signals under ambient conditions expected.

PART 2 - PRODUCTS

2.01 CHAIN LINK FENCE FABRIC

A. The fence shall be polymer coated steel fabric woven per the contract plans and per ASTM F668 with knuckle finish selvages at the bottom and twisted selvages at the top. The wire gauge is polymer coated wire.

B. Finish shall be standard mill finish.

C. There shall be no exposed zinc.

2.02 FRAMEWORK

A. Framework and coating shall be in accordance with ASTM F1083 and F1043.

B. Galvanized tubular steel pipe shall conform to the requirements of Group IA Heavy Industrial Fence Framework, Schedule 40 galvanized pipe per ASTM F1083. Exterior hot dipped zinc coating minimum average 1.8 oz/ft², interior hot dipped zinc coating minimum average 1.8 oz/ft².

C. Line posts shall be a minimum 2.375-inch O.D at 3.65 pounds per foot.

D. End, corner or pull posts shall be a minimum of 2.875-inch O.D at 5.79 pounds per foot.

E. Top rails, post braces, and intermediate rails shall be 1.66-inch O.D., at 2.27 pounds per foot.

2.03 TENSION WIRE

A. Wire ties for use in conjunction with a given type of fabric shall be of the same material and coating weight identified with the fabric type. Tension wire shall be 7-gauge polymer coated steel tension wire to match coating with the fabric type and shall conform to ASTM F1664.
2.04 BARBED WIRE
A. Barbed wire shall comply with ASTM F1665, with three strands of 14 gauge wire each consisting of two 0.80-inch double twisted strand lines made of aluminum alloy with four point barbs; each barb is spaced at an average of five inches apart on center.

2.05 FITTINGS
A. Brace Bands and Line Rail Clamps: Galvanized pressed steel complying with ASTM F626, steel thickness 1/8 in. (3.18 mm), band width 1 in. (25 mm), zinc coated 1.20 oz/ft² (366 g/m²). Secure with 3/8 in. (9.53 mm) galvanized steel carriage bolts.
B. Terminal Post Caps, Line Post Loop Tops, Rail and Brace Ends, Boulevard Clamps, Rail Sleeves: In compliance to ASTM F626, pressed steel galvanized after fabrication having a minimum zinc coating of 1.20 oz/ft² (366 g/m²).
C. Truss Rod Assembly: In compliance with ASTM F626, 3/8 in. (9.53 mm) diameter steel truss rod with a pressed steel tightener, minimum zinc coating of 1.2 oz/ft² (366 g/m²), assembly capable of withstanding a tension of 2,000 lbs. (970 kg).
D. Tension Bars: Bars for small mesh of 5/8 inch shall be attached (sandwiched) to the terminal post using a galvanized steel strap having a minimum cross section of 2 inch by 3/16 inch with holes spaced 12 inches on center to accommodate 3/8 carriage bolts which are to be thru bolted – through the strap the mesh and through the terminal post.
E. Barbed Wire Arms: This is an optional fitting. The arms shall be three strand 45 degree arm, in compliance with ASTM F626, pressed steel galvanized after fabrication, minimum zinc coating of 1.20 oz/ft² (366 g/m²), capable of supporting a vertical load of 250 pounds.
F. Match the coating class and color of chain link fabric for tie wires and hog rings, which shall be installed per ASTM F626.

2.06 MARKING
A. Each roll of fabric shall carry a tag showing the kind of base metal, kind of coating, the gauge of the wire, the length of fencing in the roll, and the name of the manufacturer. Posts, wire, and other fittings shall be identified as to manufacturer, kind of base metal, and kind of coating.

2.07 CONCRETE
A. Concrete for post footings is standard ready-mixed concrete from an approved plant and shall have a 28-day compressive strength of 2,500 psi

PART 3 - EXECUTION
3.01 GENERAL
A. The location and alignment of the fence corners and gates will be provided by the Engineer. The Contractor shall locate all intermediate line posts.
B. The Contractor shall submit shop drawings of fencing, gates and appurtenances. Shop drawings must be approved by the Engineer prior to fabrication or installation.

3.02 CLEARING FENCE LINE
A. Clearing: Surveying, clearing, grubbing, grading and removal of debris for the fence line or any required clear areas adjacent to the fence
3.03 INSTALLATION

A. Fencing, gates and appurtenances shall be erected and installed by an organization regularly engaged in this business, employing labor skilled in this type of Work to provide a complete security fencing system.

B. Post Installation:
   1. Posts shall be set plumb in concrete footings in accordance with ASTM F567. Minimum diameter for footing is 3 feet. Minimum requirements for gate posts are listed in ASTM F567. Minimum footing depth is 24 inches plus an additional 3 inches for each 1 foot increase in the fence height over 4 feet. Contractor shall verify actual needed post hole depth depending on fence alignment and height.
   2. The concrete shall be thoroughly compacted around the posts by tamping or vibrating and shall have a smooth finish slightly higher than the ground and sloped to drain away from the posts. The top of the concrete footing shall be crowned to shed water away from the post.
   3. Posts should be space not more than 10-feet apart and should be set a minimum of 36 inches apart. Line posts shall be installed at intervals not exceeding 10-foot on center.
   4. Terminal posts: End, corner, pull and gate posts shall be braced and trussed for fence 6 ft. (1.8 m) and higher. The horizontal brace rail and diagonal truss rod shall be installed in accordance with ASTM F567.

C. Tension Wire Installation:
   1. Tension wires shall be installed 4 inches up from the bottom of the fabric. Fences without top rail shall have a tension wire installed 4 inches down from the top of the fabric. Tension wire to be stretched taut, independently and prior to the fabric, between the terminal posts and secured to the terminal post using a brace band. Secure the tension wire to the chain link fabric with a 9 gauge hog rings 12 inches on center and to each line post with a tie wire.

D. Top Rail Installation:
   1. The top rail shall be continuous and shall pass through the post tops. The coupling used to join the top rail lengths shall allow for expansion. Expansion and contraction spring couplings shall be installed at intervals of 100 feet maximum. The rail shall be secured to the terminal post by a brace band and rail end.

E. Fabric Installation:
   1. Small mesh fabric less than 1-inch attach to terminal post by sandwiching the mesh between the post and a vertical 2-inch-wide by 3/16 inch galvanized steel bar using 3/8 inch carriage bolts, through bolted - through the bar, mesh and post spaced 15 inches on center.
   2. The wire fabric shall be firmly attached to the posts and bottom wire and braced in the manner shown on the plans. All wire shall be stretched taut and shall be installed to the required elevations. The fence shall generally follow the contour of the ground, with the bottom of the fence fabric no more than 2 inches from the ground surface. Grading shall be performed where necessary to provide a neat appearance.
3. Chain link fabric to be sufficiently stretched taut so as not to deflect more than 3 inches in the center of two line post at mid height subjected to a 30 pounds horizontal force. Fabric to be secured to the line post with tie wires spaced no greater than 12 inches on center and to rail spaced no greater than 12 inches on center using pre-formed 9 gauge galvanized steel power-fastened tie wire wrapped 360 degrees around the post or rail and fabric picket, twist the two wire ends together three full turns per ASTM F567. Excess wire shall be cut off and bent over to prevent injury. Secure fabric to the tension wire with hog rings spaced no greater than 18 inches apart.

F. Barbed Wire Installation:

1. Barbed wire shall be installed stretched taut between terminal posts and secured in the slots provided on the line post barb arms. Barb arms are Type I in the outward direction. Attach each strand of barbed wire to the terminal post using a brace band. Barb arms to be riveted or bolted to post.

END OF SECTION 32 31 13
PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for furnishing and installing an automatically controlled irrigation system and associated equipment.

B. This Section includes specifications for restoring existing irrigation systems as shown on the Plans. This includes maintaining existing irrigation systems in a functioning, operational condition to ensure adequate irrigation to sustain existing plant materials in a healthy growing condition during construction.

C. This Section includes a Warranty Period for the irrigation system for 12 months.

D. The irrigation system consists of a completely automatic, electrically controlled sprinkler irrigation system. The system is designed to provide complete coverage with minimum maintenance and without overspray onto walks, pavements, and structures.

E. Avoid conflicts between the irrigation system layout and plant materials, lighting fixtures, sign posts, architectural features, above and below ground utilities, and drainage systems. The irrigation system layout is schematic. Locate pipes in planting or seed areas unless shown in sleeves.

1.02 REFERENCES
A. This Section incorporates by reference the latest revision of the following documents.
   2. American Society of Mechanical Engineers (ASME):
      a. ASME B16.3 Malleable Iron Threaded Fittings.
         a. ASTM A53/A53M Pipe, Steel, Black and Hot-Dip Zinc-Coated, Welded and Seamless.
         b. ASTM B3 Soft or Annealed Copper Wire.
         c. ASTM B33 Tinned Soft or Annealed Copper Wire for Electrical Purposes.
         d. ASTM D1785 Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40 and 80.
         e. ASTM D2464 Threaded Polyvinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80.
      2. American Water Works Association (AWWA):
         a. ANSI/AWWA C500 Metal Seated Gate Valves for Water Supply Service.
      3. National Electrical Manufacturers Association (NEMA):
         a. NEMA WC5 Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
C. Local Standards: Construct irrigation system segments that are to be owned or maintained by jurisdictions other than SPU to the applicable requirements of the jurisdictional agency’s standard drawings and specifications. The Contractor is responsible for obtaining all such standards and for compliance with such standards as applicable.

1.03 DEFINITIONS

(NOT USED)

1.04 ADMINISTRATIVE REQUIREMENTS

(NOT USED)

1.05 SUBMITTALS

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.

C. Product Data: Include manufacturer’s product literature for all products to be installed in this system. Include material showing manufacturer’s name, catalog numbers, catalog cuts, technical data, and installation, operation, and maintenance instructions for each product.

D. Point of Connection Water Pressure Test: Test water pressure at the irrigation point of connection. Submit written results of test to the Engineer prior to the beginning of construction.

E. As-Built Drawings:

1. Record accurately in red ink on 1 set of black-line prints all changes in the Work constituting departures from the Contract Drawings.

2. Record the changes and dimensions in a legible manner to the satisfaction of the Engineer. Before Final Inspection of Work, submit As-Built Drawings to the Engineer for review.

3. Dimension from 2 permanent points of reference (buildings, monuments, sidewalks, curbs, and pavements). Record data on As-Built Drawings daily as the Work is being installed.

4. Show locations, depths, size, and information as applicable, of the following items:
   a. Point of connection and available static water pressure.
   b. Routing of mainline and lateral pipes.
   c. Sleeves
   d. Gate valves.
   e. Remote control valves.
   f. Quick coupling valves.
   g. Sprinklers.
h. Routing of control wires.
i. Other irrigation system component locations necessary to accurately represent authorized changes to the irrigation system.

5. Maintain As-Built Drawings on site.

F. Submit controller chart, operation and maintenance manuals, special tools, and spare parts as described in Subsection 1.05 herein.

G. Shop Drawings: Submit for review and approval by the Engineer, when indicated on the Plans for restoration existing irrigation systems. Shop drawings shall include static water pressure, product types and sizes, irrigation head layout, lateral and main line pipe layout and sizes, valve locations, sleeves, and sizes and other relevant information pertaining to the function of the existing system. Head layout shall demonstrate complete head-to-head coverage of planting areas, accommodating existing and new site features. Shop drawings must be submitted at a scale that matches the Irrigation and Planting Plans for Engineer review.

1.06 QUALITY ASSURANCE, QUALITY CONTROL

A. Contractor must be experienced in irrigation work of best-accepted trade practices and have equipment and personnel adequate to perform the work specified, including at least 3 years of experience installing irrigation systems.

B. The Contractor shall continuously maintain a competent superintendent or foreman during the progress of the work, with the authority to act for the Contractor in all matters pertaining to the irrigation work.

C. The Contractor shall progressively clean the work site of debris and rubbish as the irrigation work proceeds.

D. Site Inspections will be made by the Engineer. The Contractor shall request inspection at least 48 hours in advance of the time inspection is required. Inspections for the following items will be required:

1. Water Pressure Submittal: The contractor shall submit written documentation that the static pressure at the point-of-connection meets or exceeds the design pressure shown on drawings prior to beginning construction.

2. Mainline and Lateral Line Pressure Tests

3. Mainline and Lateral Line pipe installation prior to backfill (trench inspection)

4. Irrigation coverage test prior to planting

1.07 PERFORMANCE REQUIREMENTS

A. Coordinate installation of irrigation as shown on the Contract Drawings with all other Work, including the restoration of existing irrigation systems.

B. Coordinate layout and installation of irrigation sleeves, conduits, and pipes under paved areas and other features prior to their construction.

C. Coordinate installation of irrigation system with installation of planting areas. Refer to

D. Section 32 93 00 for requirements.

E. Install and test the irrigation system before installation of plant material or as noted otherwise on the Contract Drawings. Coordinate layout and installation of irrigation
F. system with location and installation of plant material to ensure complete and full irrigation coverage of planting areas.

G. Stake tree locations in the field prior to installation of irrigation pipe and sprinklers. Refer to the Planting Plans & Details on the Contract Drawings for plant setbacks and spacing requirements. Trees shall be located and planted prior to the installation of the irrigation system.

1.08 TURNOVER ITEMS

A. Controller Charts:
   1. Provide two (2) irrigation zone location charts, one (1) sized to fit inside of controller door and one (1) to be included in the Operation and Maintenance Manual. Show the area covered by the irrigation controller. The chart is a reduced size copy of the As-Built Drawings. In the event that the controller sequence is not legible when the print is reduced, enlarge to a readable size.
   2. As-Built Drawings require approval by the Engineer before charts are prepared.
   3. Mark the chart with a different color to show the area of coverage for each zone.
   4. When completed and approved, seal chart between 2 pieces of transparent plastic. Install chart in controller enclosure using Velcro fasteners.
   5. Complete irrigation zone location charts 10 days prior to Final inspection.

B. Operation and Maintenance Manuals: Within 10 days prior to Final Inspection, prepare and deliver to the Engineer the required descriptive materials, properly prepared in two (2) individually bound copies of the operation and maintenance manual. Describe the material installed in sufficient detail to permit operating personnel to understand, operate, and maintain equipment. Include spare parts lists and related manufacturer’s information for each equipment item installed. Include the following information in manual:
   1. Index sheet listing Contractor’s address and telephone number, including names and addresses of local manufacturer’s representatives.
   2. Complete operating and maintenance instructions on major equipment.

C. Special Tools and Spare Parts:
   1. Supply the following items as part of Contract:
      a. Provide 4 percent additional sprinklers and nozzles of each type and spray pattern shown on the Contract Drawings.
      b. Provide 2 wrenches for disassembly and adjustment of each type of sprinkler head installed.
      c. Provide 2 keys for the irrigation controller.
      d. Provide 1 coupler with 3/4 inch bronze hose bib, bent nose type with hand wheel, and 1 coupler key for each 5 quick couplers installed.
      e. Provide 1 valve box cover key for each 10 valve boxes.
   2. Deliver tools and spare parts to the Engineer at the project site at conclusion of Final Inspection.
1.09 WARRANTY

A. General Warranty: The Special Warranty specified in this Section shall not deprive SPU of other rights which SPU may have under other provisions of the Contract Documents, and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Make repairs and replacements and guarantee the satisfactory operation of the entire system in every detail for the 12-month Warranty Period. All warranty repairs and replacements are part of the Contract, except those items that were a part of existing systems that were undamaged during construction and not restored as specified herein and as shown on the Plans.

C. Fees:

1. Fees for normal inspections or observations by the Engineer will be paid for by SPU.

2. Additional inspections, travel expenses, administrative costs, and tests required because of defective work or ill-timed notices will be made at the Contractor’s expense.

D. Additional Requirements:

1. Repair settling of trenches. Restore plantings, mulch, grades, pavements or other improvements in accordance with the Contract Documents.

2. Correct irrigation system problems or damage within 24 hours of notice until the Final Inspection of the Work.

3. During the first irrigation season, be available within 1 day for required repairs to the system.

4. Provide a written statement to SPU and the Engineer stating that the Contractor shall:
   a. Warrant the satisfactory operation of the entire irrigation system including performance, parts, assemblies and workmanship.
   b. Return to the job site at the beginning of the first winter season to perform a general inspection of the system; test valves and sprinklers; repair leaks and faulty work; check operation of the system; adjust spray patterns for full coverage; drain system; show grounds staff location of drain valves and blow out points; restore areas where trenches have settled; and adjust irrigation controller scheduling if necessary.
   c. Return in spring after the first winter season for a system check, and, if necessary, restore system for spring and summer operation. Explain system and operation methods to grounds staff and have the grounds supervisor furnish a signed statement of compliance with this requirement. Adjust automatic controller scheduling if necessary.
PART 2 - PRODUCTS

2.01 MATERIALS
A. All materials and equipment shall be new and the best grade of its kind. All items of equipment or material shall be as indicated or specified by patent or proprietary name or names of manufacturer or accepted equal.
B. Proposed substitutions for products listed shall be submitted in accordance with Division 1.

2.02 PIPING
A. Pipe for buried irrigation systems shall be PVC except where noted otherwise.
B. PVC Pipe:
   1. Schedule 40 for mainline and lateral pipes: ASTM D 1785, PVC 1120 compound, unless otherwise noted on the Plans.
C. PVC Threaded Nipples: 1/2 inch diameter, Schedule 80, complying with ASTM D1785.
D. Sleeves: inside diameter not less than twice the outside diameter of pipe or 2 inches larger than the combined outside diameter of pipes installed.
   1. PVC pipe, Schedule 40.
   2. Ductile iron pipe under vehicular pavements.

2.03 PIPE FITTINGS
A. PVC Pipe Fittings:

2.04 PVC PIPE JOINT COMPOUND AND PRIMER
A. Joint compound: Slow drying, heavy-duty PVC solvent cement.
B. Primer: Tinted, compatible with joint compound, as recommended by manufacturer of PVC pipe.

2.05 IRRIGATION SPRINKLERS
A. Shall be of the type, manufacturer, and size shown on the contract drawings, or approved equal

2.06 AUTOMATIC CONTROL VALVES
A. Shall be of the type, manufacturer, and size shown on the contract drawings, or approved equal

2.07 MASTER VALVE:
A. Electric master valve shall be normally closed, electric solenoid operated with a maximum rating of 6.5 watts and 24 volts AC power. Valves shall be pressure rated 150 psi; heavy-duty brass body/ bonnet with flow control stem and a manual internal and external bleed capability. Valve shall be of size and manufacturer/model as specified on the Drawings.
2.08 MANUAL DRAIN VALVE
A. Brass, 3/4 inch stop and waste valve shall be Mueller Mark II Oriseal H-10284 or approved equal.

2.09 DRAIN VALVE
A. Provide drain valves per COS Specification 9-15.7(4) Drain Valves

2.10 MANUAL GATE VALVES
A. Provide standard gate valves per COS Specification 9-15.7(1) Gate Valves.
B.

2.11 IRRIGATION VALVE BOXES AND VALVE KEYS
A. For remote control valves: Minimum size shall be 16 inches by 12 inches by 10-3/4 inches, green with snap lock green cover. Size valve boxes to ensure 3 inches clearance around and between all connections and valves. Multiple valves may be installed in 1 box, provided that clearances are met. Color: black. Carson, or accepted equal.
C. For gate valves: as shown on Contract Drawings. Color: black.
D. Provide keys required for valves, valve box covers and protective sleeve caps.

2.12 IRRIGATION CONTROLLER
A. Provide standard SPU irrigation controller box per COS Specification 9-15.4 Irrigation automatic controllers
B. Provide controller for complete automatic operation of irrigation system: commercial grade, in weatherproof, lockable box or cabinet, pedestal mount as shown on drawings. UL listed and with adequate number of stations to operate system. Provide stations with independent time controls with 1-minute incremental settings up to 60 minutes maximum per zone. Provide controller to allow easily made changes on zone timing and programs start time without tools or disassembling. Stations may be omitted with time setting of zero minutes. Provide rapid advance between stations and override on each zone for manual operation. Provide for schedules up to 1 week and permit multi-cycle operation as often as every hour. Equip controller with manual start switch for activation of semiautomatic watering cycle.
C. Capable of operating 24-V ac remote control valves.
D. Provide a UL listed 24-V ac transformer with controller. Color-code zone wiring with irrigation zone indicator key visibly imprinted. Include pump start and circuit overload protection to prevent damage due to voltage surges.
E. Controller housing: Shall be of the type, manufacturer, and size shown on the contract drawings, or approved equal.
F. Controller type: Shall be of the type, manufacturer, and size shown on the contract drawings.

2.13 IRRIGATION CONTROL WIRE
A. Provide thermoplastic insulated, solid copper conductor conforming to ASTM B3, suitable for continuous operation at 24-V ac.
B. Direct burial control wires to remote control valves: NEC Type UF or G.E. Co. No. SI-58-51 or approved equivalent. Size wire to each remote control valve to not exceed 5 percent voltage drop from impressed voltage, not less than No. 14 AWG.


D. Wire Splice connections: 3M DBY or accepted equal.

2.14 WIRE SLEEVE
A. Wire sleeve below pavement: Schedule 40 PVC sized in accordance with irrigation details, or as required to accommodate the number of control wires at each sleeve.

2.15 PRESSURE-REDUCING VALVE
A. Shall be Wilkin’s 600XL, and size shown on the Drawings or approved equal.

2.16 QUICK COUPLING VALVES
A. Quick coupling valves shall be two-piece body type of heavy-duty brass or of heavy-duty bronze, and watertight both before and after the coupler is inserted. The valve mechanism shall be designed to ensure the valve seat is closed before the coupler is removed. Each valve shall have the manufacturer’s identification cast or stamped on the valve.

B. Type: Rain Bird Model No. 44-LRC or accepted equal.

C. Swing Joint: as shown on Contract Drawings or accepted equal.

2.17 DOUBLE CHECK VALVE
A. As shown on Contract Drawings or accepted equal.

2.18 BACKFILL MATERIALS
A. Gravel Backfill for Sand Drains (for use under valve boxes only):
   1. Three-quarter (3/4) minus round, water worn, washed gravel.

B. Sand (backfill soils around PVC pipe):
   1. Fine granular material naturally produced by rock disintegration and free from organic material, loam, clay and other deleterious substances.

C. Native Material (backfill soil around PVC pipe)
   1. Soil native to project site free of wood and other deleterious materials and rocks over one (1) inch diameter.

2.19 OTHER SUPPLIES
A. Electrical tape shall be black plastic, three-quarters (3/4) inch wide and a minimum of

B. 0.007 inches thick and the all-weather type.

C. All flexible nipples or pipe joints shall be "Toro Funny Pipe"; "Rainbird Swing Pipe"; "Triple Swing Joint" or approved equal.

D. All electrical wire splices must be made watertight with sealing 3M Direct Burial Splice Kit or approved equal.
PART 3 - EXECUTION

3.01 GENERAL
A. Verify static pressure as noted on the Contract Drawings at point of connection before installing irrigation system, including existing irrigation systems as applicable. Report any discrepancy to the Engineer.
B. The irrigation system layout shown on Contract Drawings is schematic, unless noted otherwise. With acceptance of the Engineer, make adjustments where necessary to conform to actual field conditions. Irrigation system shall be operational, with uniform and adequate coverage of areas to be irrigated prior to planting.
C. Service connections: The irrigation point of connection is shown on the Contract Drawings. Notify the Engineer at least 3 weeks before electrical and water services are required. Furnish labor and materials to connect to service connection.
D. Electrical Service: Install irrigation electrical work for service connections in accordance with Division 26, Electrical.
E. Code Requirements: Before Work of this Section, carefully inspect installed Work of other trades and verify that the Work is complete to the point where irrigation system installation may commence. Verify irrigation system may be installed in accordance with pertinent codes and regulations, original design, referenced standards and manufacturer’s recommendations.
   1. Immediately notify the Engineer of conflicts between equipment or methods indicated or specified with local codes, prior to start of installation. If Contractor fails to give notification, assume responsibility for cost of revisions necessary to comply with code.
F. Grades: Before starting Work, carefully review grades to determine if irrigation Work may proceed. Keep within specified material depths with respect to finish grade.
G. Coordination with Work of other trades. Make necessary measurements in field to ensure precise fit of items in accordance with original design. Coordinate installation of irrigation materials with other Work. Coordinate piping locations with tree and shrub locations to avoid conflicts.

3.02 INSTALLATION
A. Excavating and Backfilling:
   1. Perform excavation and backfilling as specified in Section 31 23 33. Restore existing surfaces to original condition.
   2. Trenching of mainline and lateral pipes shall be straight and without abrupt grade changes.
   3. Trenches shall be free from rock, debris or sharp articles, with a minimum depth as shown on the Contract Drawings. Trench width must allow a minimum of 2 inches between parallel pipes. Stacking of pipes is not permitted. Trench bottoms shall have a uniform slope of 1/2 percent minimum grade.
   4. Backfill any excess excavation with suitable materials in accordance with COS Standard Specifications 2-10, which is free of rocks, organic material, or other materials that may damage pipe. Thoroughly compact to give full support to pipe.
5. Backfill when pipe is not in an expanded condition due to heat or pressure. Place backfill material in 6-inch lifts and compact each lift. Backfill to ensure no future settlement of the trench. Thoroughly backfill around sprinkler heads and be especially attentive to the restriction of movement of sprinklers by external force. Repair trench settlement during the warranty of this Contract. Backfill trenches uniform with the surrounding grade.

6. Backfill in irrigation sleeve trenches shall be mechanically compacted in 2 lifts to a dry density equal to 95 percent of adjacent undisturbed soil. Backfill will conform to adjacent grades without dips, sunken areas, humps, or other surface irregularities.

7. If settlement occurs and subsequent adjustments in pipe, valves, sprinklers, lawn or planting, or pavements are necessary, the Contractor shall make all required adjustments.

8. Compaction: Use hand-operated, plate-type, vibratory, or other suitable hand tampers in areas not accessible to larger rollers or compactors. Compact initial backfill material surrounding pipes and conduits to 95 percent maximum density. For sleeves under roads or slabs, compact backfill as specified in Section 31 23 33.

B. PVC Pipe Assembly:

1. Handle plastic materials carefully, store under cover and prevent damage to pipe. Provide support beds for full lengths of pipe when transporting and storing pipe. Do not install damaged or dented pipe.

2. Cut PVC pipe square and remove burrs. Clean pipe and fittings using primer and cleaner recommended by PVC pipe manufacturer. Use tinted primer to aid in visual inspection.

3. Apply a thin, even flow coat of PVC solvent cement to outside of male fitting. Cure joints as recommended by manufacturer and keep pipe and fitting out of service during curing period. Construct watertight joints equal to or greater in strength than pipe. Do not tap pipe and fittings.

4. Wipe off excess PVC solvent cement with a clean rag. Let welded joints cure at least 15 minutes before moving them and at least 24 hours before water is permitted into pipe.

5. Install pipe fittings for sprinklers, remote control valves, and quick coupler valve outlets horizontally and facing the exterior of the planting area.

6. Do not vertically stack pipes in trenches. Install piping side by side with a 2-inch separation between parallel pipes.

C. Pipe Sleeves

1. Place pipe to be installed under pavement or through walls in a PVC pipe sleeve that has an inside diameter not less than twice the outside diameter of pipe or 2 inches larger than the combined outside diameter of pipes installed.

D. Sprinklers:

1. Install sprinklers as indicated on Contract Drawings.

2. Install rotor sprinklers a minimum of 4 inches and a maximum of 6 inches from hard surface edges.
3. Install rotary spray, and spray sprinklers a minimum of 2 inches and a maximum of 4 inches from hard surface edges. Install rotary spray sprinklers a minimum of 12 inches from walls.

4. Thoroughly flush lateral pipes and swing joints prior to installation of sprinklers.

5. Upon completion of installation, adjust sprinklers to properly distribute water to all planting areas. Rotate individual sprinkler nozzles to keep sprays within planting areas and eliminate overspray onto pavements, walls, site features and the building.

E. Swing Joints:
1. Connect sprinklers to lateral pipes using a swing joint assembly as shown of Contract Drawings.

F. Control Wire:
1. Tape control wires together at 5-foot intervals with electrical tape. Tape this bundle to the bottom of the mainline at 10-foot intervals with at least one full wrap of duct tape. Tie a loose 30-inch loop in all wiring runs at changes of direction greater than 30 degrees. Untie all loops after all connections have been made.
2. Install wire under pavement in PVC pipe sleeves.
3. Install 2 orange spare wires to run from the controller to the furthest ends of each branch of the mainline. Provide an extra 4-foot length of coiled wire in the valve box.
4. Splice connectors: Encapsulate all splices with wire splice connectors. Wire runs between remote control valves and controller shall be continuous with no splices unless noted otherwise on the Contract Drawings. Leave a minimum of 4 feet of excess conductor at splices. Install splices in valve boxes when splices are required between the irrigation controller and remote control valves.

G. Controller Installation:
1. Install in accordance with manufacturer’s instructions.
2. Coordinate electrical service to controller location. Install controller in a pedestal mount exterior, weatherproof cabinet.
3. Install conduit for control wires from the controller to nearest mainline location. Wires below grade adjacent to mainline do not require conduit.

H. Automatic Control Valves:
1. Install as shown on "Automatic Control Valve" detail.
2. Before installation of any automatic valves, the supply line must be thoroughly flushed.
3. All automatic valves shall be enclosed in valve boxes set above finish grade as shown on details. Valve box extension may be required. Locate valve boxes in shrub and groundcover planting beds wherever possible and at points of easy access from paved and/or lawn areas.
4. Locate outside of paved areas and grouped together where possible. Where valves occur adjacent to paved areas, install valves so that valve boxes will not be closer than twelve (12) inches to paving. Valve boxes shall be perpendicular or parallel to pavement and grouped to provide a neat appearance.

5. Pressure Reducing Valve
   1. Install as shown on "Pressure Reducing Valve" detail.

J. Quick Coupling Valves:
   1. Install as shown on “Quick Coupling Valve” detail. Locate all quick couplers in shrub and/or groundcover planting beds when possible and at points of easy access from paved and/or lawn areas.

K. Manual Drain Valve
   1. Install as shown on "Manual Drain Valve" detail.

L. Manual Gate Valve
   1. Install as shown on "Manual Gate Valve" detail.

M. Double Check Valve
   1. Install as shown on "Double Check Valve" detail.

3.03 INSPECTION
A. At completion of installation, and before planting, inspect overall coverage of system. Demonstrate the working system to the Engineer.

B. Do not cover installed Work before the Engineer has inspected installation. Uncover covered Work at no additional cost to SPU.

C. Completely check system operation within 5 days before Final Inspection. Properly align sprinklers and adjust for coverage. Clear system of foreign materials. Properly adjust valves. Check sprinkler controller valve chart for accuracy.

D. At end of Warranty Period, schedule a Final Inspection of system with the Engineer.

3.04 TESTING
A. Perform tests in presence of the Engineer. Give at least 48 hours advance notice of tests.

B. Hydrostatically test irrigation system pipes as follows:
   1. Leave all system joints, connections, and other fittings exposed until after completion and acceptance of pressure test. All subsequent breaches of integrity of the mainline shall require re-testing.
   2. Mainline pipes: 1 hour at 120 psi. Test will fail if pressure loss is greater than 5 psi during the duration of the test. Ensure means of air release at terminations and bleeding of all trapped air.
   3. Laterals: Test lateral pipes at static water pressure for 30 minutes. Lateral test will include all swing joint assemblies with temporary threaded caps on the downstream Marlex fitting. Wrap caps with 3 wraps of Teflon tape. Ensure means of air release at terminations and bleeding of all trapped air. Test will fail if pressure loss is greater than 5 psi during the duration of the test.
4. Center load pipe with small amount of backfill to prevent arching and movement under pressure. Leave joints exposed for inspection during pressure test. No water is permitted in pipe for pressure testing until a period of at least 24 hours has elapsed for solvent weld setting and curing.

5. Test by capping each outlet, filling pipes with water, and applying pressure with a pump. Measure pressure with a pressure gauge. Immediately correct leaks and retest. No pipe, fitting or joint showing leakage will be accepted. After piping has been tested to satisfaction of the Engineer, backfill pipe trenches.

6. Furnish necessary force pump, pressure gauge and other test equipment necessary for tests.

C. Automatic Irrigation Controller:

1. Test controller for 7 days just before end of the Warranty period. Operate system automatically in manner indicated.

2. Test the electronic operation of the irrigation system after installation. Test will include operation of remote control valves via the controller.

3.05 SYSTEM PROTECTION

A. Deactivate and drain the system prior to the onset of autumn and reactivate at the onset of spring. Coordinate specific dates with the Engineer. Accomplish each at least once during the Warranty Period. If construction is completed when the system is not in use, winterize after testing. Certify by letter the dates of winterization and activation. Repair damage from failure to comply.

B. When using compressed air to winterize the system, do so in short cycles at no more than 40 psi air pressure through quick couplers. Do not allow pipe close to the compressor to get hot to the touch.

3.06 CLEAN UP

A. Upon completion of Work, clean up excess materials, equipment, and rubbish resulting from Work. Leave premises in a clean, neat and orderly condition.

3.07 TRAINING

A. The Contractor shall provide a course on the use, adjustment, and maintenance of the automatic controller and irrigation system within 30 days of Final Inspection. The instructions shall be given in 1 course of one 8-hour session on-site, as arranged by SPU.

B. Approximately 4 maintenance persons will attend the course. The Contractor shall schedule the course through the Engineer at a time convenient to SPU. The Contractor shall notify the Engineer of the proposed course dates at least 6 weeks before those scheduled dates.

END OF SECTION 32 84 00
PART 1 - GENERAL

1.01 SUMMARY

A. Furnish all materials, equipment, labor and related items necessary to complete the work shown on the Drawings and/or as specified in the Specifications. The work included in this Specification (whether mentioned or not) shall consist of all labor, tools, materials, tests, permits and other related items necessary for the provision and installation of all plant materials in a first quality workmanlike manner. Section includes:
   1. Plant Material Installation & Establishment
   2. Seeded Lawn Installation & Establishment
   3. Soil Preparation.
   4. Amendments, Fertilizing, and Mulching.
   5. Root Barrier.
   6. Logs
   7. Earth Anchor System
   8. Landscape Establishment During Warranty Period
   9. Warranty Period

B. Install landscaping using the materials as shown on the Drawings and/or as specified in the Specifications. The landscaping shall be installed to grades and conform to areas and locations as shown on the Drawings.

C. Restore new and existing landscaped areas impacted by construction to existing or improved conditions per Drawings.

1.02 REFERENCES

A. This specification section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this specification section and the listed documents, the requirements of the contract specification sections shall prevail:

1.03 DEFINITIONS

A. Nomenclature for plants and varieties shall be in accordance with the current edition of Hortus Third, The Staff of the L. H. Bailey Hortorium. 1976. MacMillan Publishing Co., New York, or as otherwise defined in the City of Seattle Standard Specifications for Road, Bridge, and Municipal Construction.
B. The term "Contractor" as used in this Specification section shall refer to the Landscape Contractor.

C. Trees, shrubs and groundcovers will hereinafter be collectively referred to as, “plants” or “plant material.”

1.04 PRECONSTRUCTION CONFERENCES

A. Arrange a preconstruction conference at least 14 days prior to start of work. Include the Resident Engineer, Landscape Architect, Contractor, Planting and Irrigation Subcontractor(s), and other Subcontractors involved in the excavation or importation of soil affecting the planting areas.

1. Review the proposed landscape schedule, source of soils and plants, consideration of substitutions, review of specifications, and planting and irrigation procedures.

2. Provide meeting notes for approval by Resident Engineer.

B. An earth anchor system preconstruction conference shall be held at least 5 working days prior to the Contractor beginning any earth anchor system Work at the site to discuss construction procedures, personnel, and equipment to be used. The materials will also be discussed.

1. Those attending shall include:
   a. (representing the Contractor) The superintendent, on site supervisors, and all foremen in charge of installing and testing the earth anchor system.
   b. (representing the Contracting Agency) The Project Engineer and key inspection personnel.

2. If the Contractor’s key personnel change, or if the Contractor proposes a significant revision of the approved earth anchor system plan, an additional conference shall be held before any additional earth anchor system operations are performed.

1.05 SUBMITTALS

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.

1. Plant Material Documentation:
   a. Within thirty (30) calendar days after award of a Contract, submit written documentation to the Engineer that all specified plant materials have been ordered. Should the Contractor neglect to provide this documentation within the allocated time, Contractor may forfeit any substitution benefits.
   b. List plant suppliers’ names, addresses, and phone numbers.
   c. List respective growing or storage locations with addresses.

C. Tree, Vegetation and Soil Protection Plan (TVSPP) per City of Seattle (COS) Standard Specification 8-01.3(2)B and 8-01.3(3).

E. Supplier Certifications for Soil, Amendments, Compost, Bark Mulch, Root Barrier, and Steel Edging.

F. Watering Schedule: Prior to final acceptance of the Landscaping, the Contractor shall submit a written "watering schedule" to SPU, coordinated with the Irrigation Contractor, to ensure adequate watering (summer, fall, winter & spring) of all plant materials during the Warranty Period of this Contract.

G. Weed and Pest Control Plan.

H. Earth Anchor System submittals

1. The Contractor shall submit a Working Drawing consisting of a detailed description of the construction procedure proposed for use.

2. The Contractor shall submit a Working Drawing consisting of shop plans for the tipping-plate anchor.

3. The Contractor shall submit Working Drawings consisting of the method proposed to be followed for the earth anchor system testing.

1.06 QUALITY ASSURANCE

A. All work shall be performed by a licensed and bonded Landscape Contractor registered in the State of Washington and shall be qualified for landscaping work through certification by the Washington Association of Landscape Professionals (WALP) or by the Washington State Nursery and Landscape Association (WSNLA).

B. Contractor must be experienced in landscape work of best-accepted trade practices and have equipment and personnel adequate to perform the work specified, including at least 3 years of experience installing planting and plant establishment.

C. Contractor must be familiar and comply with American Standard for Nursery Stock published by the American Landscape & Nursery Association.

D. The Contractor shall continuously maintain a competent superintendent or foreman during the progress of the work, with the authority to act for the Contractor in all matters pertaining to the landscape work.

E. The Contractor shall progressively clean the work site of debris and rubbish as the landscape work proceeds.

F. Site Inspections will be made by the Engineer. The Contractor shall request inspection at least 24 hours in advance of the time inspection is required. Inspections for the following critical path items will be required:

1. When subgrade has been established and scarification completed.

2. During soil preparation and soil installation activities.

3. Finish grading prior to any planting.

4. Inspection of plant materials before planting.

5. Layout of plant material.

6. Tree planting and proper staking.

7. Installation of mulch.
8. For Substantial Completion of all work (development of physical punch list items).
9. For Physical Completion of all work (physical punch list items satisfactorily completed).
10. Quarterly reviews of maintenance, plant establishment during the one-year Warranty Period.
11. Final Acceptance of all work at the completion of the Warranty Period.

1.07 PERFORMANCE REQUIREMENTS
A. Before proceeding with any work, the Contractor shall inspect the site, carefully check all grades and verify all dimensions and conditions affecting the work.
B. Existing known utilities have been shown on Drawings and will be made available from SPU or the Utility Companies. The Contractor shall be responsible for the protection of known utilities. Promptly notify the Engineer of any conflict between proposed work and obstruction(s). Failure to follow this procedure places upon the Contractor the responsibility and expense of making any and all repairs for damage from work therefrom.
C. In the event that undisclosed boulders, soils contaminated with toxic substances, hardpan, or underground construction work and/or obstructions are encountered in any plant excavation work to be done under this contract, alternate planting locations may be selected by the Engineer. Where alternate planting locations are not approved, the obstruction shall be removed to a depth of not less than three (3) feet below the bottom of ball or roots when plant is properly set at the required grade or other solutions to the planting problem will be reviewed with SPU. The Contractor shall be paid for work required to solve the planting problem, such as, the removal of such rock, contaminated soils, hardpan or underground obstruction encountered at a unit price basis and agreed upon by a Change Order prior to commencement of work.
D. Confine work to designated areas. Do not disturb existing vegetation outside project limits and protect all trees, shrubs and groundcovers within project limits not designated to be removed. Do not permit vehicular traffic or materials storage under or around new or existing trees.

1.08 PROTECTION OF WORK, PROPERTY AND PERSONS
A. Take all necessary precautions to protect work in progress, all property, persons, walks, curbs, utilities, pavement, and buildings from any damage that might be incurred arising from this Contract. The Contractor shall pay for any damage incurred by failure to take precautions at the Contractor's expense.
B. Protect all paved surfaces (permeable and impermeable) from staining or clogging by planting soil and mulch. Do not remove protection until after initial acceptance of all work.
1.09 **WARRANTY PERIOD**

A. **Warranty Period** shall be for 365 days after the Physical Completion date.

B. **Guarantee work of this specification section against all defects of materials and workmanship, and plant material to remain alive and be in a healthy, vigorous condition. Replace plants and seeded areas not in normal healthy growing condition at the end of the warranty period. This includes dead or missing plants and plants stolen or damaged by the acts of others. Replace with plants with identical species and size. The cost of such replacement(s) is at the Contractor's expense.**

C. Any plant material that is twenty-five (25) percent or more dead or disfigured shall be considered dead and must be replaced at no charge. A tree shall be considered dead when the main leader has died back or when twenty-five (25) percent of the canopy is dead. Plants shall be considered disfigured when excessive dead wood has been removed or when the symmetry, typical habit of growth, or sculptural form has been compromised by the removal of the dead wood.

D. All plants are subject to one (1) replacement per item during the warranty period, and the Contractor shall submit, after each replacement, a marked planting plan showing the exact location of each item replaced and the date when the replacement was made. SPU may require the contractor to replace dead plants prior to the end of the warranty period at no additional cost. This applies only after the date of physical completion.

E. Contractor has the right to enter upon the property for inspection, maintenance, and curative treatment of any plants and materials needing such, and which are still under warranty during the entire warranty period. SPU is to be notified in advance of any inspection, maintenance, corrective treatment measures, or curative treatment measures so as to arrange for approved, security clearance (if applicable) and convenient access to the area.

F. The above warranty shall be applicable to any growing conditions through which plants of like kind could be expected to survive and any deformity or cause of death which could be attributed to, or affected by, the physiological condition of the plant shall be deemed replaceable cause. However, this would not apply to plant losses due to:

1. Extreme weather conditions such as wildfires, floods, freezing rain, excessive wind damage (with recorded wind speeds greater than 60 MPH), drought, winter kill caused by extreme cold and severe winter conditions not typical of planting area, or abnormal rains, as determined by the National Weather Service.


G. Inspection: Plants and lawn areas will be inspected quarterly by SPU during the warranty period. Should SPU determine that the Contractor is not providing regular adequate and proper care of plant material and lawns or is performing unacceptable work, SPU will provide written notice to the Contractor to correct and remedy unacceptable work or practice(s). The Contractor shall reply to SPU within seven (7) Days of the date of written notice with proposed corrections. Such corrective measures shall occur within fourteen (14) Days after the date of written notice unless SPU agrees otherwise.
H. Approximately fifteen (15) Days before the end of the warranty period, the Contractor shall request a final site inspection by SPU. Conditions found unacceptable by SPU shall be corrected by the Contractor within a ten (10)-Day period immediately following the inspection. After correction, the Contractor shall notify SPU for a re-inspection. Corrective Work shall include replacement of dead, missing, or unacceptable plant material; weeding; pick-up of all litter; and repair and/or readjustment of the irrigation system. Necessary replanting shall be arranged by SPU in accordance with the best planting time of the year.

I. Final Transfer of Maintenance to SPU, or other Owner(s): When all maintenance and warranty items are completed and Final Acceptance provided, Contractor shall provide a memorandum to SPU, formally transferring the landscape maintenance to SPU’s Operations & Maintenance Division, or other Owner(s).

J. Final Acceptance:
   1. Acceptance of seeded lawn areas as specified herein shall be based on a healthy, full, vigorously growing, and well-manicured stand of grass at the end of the warranty period. Areas that are bare, have a poor stand of vegetation, are dead or dying, have weeds, or have a spotty or non-uniform grade through any cause shall be remedied by regrading, removing and reseeding, removing, and rewatering, as appropriate.
   2. Acceptance of Plant Material. Final Acceptance of all planting work described in this Specification section, shall be made by the Engineer to determine one hundred (100%) percent completion of the Contract work as specified herein.
   3. Final Acceptance of the landscaping will be certified in writing by SPU at the end of the Warranty Period.

1.10 LANDSCAPE ESTABLISHMENT DURING WARRANTY PERIOD

A. General: It is expressly understood that the Contractor will be responsible, during the Warranty Period, for normal landscape establishment of the project. The landscape establishment shall include, but not be limited to, regularly scheduled watering, mowing, weeding, monitoring and treating any disease and/or pest-problems, cultivating and any other proper care according to best practices according to Seattle Parks Best Management practices, to keep the plants in a normal healthy growing condition.

B. Once all other Work is physically complete, Contract Time will not be assessed for the landscape establishment work during the Warranty Period. No supplemental Contract for the landscape establishment work during the warranty period.

C. Weed Control Plan: The Contractor shall maintain all areas, whether mulched or not, in a weed-free condition during the Warranty Period. Removal shall be by mechanical control methods unless alternatives are approved by SPU in writing. At least five (5) working days before the beginning of the landscape establishment work, the Contractor shall submit a weed control plan for approval by SPU. The weed control plan shall identify the means, manner, methods, and timing intervals to assure weed control throughout the warranty period. This control plan will be subject to revision dependent on results of the implemented plan.

D. Pest Control: Pesticides should be used as last resort only. If the Contractor chooses to use them, a formal request must be submitted to SPU on a SPU Chemical Use Request Form for approval. For application of pesticides, see Seattle Parks Department Best Management Practices.
E. Watering Schedule:

1. The Contractor shall water plants as needed to promote healthy and vigorous growth.

2. For hand watered trees, fifteen (15) gallons shall be applied per tree per watering on a three (3) Day schedule. Slow release watering bag must be installed and maintained per the manufacturer’s recommendations for efficient hand watering of trees during the growing season. Use a single-bag installation for 1-inch to 3-inch caliper trees. Remove all sharp objects from the irrigated area before installation. Place the slow release water bags on top of mulch, not directly on soil. Place each bag around the tree trunk with the zippers on the uphill side of the trees. Wrap both sides of bag until zippers meet and zip together from bottom to top. Lift tag to expose fill opening at top of bag. Fill bag to 1/4 capacity. Gently lift up on straps at top of bag to expand bottom. Fill the bag to desired level and let empty. Fill 1-2 times per week during the growing season during the Landscape Establishment period, frequency based on adequate soil moisture to support root growth and tree vigor.

3. Automatic irrigation systems shall be operated fully automatic during the warranty period, shall operate during the time period of 2:00AM to 5:00AM, and shall be coordinated with all work in this specification. Change in the established watering schedule may be required to accommodate weather, seasonal factors, and as necessary; however, the Contractor shall provide at least three (3) Working Days advance notice of such proposed change, including the reasoning for the proposed change.

4. The contractor shall monitor watering to ensure compliance with the Tree, Vegetation and Soil Protection Plan (TVSPP) see Section 8-01 of the City of Seattle Standard Specifications.

F. Mowing Schedule: The Contractor shall submit at least five (5) Working Days in advance, the proposed mowing schedule to SPU. Lawn Establishment shall be per Standard Specification 8-02.3(15).

G. Bark Mulch: Mulch topdressing shall be applied to the required thickness and shall be maintained by applying additional topdressing of mulch when needed to maintain the specified depth.

H. Fastenings: Tree fastenings shall be kept intact and effective in maintaining firm support for plants. Fastenings shall be adjusted as needed by the Contractor to prevent tree trunk strangulation and non-plumb growth of the leader. Fastenings and stakes shall be removed at the completion of the warranty period. Reusable, doweled wood stakes shall remain the property of SPU and arrangements shall be made by the Contractor to provide for their delivery to an SPU storage facility identified by SPU.
I. **Seed Establishment**: Seed establishment shall consist of providing adequate and proper care for all seeded areas installed within the limits of the project. The seed establishment period shall begin upon physical completion by SPU based upon both a uniform stand of grass and upon completion of the third mowing for seeded lawn areas. During the warranty period, the Contractor shall ensure the continuing healthy growth of the seeded areas. Adequate and proper care shall include the labor, materials, and equipment necessary to keep installed seed in a presentable condition including, but not limited to, watering, mowing, trimming, cutting with an acceptable mulching mower, litter and debris removal, edging, weed control, repair and reseeding of damaged seeded areas. Mowing shall meet requirements as specified herein.

J. **General Cleanup**: A general cleanup shall be made after any landscape establishment work. The Contractor shall remove all litter, to provide a clean appearance at the time of inspections.

1.11 **PLANT REPLACEMENT**

A. The Contractor shall be responsible for providing enough plants for replacement of unacceptable plant material through the warranty period.

B. Plant material replacements made by the Contractor shall be completed during the spring (March 15 to May 15) or autumn planting periods (Sept 20 to Nov 15) and shall be subject to the same conditions and shall be made in the same manner as specified for the original planting, and shall be done at no extra cost to SPU.

C. Make replacements within seven (7) days of notification from SPU. Remove dead plants within two (2) days of notification and mark planting plan showing the exact location of replaced plants.

D. All replacement plants shall be of the same species, caliper, and/or equal size as the plants they replace, and shall be healthy and vigorous, unless SPU determines a substitute plant of equal value may be provided.

E. Scheduling of plant replacement during Warranty Period shall be coordinated with SPU.

**PART 2 - PRODUCTS**

2.01 **PLANTING SOIL**


2.02 **SEEDED LAWN AREA SOIL**

A. Soil for all seeded areas must be General Turf Area Soil mix, components shall be per COS Standard Specification 9-14.1(1), 9-14.1(6).

2.03 **COMPOST**


2.04 **LIME**

A. Agricultural lime must be per COS Standard Specification 9-14.3(2).

2.05 **BARK MULCH**

A. Bark Mulch: must be per COS Standard Specifications 8-01.3 (6)D and 9-14.4(3).
2.06 **ARBORIST WOOD CHIP MULCH**
A. Arborist Wood Chip Mulch: must be per COS Standard Specifications 9-14.(4).

2.07 **CEDAR MULCH**
A. Cedar Wood Chip Mulch: 2-1/2” cedar chips.

2.08 **PLANT MATERIAL**
A. Plant Material Quality:
   1. All plant material furnished by the Contractor shall conform to the requirements of the current issue of “American Standard for Nursery Stock” and in addition, shall comply with the following provisions:
      a. All plant material shall meet State and Federal requirements with respect to plant health and absence of diseases and insect infestation. Inspection certificates required by law shall accompany each shipment of plant material and shall be filed with SPU prior to planting.
      b. All plant material specified shall be first-class representatives of their normal species or varieties in healthy growing condition with normal well-developed branch system and vigorous root systems. They shall be free from disease and insect infestation, disfiguring knots, sun-scalds, abrasions of the bark, broken tops, broken branches, torn roots, and any other objectionable features. They shall not have weeds at the tops of rootballs or any foreign plant growth.
      c. Large plants cut back to meet specified sizes will not be accepted.
      d. All plants shall be nursery grown stock that has been held in a nursery for at least one year.
      e. Trees shall be self-supporting, with straight trunks and with single straight leaders. Trees having damaged or missing leader, multiple leaders, or “Y” crotches will be rejected. The canopy shall be full. Trees shall not be pruned within six (6) months prior to delivery.
      f. Plants shall not have cuts or pruning wounds over 3/4-inch diameter that are not satisfactorily callusing over.
      g. Plants furnished in pots or other containers shall be acclimated to outside conditions and equal to field grown stock. To acclimatize plants to Northwest conditions, all plants used on the project shall be grown continuously outdoors north of the 42nd Latitude (Oregon-California border) from not later than April 1 of the year prior to the time of planting.
      h. Root balls of plant materials shall be solidly held together by a fibrous root system and shall be composed only of the soil in which the plant has been actually growing. The ball shall be securely wrapped with non-treated, jute burlap, or other packing material that is not injurious to the plant’s life.
i. Trees shall have been grown with sufficient spacing to allow for symmetrical branch development which reflects the natural characteristics of the species. Tree trunks shall not be noticeably imperfect in vertical alignment, have straight leaders, and there shall be no “included bark” in the crotches between the trunk and side branches. Dig balled and burlapped trees with firm, natural balls of earth of sufficient diameter and depth to encompass the fibrous and absorbing tree root system necessary for full recovery of the plant. Provide tree root ball sizes complying with the latest edition of the ASNS. Cracked or mushroomed balls are not acceptable.

j. Container grown plants shall be plants transplanted into a container and grown in that container sufficiently long enough, for new fibrous roots to have developed and so that the root mass retains its shape and holds together, when the root mass is removed from the container. Plant material which is root bound will be rejected.

k. Container sizes for plant material of a larger grade than provided for, in the container grown specifications of the ASNS, shall be determined by the volume of the root ball specified in the ASNS for the same size plant material.

l. Average height to spread proportions and branching shall be in accordance with the applicable sections, illustrations, and accompanying notes of the ASNS.

m. Plants, which have suffered damage as the result of girdling of the roots, stem, or a major branch; have deformities of the stem or major branches; have a lack of symmetry; have dead or defoliated tops or branches; or have any defect, injury, or condition which renders the plant unsuitable for its intended use, will be rejected.

B. Shipping and Handling:

1. All plants shall be dug with care. The root system of all plants shall not be permitted to dry out at any time.

2. Evergreen and deciduous trees shall be furnished balled and burlapped (B&B) unless otherwise specified in the Contract. Broken or “made” root balls will not be accepted. Balled and burlapped trees shall be handled by the ball of earth and not the plant.

3. All container grown plants shall be handled by the container. Unless otherwise specified in the Contract, plants may be supplied in suitable containers acceptable to SPU should the Contractor so desire. Container grown plants shall be well-developed to hold the earth intact after removal from the container without being root bound.

4. Balled and burlapped trees wrapped in treated or synthetic material shall have all wrapping material removed from the tree at the time of planting. Balled and burlapped trees with wire or other material reinforcement of the burlap material shall have all wire or other reinforcement material removed at the time of planting. In all cases, the entire rootball shall have all wrapping material of any kind cut away and completely removed from the root ball and planting hole before planting the tree.
5. Plants shall be packed for shipment in accordance with prevailing practice for the type of plant being shipped, and shall be protected at all times against drying, sun, wind, heat, freezing, and similar detrimental conditions both during shipment and during related handling. Where necessary, plants shall be temporarily heeled in. When transported in closed vehicles, plants shall receive adequate ventilation. When transported in open vehicles, plants shall be protected by tarpaulins or other suitable cover material.

2.09 PLANT TAGS
A. Plant tags shall be per COS Standard Specification 9-14.6(4).

2.10 PLANT INSPECTION
A. The Contractor shall, as soon as practical, inform the Engineer as to the source of plant materials for the project (See Section 1-06.1 of the COS Standard Specifications.) The Contractor shall notify the Engineer not less than 48 hours in advance of delivery of plants from the nursery.
   1. All trees will also be inspected by the Engineer at the project site prior to planting.
   2. Root condition of plants furnished in containers shall be determined by removal of the plant from the container. Plants not meeting the requirements herein specified shall be immediately removed from the Project and replaced by the Contractor at the Contractor’s sole expense.
   3. Plant material delivered, inspected and approved for planting shall be planted immediately. Plants not immediately planted by the Contractor may be temporarily stored per the COS Standard Specification 9-14.6(7) TEMPORARY STORAGE after receiving approval from the Engineer.
B. The Contractor has three (3) options to secure approval of plant materials:
   1. Submit plant samples to the Engineer’s office or have samples available at the project site for review during scheduled site visits.
   2. Submit color photographs of representative specimens of each type of tree and shrub on the plant list. Photos shall be 3 x 5 inches, taken from an angle that depicts the size and condition of the typical plant to be furnished. A scale rod or other measuring devise shall be included in the photograph. For species where more than 20 plants are required, include a minimum of three photos that show the average plant, the best quality plant, and the worst quality plant to be provided. Label each photograph with the plant name, plant size, and name of the growing nursery.
   3. Have Engineer review plants at the place of growth at the Contractor’s expense.

2.11 SUBSTITUTION OF PLANTS
A. No substitution of plant material, species or variety, will be permitted unless evidence is submitted in writing to the Engineer that a specified plant cannot be obtained and has been unobtainable since the Award of the Contract. If substitution is permitted, it can be made only with written approval by the Engineer per COS Standard Specification Section 1-05.3(6)D. The nearest variety, size, and grade as approved by SPU shall then be furnished.
2.12 **TREE STAKES AND FASTENING**
A. Stakes shall be 8-foot long 2-inch diameter pressure-treated lodgepole pine wood stakes, with chamfered tops and 6-inch long conical points. The stakes shall be installed as shown in the Drawings.
B. Fastening shall be webbed fabric tape, ½” – 1” wide, “Arbor Tie” or approved equal.

2.13 **AMENDMENTS AND FERTILIZERS**
A. General
   1. Shall be complete commercial brand fertilizer and/or amendments with chemical analysis shown on unopened container when delivered. Deliver fertilizer materials in original, unopened, and undamaged containers showing weight, analysis, and name of manufacturer. The Contractor shall store fertilizer and/or amendments in such a manner as to prevent wetting and deterioration.
   2. Commercial fertilizer and/or amendments for trees, shrubs, groundcover, shall meet soil laboratory recommendations.
   3. Fertilizer and amendments shall be approved prior to application.
B. Seeded Lawn Areas Starter Fertilizer shall be ‘Starter Feed’ (7-7-2) 100% Organic Fertilizer, as manufactured by Walt’s Organic Fertilizer Co. or approved equal.
C. Seeded Areas Follow-Up Fertilizer shall be ‘Regular Feed’ (9-3-5), and shall be 100% Organic Fertilizer as manufactured by Walt’s Organic Fertilizer Co., or approved equal.

2.14 **ROOT BARRIER**
A. Root barrier shall be made of copolymer polypropylene, containing 50% post-consumer recycled plastic.
B. Root barrier panels shall be .08” thick and twenty-four (24) inch high/deep.
C. In locations as shown on the plans and details, root barrier material shall be installed at 24-inch-deep, interlocking reinforced polypropylene panels, or approved equal.
   Recommended sources for root barriers are as follows:
   4. Or approved equal.
2.15 SEED
A. A complete analysis of the seed shall be submitted to the Engineer, including percent of pure seed, germination, other crop seed, inert and weeds, and the germination test data. The seed mixture shall be no less than 98% pure, have a minimum germination rate of 90%, contain more than ½% weed seed, and contain less than 1.5% inert material. All crop seed in excess of one (1) percent must be itemized. Provide a complete copy of manufacturer’s container label or seed technical data with the seed analysis for each seed mix specified.

B. Seed of the type specified shall conform to the standards for “Certified grade seed or better as outlined by the State of Washington Department of Agriculture “Rules for Seed Certification.”

C. All seed mixes shall be free of weed seed listed as primary noxious by the Washington State Seed Law singly or collectively in excess of the labeling tolerance specified by the Washington State Seed Law. Reference Specification; Chapter 15.49, Washington State Seed Act.

D. Seed shall be packed in clean, sound containers of uniform weight. Deliver mixed seed to the project site in the original, unopened containers bearing the manufacturer’s guaranteed analysis, manufacturer’s name, trademark, and conformance with law.

E. Containers shall show the following information clearly marked for each kind of seed in accordance with applicable state and federal law:
   1. Common name of seed and its strain.
   2. Lot number.
   4. Percentage of purity.
   5. Percentage of germination.
   6. Percentage of weed seed content and inert material.
   7. Place of origin.
   8. Amount of Pure Live Seed per bag.

F. Seeded Lawn Mix
   1. Seeded Lawn mix must be composed of the following, by weight:
      a. 50% Turf-type Perennial Ryegrasses (2 or more varieties). Turf-type Perennial Ryegrass varieties shall be from those varieties ranked “Best” by the most current succeeding year’s WSU “Turfgrass Cultivars Evaluated in Western Washington/Oregon in Recent Years” list.
      b. 30% Chewings Fescue.
      c. 20% Hard Fescue.

2.16 TACKIFIER
A. Tackifier shall be per COS Standard Specifications 9-14.4(7).

2.17 WOOD CELLULOSE FIBER MULCH
A. Wood Cellulose Fiber Mulch shall be per COS Standard Specifications 9-14.4(2).
2.18 **EROSION CONTROL BLANKET**

A. The biodegradable erosion control blanket shall be 100% coir and shall biodegrade within a life span not less than two years. The blanket Mass per Unit Area as tested by ASTM D6475 shall be a minimum 38 oz./sq. yd. 100% coir fiber woven fabric rolls for use in slope stabilization applications shall be furnished in rolled strips approximately 50 yards in length. Fabric width shall be 14 feet.

1. Weight: 900 grams
2. Thickness: 338.30 mm
3. Open area: 38%
4. Dry ultimate strength: 164.0 lbs/in in roll machine direction, 66.3 lbs/in in cross machine direction
5. Wet ultimate strength: 124.40 lbs/in in roll machine direction, 60.30 lbs/in in cross machine direction.

2.19 **LOGS**

A. Logs shall be in compliance with COS Standard Specification 9-14.15 and length of each log and species shall be per drawing. Logs must taper no more than 1” diameter per 10’ of length. Any logs found to be defective must be removed from the Project Site and replaced at no cost to the Owner.

2.20 **EARTH ANCHOR SYSTEM**

A. Materials required include a tipping-plate anchor and all rods, devices, couplers and hardware as detailed in plans.

B. The Contractor shall select the type of earth anchor system and the installation method as detailed in plans. The Contractor shall install the earth anchor system to withstand the load indicated in the Plans and verified by tests specified in this section.

**PART 3 - EXECUTION**

3.01 **GENERAL**

A. The Contractor shall protect soil in compliance with the Tree, Vegetation, and Soil Protection Plan (TSVPP) per COS Standard Specification 8-01.3(2)B and shall provide adequate and proper care of all plant material (both retained and newly installed) and landscape work, including irrigation, done on the project from the time of installation to the end of the warranty period.

B. Care should be taken to avoid damage to existing trees and their roots. Where excavating for new construction is required within tree and plant protection areas, excavate by hand to minimize damage to roots and perform as follows:

1. Use narrow tine spading forks and comb soil to expose roots.
2. If main lateral roots are immediately adjacent to location of new construction, the contractor shall notify SPU prior to any excavation.
3. Do not allow exposed roots to dry out.
4. Provide temporary minimum four (4) inch depth of mulch, or equivalent.
5. Maintain in moist condition until covered with planting soil or mulch.
3.02 INVASIVE SPECIES REMOVAL

A. Invasive plant species shall be completely removed from all areas within the construction limit-of-work. Removal and disposal techniques shall comply with Seattle Parks and Recreation Best Management Practices, Chapter 5 referencing the “King County Noxious Weed Program” for individual species.

B. Invasive plant species include, but are not limited to reed canary grass, English Ivy, Himalayan blackberry, evergreen blackberry, butterfly bush, scotch broom, policeman’s helmet, bamboo, yellow flag iris, and Japanese knotweed. The Contractor shall have on-site current copies of the King County Noxious Weed list.

C. Any Japanese Knotweed found on-site shall be stem injected according to Seattle Parks and Recreation Best Management Practices after issuance of contract but prior to initial site excavation and grading. Timing of stem injection shall be determined in consultation with Engineer, but should occur within a minimum of three (3) weeks prior to excavation activities including clearing, grubbing, and mechanical removal of invasive plants.

3.03 SUBGRADE PREPARATION

A. It shall be the Contractor’s responsibility to verify the existence of proper subgrade elevations prior to beginning subgrade preparation work. All areas shall allow for planting soil and mulch to be added to individual planting areas as specified herein. All grades shall flow smoothly into one another and produce positive stormwater drainage. The Contractor is responsible for any adverse drainage conditions that may affect plant growth unless the Contractor contacts the Engineer immediately, indicating any possible problem. Verify all grades with Engineer before commencement of planting.

B. Areas to receive plant material shall be cleared, grubbed, cultivated and graded to accommodate the Work prior to planting and to provide the optimum conditions for plant and seed establishment and growth. Weed clearing shall be by nonchemical methods unless the Contract specifies otherwise, or the Contractor requests and receives approval from SPU to apply pesticide as specified.

C. Prior to installing planting soil, and seed area soil, a percolation test shall be performed. This shall be accomplished by excavating three (3) pits that are two (2) feet in depth and minimum two (2) feet in diameter. Location of all three (3) pits shall be per Engineer field directive. Fill each pit with water and allow the pit to drain for twenty-four (24) hours.

D. After twenty-four (24) hours, re-fill the pit with water. If the time required for the pit to drain completely after being filled the second time is greater than twenty-four (24) hours, the Contractor shall notify the Engineer immediately. The Contractor shall be paid for work required to solve the drainage problem, such as, installation of french drains or drainage sumps at a unit price basis and agreed upon by a Change Order prior to commencement of work.

E. Preparation of Sub-grade: Subgrade shall be cleaned of all debris including concrete, stumps, sticks, roots, and rocks or lumps larger than one (1) inch. Scarification process shall be observed and approved by the Engineer prior to installing amendments and soil. Sub-grade elevations shall be as shown on Drawings.

F. It shall be the Contractor’s responsibility to verify a weed and pest free subgrade prior to beginning subgrade preparation work.

G. Subgrade preparation shall be reviewed and approved by the Engineer prior to proceeding with the placing of planting soil.
H. Placing of planting, seed area soil shall constitute acceptance of subgrade conditions by Contractor.

3.04 SOIL PREPARATION

A. General

1. Soil shall not be placed or worked when the ground or planting soil is frozen, excessively wet, there is ponding water, or, in the opinion of the Engineer, in a condition detrimental to the Work.

2. Incorporation of amendments in response to soil test recommendations and placing of soils shall result in a homogeneous blend to a minimum depth as shown on the details. The Contractor shall apply and shape the lifts in such a manner that the planting area has a continuously sloped final surface allowing for drainage from higher elevations to lower outer edges of the planting area. Where possible, ridges and ridge lines shall be the approximate center point, or centerline(s), of the planting area.

B. Placing Soil and Soil Amendments:

1. For Seeded Areas:
   a. Install seeded lawn area soil to 8” minimum depth.
   b. Apply and mix amendments with a small excavator; do not use a rototiller. Compact by hand or one pass of a motorized tamper. Compact each lift of seed area soil before installing the additional lift of soil. SPU’s Engineer shall review and approve soil preparation work between steps.
   c. Incorporate the following soil amendments by broadcasting over seed area soil at an even distribution and rate prior to placement of seed. Then, rake the amendments into the top two (2) inches of soil.
   d. Dolomite Lime. If required by the soil laboratory recommendations. Recommended application rate: Incorporate fifty (50) pounds of Dolomite Lime per 1,000 square feet in direct broadcast application.
   e. Seeded Areas Starter Fertilizer (7-7-2). Recommended application rate: Incorporate one (1) pound of starter fertilizer per 1,000 square feet in direct broadcast application.
   f. Finish grades shall be rolled with a standard, water filled, 200 pounds per square foot ground pressure roller. If soil is dry, lightly sprinkle with water prior to rolling. The seed area shall be rolled, and raked in two directions, the second rolling at right angles to the first. Grades after rolling shall be flat and approved by the Engineer prior to seeding.

2. For Landscape Planting Areas:
   a. Install planting soil to the following depths:
      1) Trees – Minimum 24” depth and twice the diameter of the rootball around each tree.
      2) Shrubs & groundcovers – Minimum 18” depth.
b. Apply and mix amendments with a small excavator; do not use a rototiller. Compact each lift of planting soil before installing the additional lift of soil. Compact by hand or one pass of a motorized tamper. SPU’s Engineer shall review and approve soil preparation work between steps.

c. Incorporate soil amendments by broadcasting over planting soil at an even distribution and rate prior to installation of plants. Then, mix the amendments into the top six (6) inches of planting soil.

d. Soil amendments for planting areas shall be applied per soil testing laboratory recommendations. The soil amendments shall be thoroughly mixed with soils to produce a broadly-mixed blend at rates per soil laboratory recommendations. All amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer’s name and guaranteed components analysis. In lieu of containers, amendments may be furnished in bulk, with a Manufacturer's Certificate of Compliance indicating the components analysis complies with the Contract.

C. Finish Grading

1. After installing soils and amendments, drag to an even grade, remove debris and rocks larger than one (1) inch in diameter that appear at the surface, and then roll for firmness prior to planting.

2. Rake and roll two (2) times for smooth finish grade prior to seeding or planting.

3. Finish grade is defined as the top surface of soil prior to the installation of mulch and seed unless otherwise noted on the Drawings.

4. Finish grading shall consist of placing, grading and lightly rolling soil, providing for surface drainage, cutting all necessary drainage swales and generally conforming to finish grades shown on the Drawings and as directed by the Engineer.

5. Compact finish grade of planting and seed areas to eighty-five (85) percent of maximum dry density as determined by ASTM: D 1557.

6. After settling, finish grades in seed areas shall be a half (1/2) inch below all walks, curbs and/or other hard surfaces.

7. After settling, finish grades in planting areas shall be three (3) inches below all walks, curbs, and/or other hard surface edges.

8. All planting areas shall be finish graded and accepted by the Engineer before commencement of planting, preferably at time of staking and layout.

9. The grade of planting areas after bark mulch top dressing is placed shall flush with the finished grade of any paved surface improvement such as sidewalk, curb, and other pedestrian walking area.

3.05 MOVING PLANT MATERIAL

A. Transport all plants carefully. Prevent damage to all plant materials. Do not drag plant material without proper root and branch protection.

B. Tie branches on trees and large shrubs as necessary. Use burlap bags to protect tree bark from rope chafing.
3.06 TEMPORARY STORAGE OF PLANT MATERIAL

A. Plants that cannot be planted within one (1) day after arrival to the project site shall be “heeled-in” in accordance with accepted horticultural practice and the following requirements:

1. Protect rootball of balled and burlapped plants with moist earth, sawdust or other acceptable material. Do not use straw or hay to retain moisture.

2. Protect plant materials at all times from extreme weather conditions.

3. Protect plant materials from mechanical damage, wind, excessive sun, and drying out. If planting is delayed more than four (4) hours after delivery, set plants in shade and keep roots moist by covering with mulch, soil or other acceptable means of retaining moisture.

4. Transport plants in enclosed trucks. Large trees shall be totally wrapped to prevent damage and windburn. Provides adequate protection so that trunks are not scarred in transport and branches are not broken. Tree trunks shall be wrapped with protective covering prior to handling and loading. Covering shall be removed at the time of plant materials inspection at the job site.

3.07 PLANT LAYOUT

A. Plants shall be placed at spacing and locations as indicated in the Contract. Location layout and staking shall be the responsibility of the Contractor, subject to the approval of SPU, before planting or construction of each item begins.

B. The Contractor shall notify SPU at least five (5) Working Days in advance of projected completion of staking and allow two (2) Working Days after the projected completion date for review and any adjustments of the layout by SPU. The Contractor shall sequence the installation of plants to minimize disturbance to new plants and existing landscaping, and to comply with the TVSPP, per COS Standard Specifications 8-01.

C. All plant material shall be inspected and determined by the Engineer to be acceptable for planting, prior to installing.

3.08 PLANT INSTALLATION

A. General:

1. Plants brought to the planting site shall be, balled and burlapped, or in containers, depending on how specified in the planting schedule in the Contract for the particular type of planting material. Plants shall not be planted during freezing weather or when the ground is frozen. Plants shall not be planted during excessively wet conditions. Do not install plants when ambient temperatures may drop below 40 degrees Fahrenheit or rise above 80 degrees Fahrenheit. Do not install plants when wind velocity exceeds 30 MPH. Plants shall not be placed in areas that are below finished grade.

2. Dates to plant: Planting shall be performed during the period between March 15th and May 15th. Planting at other times shall only be done by written permission by the Engineer and only if an automatic irrigation system is available.

3. If groundwater is encountered upon excavation of planting holes, the Contractor shall promptly notify SPU.
4. Plants shall be removed from containers in a manner that prevents damage to the root system. Containers may require vertical cuts down the full depth of the container to accommodate removal. All circling roots shall be loosened to ensure natural directional growth after planting.

B. Trees:

1. The Contractor shall provide SPU a minimum four (4) Working Days advance notice of the first tree(s) to be planted. SPU shall be present to approve the planting method of the first tree(s). The approved method shall be consistently applied for all remaining planting of trees.

2. Tree planting holes shall be excavated per details on drawings and to a depth one (1) inch less than to the depth of the rootball. Tree pit excavation near a curb or sidewalk shall allow a horizontal clearance of at least three (3) inches from the curb or sidewalk without undermining foundation support of adjacent improvements.

3. Before planting, completely remove all twine, burlap, wrapping material, fabric grow bags, and wire baskets and completely remove material from the planting hole. All containers shall be removed from rootballs before planting. Containers may require vertical cuts down the full depth of the container to accommodate removal. For ball and burlap and container trees, roots showing at the edge of the root ball shall be loosened without tearing. The rootball shall be placed in the planting pit in a manner that ensures the roots are properly spread for lateral directional growth.

4. Set trees in the planting pit to proper grade and alignment. Set trees upright, plumb, and faced to give the best appearance or relationship to each other or adjacent structure. Set crown of rootball up to one (1) inch above the finish grade elevation, unless otherwise noted in drawings.

5. Backfill shall be carefully placed and compacted by water settling. When planting hole is 3/4 backfilled, apply water to water settle the backfill and remove voids. If settling occurs, the Contractor shall add enough soil to cover the roots but shall not rework the soil. Do not use frozen or muddy mixtures for backfilling. No soil filling will be permitted against trunks or stems or above grafts on grafted trees. Form a watering ring of soil around the edge of each planting pit to retain water.

6. Three (3) inches of mulch shall then be added to top dress the entire tree pit including the watering ring, with the depth tapered at the tree to prevent contact at the trunk. Ensure that planting soil is moist before installing mulch. Do not install mulch on top of dry planting soil.

C. Shrubs and Groundcovers:

1. Planting holes for shrub and groundcover plants shall be as shown on plans. All plastic, burlap, ties, and other container material shall be removed from the plant prior to planting. Containers may require vertical cuts down the full depth of the container to accommodate removal. Backfill shall be firmly tamped or compacted without voids around the roots, then covered with mulch, and watered immediately after planting.

2. Space groundcover plants using triangular spacing in accordance with indicated dimensions and offsets. Adjust spacing as necessary to evenly fill planting bed with indicated quantity of plants.
D. Pruning and Tree Staking:

1. Pruning:
   a. Pruning necessary for the Work shall be in accordance with the TVSPP per
   b. COS Standard Specifications 8-01.
   c. At the time of planting, all plants shall be pruned to remove any minor broken or damaged twigs and branches. No trees or plants shall be headed or pruned without reason or prior approval by consulting arborist.
   d. When existing tree roots are encountered during construction and pruning is necessary in accordance with the TVSPP, all roots shall be pruned a minimum four (4)-inches from improvement limits defined and as determined by SPU to be necessary for construction forms or safety systems.
   e. Pruning shall be done in such a manner as to retain or to encourage the natural growth characteristics and proper form of the particular plant. Pruning shall be done with a sharp tool to produce a clean cut without bruising or tearing the bark. All completed pruning cuts shall be in the living wood where callous tissue can develop properly.
   f. All tree trimming shall be done by a certified arborist, or a trained arboricultural technician working under the immediate supervision of a certified arborist and shall adhere to ANSI A300 standards. Tree pruning shall be either minor or major as follows:
   g. Minor pruning is limited to: removal of less than 10 percent of the foliage, or if foliage has not developed, less than 10 percent of the foliage buds including branches up to 1-1/2-inches diameter; and removal that does not adversely impact the central leader, and does not significantly alter the natural form of the tree being pruned.
   h. Major pruning Work is all other pruning Work. When major tree pruning Work is required, the Contractor shall notify SPU three (3) Working Days prior to start of pruning and provide the name of the company or individual(s) proposed for doing the pruning. All major pruning work shall be done by an arborist with current certification by the Washington State Chapter of the International Society of Arboriculture, and shall arrange in advance with SPU for observing and approving the pruning of the first tree(s). The first pruning shall be representative of all trees to be pruned and shall be adequate demonstration of the proper pruning method to apply to all trees.

2. Tree Staking and Fastening:
   a. All trees shall be staked at the time of planting as indicated on plans. Each tree shall be staked as indicated on plans and tied to stake with Webbed Fabric Tape to allow for trunk growth.
   b. Damaged stakes shall be promptly removed and replaced.
c. Trees and shrubs found out of plumb by wind or other cause shall be re-plumbed by loosening the soil around the root system and re-plumbing the tree or shrub, and backfilling and compacting as necessary. Adjustment shall not be made by pushing, pulling or restraining the trunk or stem. If, in the opinion of SPU, damage to the root system has occurred as a result of re-plumbing a tree or shrub, the tree or shrub shall be replaced by the Contractor.

d. Alternate methods of staking may be proposed by the Contractor and require approval of SPU.

e. Tree stakes shall be removed at the end of the Warranty Period. Bark Mulch:

3. Mulch planting areas with required bark mulching material at least three (3) inches deep immediately after planting. Soil surface interface should be damp prior to application of mulch. Do not install wood chip mulch on top of dry planting soil. Three (3) inch depth is measured after settling and/or compaction has occurred. Thoroughly water mulched areas. After watering, rake mulch to provide a uniform finished surface.

3.09 SEED INSTALLATION

A. Installation:

1. Seeding shall be accomplished in the spring (April 10 to May 31) or fall (September 1 to October 20) of the year and/or when weather conditions are favorable for proper working of the soil and seed germination as determined by the Engineer. Application of pre-germinated seed, moisture retention agents, and provisions for supplemental watering may be required by the Engineer should the Contractor schedule seeding outside of allowable time frames.

2. Seed shall be spread by an acceptable hand-mechanical (hopper or culti-packer) or hydro-seed/mulch methods only.

   a. Hydro-seeding shall include first application with seed and 10% mulch fiber; second application with no seed and 90% mulch fiber.

   b. For hand-mechanical seeding, rake seed and fertilizer into top 1/2 to 1 inch of soil. After raking, roll the finished grade one direction for a flat, uniform surface and water thoroughly.

3. Seeding shall be done only after finish grading and adjacent construction and plantings have been completed.

B. Wood Cellulose Fiber Mulch shall be in accordance with Wood Cellulose Fiber Mulch Section herein and be added at the following rates:

1. 2,000 pounds per acre, for areas having zero to 4H:1V slope.

2. 3,000 pounds per acre, for areas having between 2H:1V and 4H:1V slope.

C. Tackifier shall be in accordance with Tackifier Section herein and applied at a rate of at 80 pounds per acre.

D. Any seeded areas that have become compacted prior to seeding must be scarified to a depth of four (4) inches by acceptable means, then finish graded as herein before described.
E. The application rate for Seeded Lawn Mix shall be six (6) pounds of seed per thousand (1000) square feet.

F. Temporary flagging and warning signs shall be installed preventing the public from disturbing or damaging the newly installed seed planting.

G. Water seeded area thoroughly with a fine spray immediately after seeding. Provide one (1) inch average application of water without uncovering seed, washing seed away, and without causing erosion or sedimentation.

H. Flagging, fencing, and warning signs or other appropriate method of seed protection shall be installed and remain until the seed has become established.

I. Water: Watering shall be accomplished as frequently as needed from March through September to meet requirements specified herein for Seed Establishment. At a minimum, a uniform application of one (1) inch of water shall be required over all seeded areas each week. The Contractor shall be prepared to water more frequently should very dry conditions persist and based on input from SPU.

J. Mowing:
   1. The Contractor shall be responsible for mowing all seed lawn areas.
      a. For the first three (3) mowings, mow whenever lawn reaches an average height of two (2) inches. For the first three (3) mowings, the cutting height shall be one and one half (1.5) inches with all cuttings retained using mulching mower equipment.
      b. For the fourth and all subsequent mowings, mow whenever lawn reaches an average height of three (3) inches and set the cutting height at two (2) inches with all cuttings retained using mulching mower equipment.
      c. Mowing shall be done by an acceptable “reel” type mower. Power driven equipment shall not cause ruts or deformation of improved areas. The equipment and tools shall be in good repair at all times and maintained so that a clean, sharp cut of the grass results. Each mowing shall be considered as one, complete coverage of all lawn grass areas to be mowed within a defined area.
      d. Trimming around traffic facilities, structures, curbs, tree pits, planting areas, or other features extending above ground shall be accomplished by use of tools that achieve a neat and uniform appearance. Edging along curb and sidewalk interfaces shall be incidental to mowing and shall be provided by the Contractor to control encroachment of grass.
      e. Grass cutting equipment shall be operated in such a manner and equipped with suitable guards as to avoid throwing rocks or debris onto the pedestrian and vehicular traffic areas or onto permeable pavement areas. Equipment that pulls or rips the grass or damages the turf in any manner will not be allowed. SPU will be the sole judge of the adequacy of the equipment and methods of use. The Contractor shall return and disperse all lawn clippings to the lawn from all pedestrian and vehicular traffic areas, and from any other improvement.
K. Follow-up Fertilizing: After the first mowing or approximately 30 days after the initial installation (whichever comes first) broadcast 'Regular Feed'. Broadcast at a rate recommended by manufacturer for lawn areas. Apply once a month for the first four months of the growing season.

L. Watering: To encourage deep rooting, each watering shall be thorough enough to provide soil moisture a minimum of six (6) inches below soil surface. Permit soil to dry sufficiently between watering, but not so dry as to damage the planting. Lawn Establishment shall be per Standard Specification 8-02.3(15).

M. Inspection: Check for barren areas, maximum three (3) inches square, in seed bed approximately twenty-one (21) days after seeding and over-seed as originally specified and at such time as weather and season permit for proper seed germination or as accepted by the Engineer.

N. Seeded areas shall be deemed physically complete when uniform, healthy, green, and vigorous growth is evident, with no dry or dead spots larger than 3-inch square, and after the fifth mowing has occurred. Upon physical completion, temporary flagging, warning signs, and other seed protection measures may be removed.

3.10 ROOT BARRIER INSTALLATION

A. Install root barrier panel per manufacture’s recommendation and specifications in locations as shown on the Contract Drawings. Install panels immediately adjacent to paving with ribs facing towards the tree roots. Trenches shall be deep enough so that top of root barrier is 2 inches below adjacent pavement.

3.11 EARTH ANCHOR INSTALLATION


B. Each earth anchor system shall be tested. Five percent of the earth anchor systems or a minimum of three earth anchor systems, whichever is greater, shall be tested under the supervision of The Engineer, and The Engineer will record test data.

1. The testing equipment shall consist of a mechanical force gauge capable of measuring up to 20,000 lb capacity minimum. Load ratings for the test rigging should be equal to or greater than the maximum load the equipment can produce and greater than the rated breaking strength of the strap attached to the anchor. Test equipment should not be operated at loads greater than the rated breaking strength of the anchor strap.

2. When an earth anchor system fails, the Contractor shall modify the design, the construction procedures, or both. These modifications may include, but are not limited to, installing replacement earth anchor systems, modifying the installation methods, or changing the tipping-plate anchor type. Any modification that requires changes to the log structure shall have prior approval of the Engineer. Any modifications of design or construction procedures shall be at the Contractor’s expense.

3.12 CLEAN UP

A. Perform cleaning during installation of the landscape work. Water, dirt, debris, and rubbish to be kept off of all paved areas, and pathways, and permeable pavements.
B. Upon completion of landscape work, all excess materials, soil, debris, and equipment shall be removed from the site.

C. Repair any damage resulting from landscape work at Contractor’s expense.

D. Planting areas immediately adjacent to walks, curbs, pavements, driveways, and other improvement shall be compacted and raked to accommodate the depth of mulch cover, with the mulch surface flush with the surface of adjacent improvement. Planting beds shall have a fine, even grade around all plants.

E. Remove all metal, wood, and concrete debris, protective wrappings and coverings, and shipping materials from the project site. Remove all residues, repair all stains, scuffs, and abrasions.

F. Leave project in first quality condition.

3.13 PHYSICAL COMPLETION

A. Inspection to determine Substantial and Physical Completion of planted areas will be made by the Engineer, upon the Contractor’s request. Provide notification at least five (5) working days before requested inspection date.

1. Planted areas will be accepted provided all requirements, including the maintenance have been complied with and plant materials are alive and in a healthy, vigorous condition.

B. Upon Final Acceptance and the completion of the Landscape Establishment during Warranty Period, SPU shall assume all plant maintenance.

3.14 FINAL ACCEPTANCE

A. Final acceptance of all landscaping work described in this Specification section, shall be made by the Engineer and/or approved by SPU to determine one hundred (100) percent completion and acceptance of the Landscape Establishment during Warranty Period work. This review shall be made upon written request to the Engineer no less than forty-eight (48) hours prior to the anticipated date of inspection.

END OF SECTION 32 93 00
PART 1 - GENERAL

1.01 SUMMARY

A. Specification Section Includes:
   1. Precast concrete maintenance hole structures and appurtenant items:
      a. Storm drain maintenance holes 1, 2, and 3 and appurtenances.

1.02 REFERENCES

A. The following is a list of standards that may be referenced in this Specification Section:
   1. American Association of State Highway and Transportation Officials (AASHTO):
   2. ASTM International (ASTM):
      e. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
      g. C14, Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
      h. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
      l. C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
u. C1244, Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
v. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

3. City of Seattle, 2017 Edition:
a. Standard Specifications for Road, Bridge and Municipal Construction
b. Standard Plans for Municipal Construction

B. Manufacturer Qualifications:

1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with three (3) years’ experience producing precast concrete products of quality specified.

2. Precast Plant: PCI certified plant with current certification.

1.03 DEFINITIONS

(NOT USED)

1.04 SUBMITTALS

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
C. Structural Calculations:

1. Structural calculations following current design codes that verifies precast maintenance hole design in both strength and service requirements. Calculations are to be stamped and signed by a licensed PE in the State of Washington.
   a. Maintenance hole shall be designed to ACI-318-05 Building Code to meet the following load conditions:
      1) ASTM C-857 "Minimum structural design loading for underground precast concrete utility structures"
      2) Buoyancy calculations for anti-buoyancy measures proposed for maintenance holes, catch basins, and utility vaults.

D. Shop Drawings:

1. Shop Drawings including details of construction, reinforcing and joints, anchors, lifting eyelets, external straps, erection inserts, steps/rungs, and other items cast into members:
   a. Channeling and filling plans and sections.
   b. Locations and sizes of knockouts cast into structures. Ensure that pipe penetrations cast into structures are adequately sized to accommodate indicated pipe sizes and materials without requiring additional field modifications. Show clearances for removal of diversion structure bar screen. If modified in the field, repair as indicated in this specification.
   c. Non-standard top or base slabs called for in the Drawings.
   d. Buoyancy shop drawings for anti-buoyancy measures proposed for maintenance holes, catch basins, and utility vaults.

2. Product Data:
   a. Material cut sheets for each of the products listed in Part 2 Products.

E. The Contractor shall submit to the Engineer for approval, the single Material of choice for step, handhold, and ladder from Section 9-12.2 – Materials of the City of Seattle Standard Specifications and shall consistently use this single chosen Material in every Structure. Should the Contractor request a different Material between or among different structures, then the submittal shall be clear in identifying which Material is for which Structure.

F. Shop Drawings of joint details and end details in City of Seattle Standard Plan nos. 204a through 212b shall be submitted to the Engineer for review and issuing of approval prior to the start of manufacture.

G. Miscellaneous Submittals:

1. Experience Record:
   a. Precast concrete production capabilities.
   b. Evidence of current PCI plant certification.

3. Test Reports:
   a. Precast manufacturer’s concrete test cylinders.
   b. Core compression test.
   c. Absorption test.

4. Certified load test data for precast maintenance hole steps.

5. Manufacturer’s recommended installation instructions including lifting, handling and erection.

6. Field quality control report.

7. Written verification that products submitted meet requirements of standards referenced.

PART 2 - PRODUCTS

2.01 MAINTENANCE HOLE GENERAL REQUIREMENTS

A. Maintenance holes shall be in accordance with City of Seattle Standard Plan nos. 204a through 212b.

B. Anti-buoyancy measures shall be constructed to counter buoyancy forces acting on drainage structures. The anti-buoyancy measures shall assume a groundwater elevation equal to the rim of the drainage structure and the design shall provide for a 1.25 factor of safety against flotation. Concrete fill and channeling may be used as dead load for flotation resistance. Side wall friction may be considered in accordance with the Geotechnical Report recommendations.

C. Materials of Construction and Service Conditions:
   1. Screws, Bolts, or Nuts: Type 304 stainless steel conforming to ASTM F593 and ASTM F594.
   2. Materials shall be compatible with each other and maintenance hole materials.

D. Structures shall meet requirements of ASTM C478, this Specification Section and the following:
   1. Concrete:
      a. Reinforced Concrete: In accordance with Section 9-12.1 of the City of Seattle Standard Specifications.
      b. Cement: In accordance with Section 9-01.2 of the City of Seattle Standard Specifications.
      c. Aggregates for cast-in-place concrete shall conform to ASTM C 33.
   2. Reinforcement: Reinforcement shall consist of wire conforming to ASTM A 82 or ASTM A 496, or wire fabric conforming to ASTM A 185 or ASTM A 497, or Grade 60 steel bars conforming to ASTM A 615 or Grade 80 steel bars conforming to ASTM A 306.
   3. Ring: Custom made with openings to meet indicated pipe alignment conditions and invert elevations.
4. Floor: Minimum 3-inches below pipe to provide clearance for grouting channels.

5. Joint:
   a. Form joint contact surfaces with machined castings.
   b. Surfaces shall be parallel with nominal 1/16-inch clearing and tongue equipped with recess for installation of O-ring rubber gasket.


7. Grout for filling the void in Storm Drainage Structures where pipe connections are made shall be non-shrink cement sand grout complying with the requirements of Section 9-04.3 of the City of Seattle Standard Specifications and with smooth transitions to insure an unobstructed flow through the maintenance hole.

2.02 PRECAST MAINTENANCE HOLES

A. Riser Sections:
   1. Fabricate in accordance with ASTM C478.
   2. Wall Thickness as shown on City of Seattle Standard Plans.
   3. Top and bottom surfaces shall be parallel.

B. Cone Sections:
   1. Concentric or eccentric as shown on the Drawings.
   2. Same wall thickness and reinforcement as riser section.
   3. Top and bottom surfaces shall be parallel.

C. Top Slab:
   1. Unless otherwise noted on the Drawings, top slabs for Type B maintenance holes shall be per City of Seattle Standard Plan nos 204B through 212B for Municipal Construction.
   2. Top slab shall be designed for a live load of AASHTO HL-93 or HS-25 (whichever is more restrictive) truck load including impact and dead load including self weight of top slab and earth load.
   3. Top slabs that are non-typical shall be submitted as detailed or dimensioned on the Drawings per this Specification Section.

D. Base Sections and Base Slab:
   1. Base slab integral with sidewalls where shown on Contract Drawings.
   2. Fabricate in accordance with ASTM C478.

E. Maintenance Hole Extensions:
   1. Concrete grade rings; maximum 6-inches high.
   2. Fabricate in accordance with ASTM C478.
F. Joint Seal Manufacturers and Products:
   1. Butyl Gaskets:
      a. Hamilton Kent, Sparks, NV; Kent-Seal No. 2.
      b. Trelleborg Engineered Solutions, Park Hills, MO; NPC Bidco C-56.
      c. Or approved substitute.
   2. Confined Plastic or Rubber O-Ring:
      a. As recommended by pre-casting manufacturer.
      b. Meet requirements of ASTM C443.

2.03 CAST-IN-PLACE MAINTENANCE HOLE BASE SLAB
   A. Concrete: As specified in Specification Section 03 30 00.
   B. Reinforcing Steel: As specified in Specification Section 03 20 00.
   C. Aggregates shall conform to ASTM C33.

2.04 PRECAST UTILITY STRUCTURES
   A. Materials equipment, and accessories specified in this section shall be products of the following manufacturers:
      1. Oldcastle Precast.
      2. Jensen Precast.
      3. Hansen Pipe and Precast.
      5. Or approved substitute.
   B. Design Requirements:
      1. As noted on Drawings and in accordance with Section 03 48 11 for Diversion Structure and WQF Valve Vault.
      2. In the event of a conflict between or among standards, the more stringent standard shall govern.
      3. Grout for filling the void in the Diversion Structure where pipe connections are made shall be non-shrink cement sand grout complying with the requirements of Section 9-04.3 of the City of Seattle Standard Specifications and with smooth transitions to insure an unobstructed flow through the maintenance hole.
      4. Access frames and covers: In accordance with Section 08 31 20.
      5. Floor access doors: In accordance with Section 08 31 20.
2.05 MAINTENANCE HOLE AND UTILITY STRUCTURE FRAMES AND COVER

A. Castings:
   1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, cracks and other defects.
   3. Ductile Iron: ASTM A536, Grade 80-55-06.
   4. Plane or grind bearing surfaces to ensure flat, true surfaces.

B. MH Frames & Covers: City of Seattle Standard Plan no. 230. True and seat within ring at all points. With the word DRAIN for storm drain maintenance holes in 3-inch raised letters.

C. See Section 7-05.3(1)R of the City of Seattle Standard Specifications for additional requirements.

D. Water Valve Chamber Frame and Covers: City of Seattle Standard Plan no. 361. True and seat within ring at all points. With the word WATER in 3-inch raised letters.

2.06 LADDER, STEPS AND HANDHOLDS

A. Refer to the Drawings for non-standard maintenance hole furnishing requirements. Some maintenance holes shall be provided without standard equipment and furnishings as specified in the City of Seattle Standard Plans for Municipal Construction.

B. Base sections of precast maintenance holes more than 3-feet in height shall be provided with a ladder as detailed in City of Seattle Standard Plan no. 232. Where ladders are required, the bottom step in which the ladder is hung shall be manufactured of the same Material as the ladder.

C. Steps, handholds, and ladder made of copolymer polypropylene plastic manufactured only by Lane International Corp., M. A. Industries, Inc., or approved substitute will be accepted.

D. Where a flat slab is required in the construction of a maintenance hole, the handholds normally required in this area may either be installed in the slab itself, or installed between the slab and leveling bricks, provided that the overall distance to the upper handhold or step, or the distance between the upper handhold or step to the top of frame, is no more than 12 inches. See Sections 7-05.3(1) of the City of Seattle Standard Specifications for additional requirements.

E. Ladder Safety Post
   1. Furnish and install where indicated on Drawings. The ladder safety post shall be pre-assembled from the manufacturer.
   2. Performance characteristics:
      a. Tubular post shall lock automatically when fully extended.
      b. Safety post shall have controlled upward and downward movement.
      c. Release lever shall disengage the post to allow it to be returned to its lowered position.
d. Post shall have adjustable mounting brackets to fit ladder rung spacing up to 14" on center and clamp brackets to accommodate ladder rungs up to 1-3/4" in diameter.

3. Post: Shall be manufactured of high strength square tubing. A pull up loop shall be provided at the upper end of the post to facilitate raising the post.

4. Material of construction: Shall be Type 304 stainless steel or aluminum.

5. Balancing spring: A stainless steel spring balancing mechanism shall be provided to provide smooth, easy, controlled operation when raising and lowering the safety post.

6. Hardware: All mounting hardware shall be Type 316 stainless steel.

7. Finishes: Factory finish shall be yellow powder coat steel; or hot dip galvanized steel; or mill finish stainless steel; or mill finish aluminum.

2.07 MAINTENANCE HOLE FRAME CONNECTION TO STRUCTURE

A. Install frames and covers on top of manholes grade rings. Frames shall be set in a bed of mortar with the mortar carried over the flange of the frame. Set frames so tops of covers are flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

B. See Section 7-05.3(1)R of the City of Seattle Standard Specifications for additional requirements.

2.08 MORTAR

A. Mortar for Plaster-Coating: Mortar for lining masonry unit maintenance holes shall be proportioned according to either of the two alternates tabulated as follows:

<table>
<thead>
<tr>
<th>Alternate</th>
<th>Parts by Volume Portland Cement</th>
<th>Parts by Volume Masonry Cement</th>
<th>Volume Hydrated Lime or Lime Putty</th>
<th>Plaster Sand Measured in Damp Loose Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1 (Type II)</td>
<td>0</td>
<td>Not less than 2-1/4 and not more than 3 times the sum of volumes of cement and lime</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1/4</td>
<td></td>
</tr>
</tbody>
</table>

2.09 BACKFILL AROUND AND UNDER MAINTENANCE HOLE

A. Structural fill as specified in Specification Section 31 23 33.
2.10 FLEXIBLE JOINTS FOR SEALING PIPES IN MAINTENANCE HOLES

A. Manufacturers and Products:
   1. NPC, Inc., Milford, New Hampshire; Kor-N-Seal flexible rubber boot with stainless steel accessories.
   2. A-LOK Products, Inc., Tullytown, PA; Z-LOK XP or A-LOK flexible connectors.
   3. Or approved substitute.

B. Maintenance hole Over Existing Pipe:
   1. Green Streak; hydrophilic waterstop CJ-0725-3k.
   2. Or approved substitute.

C. See Section 7-05.3(1)S of the City of Seattle Standard Specifications for additional requirements.

D. Large diameter pipe connections to maintenance holes and structures shall be as shown on the Drawings.

2.11 SOURCE QUALITY CONTROL

A. Prior to delivery of precast maintenance hole sections to Site, yard permeability tests may be required at point of manufacture. Engineer or SPU will select precast sections not to exceed 5 percent of the total project quantity to test from material which is to be supplied to Project. Test specimens shall be mat tested and meet permeability test requirements of ASTM C14.

B. Concrete Testing: Test two concrete test cylinders for each maintenance hole. Compressive strength shall be tested in accordance with ASTM C31/C31M, ASTM C39/C39M, and ASTM C192/C192M.

C. Inspection:
   1. Material Quality:
      a. Manufacturing process and finished sections shall be subject to inspection and approval by SPU and Engineer:
         1) Inspections may take place at manufacturer’s plant, at Site after delivery, or at both.
         2) Sections not meeting requirements of this Specification Section or that are determined to have defects which may affect durability of structure are subject to rejection.
         3) Sections rejected after delivery shall be removed and replaced.
         4) Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of SPU and Engineer.
         5) If structure cannot be repaired, it shall be removed and replaced entirely at Contractor’s expense.
2. At the time of inspection, the sections will be carefully examined for compliance with ASTM C478 or ASTM C858 and with manufacturer’s drawings. Sections will be inspected for general appearance, dimensions, scratch strength, blisters, cracks, roughness, and soundness. Surface shall be dense and close textured.

3. Imperfections may be repaired, subject to approval of Engineer, after demonstration by manufacturer that strong and permanent repairs result.

### 2.12 CATCH BASINS, INLETS AND JUNCTION BOXES

A. Catch basins shall be in accordance with Section 33 40 00.

### PART 3 - EXECUTION

#### 3.01 MAINTENANCE HOLE GENERAL REQUIREMENTS

A. Prior to installation, inspect materials:

1. Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.

2. Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of SPU and Engineer.

3. Remove and replace structure that cannot be repaired.

B. If needed, dewater excavation during construction and testing operations.

C. Set and adjust frame and cover final to match finished pavement or finished grade elevation using adjustment brick or precast adjuster rings. Concrete masonry units or concrete (masonry) rings may be used for adjustment of the casting to final street grade.

#### 3.02 EXCAVATION AND BACKFILL FOR MAINTENANCE HOLES

A. Excavation: As specified in Specification Section 31 05 00.

B. Backfill: As specified in Specification Section 31 23 33.

#### 3.03 INSTALLATION AND INSPECTION OF PRECAST MAINTENANCE HOLES

A. Concrete Base:

1. Precast: Maintenance holes and catch basins constructed with precast base sections shall be placed to grade upon a 6-inch minimum thickness of Mineral Aggregate Type 9 per Section 9-03 of the City of Seattle Standard Specifications mixed with 4 sacks of Portland cement per cubic yard of Mineral Aggregate, with sufficient water added to form a stabilized foundation. The mixed material shall be placed across the area of the excavation for the base to a minimum distance beyond the face of the maintenance hole as indicated on the City of Seattle Standard Plans and shall be graded to provide uniform bearing support with the precast base section.

2. Properly locate, ensure firm bearing throughout, and plumb first section.
3. Carefully place precast base placed on the prepared bedding so as to be fully and uniformly supported in true alignment and ensuring that all entering pipes can be inserted on proper grade.

4. No more than two lift holes shall be cast into each section. Holes shall be so located as to not damage reinforcing or expose it to corrosion. All lift holes shall be thoroughly wetted and then completely filled with mortar and smoothed both inside and out. At the manufacturer’s option, steel loops may be provided for handling, in lieu of lift holes. When loops have been provided in lieu of lift holes, the loops shall be removed flush with the inside wall surface. No sharp cutoff protrusion will be permitted. If concrete spalling occurs as a result of the loop removal, the spalled area shall be restored to a uniform smooth surface with mortar.

5. Cast-in-Place:
   a. All cast-in-place bases for maintenance holes shall be poured to grade upon a properly prepared foundation as indicated in the City of Seattle Standard Plans. Imported Mineral Aggregate Type 2, when required in the Contract, shall be placed and compacted to the same limits specified in Section 7-05.3(1)B of the City of Seattle Standard Specifications. The concrete base shall meet the requirements indicated in the City of Seattle Standard Plans.
   b. First section of maintenance hole shall be cast in concrete base.
   c. Cast in place over the existing pipe for MH-3 as detailed on drawings and specified in Section 03 48 11.
   d. Upon completion of concrete casting, the precast components shall be protected and cured in a moist atmosphere maintained by injection of steam for the requisite length of time and at the required temperature to develop the compressive strength required for maintenance hole components. Precast components may also be water-cured by any approved method that keeps the components continuously moist during the curing period. Cast-in-place components shall be moist cured for a period not less than seven (7) Days, except that Type III Portland cement concrete shall be cured for not less than three (3) Days.

B. Sections:
   1. Inspect precast maintenance hole sections to be joined.
   2. Clean ends of sections to be joined.
   3. Do not use sections with chips or cracks in tongue.
   4. Locate precast steps in line with each other to provide continuous vertical ladder.
5. Precast wall sections shall meet the requirements of ASTM C478. All joints between precast sections shall be rubber-gasketed and meet the requirements of ASTM C443. Precast sections shall be placed and aligned so as to provide vertical sides and vertical alignment of the ladder rungs. The completed maintenance hole shall be rigid, true to dimension, and watertight. No more than two lift holes shall be cast into each section. Holes shall be so located as to not damage reinforcing or expose it to corrosion. All lift holes shall be thoroughly wetted and then completely filled with mortar and smoothed both inside and out. At the manufacturer’s option, steel loops may be provided for handling, in lieu of lift holes. When loops have been provided in lieu of lift holes, the loops shall be removed flush with the inside wall surface. No sharp cutoff protrusion will be permitted. If concrete spalling occurs as a result of the loop removal, the spalled area shall be restored to a uniform smooth surface with mortar.

C. Precast Cones:

1. Precast cone sections shall meet the requirements of the City of Seattle Standard Plans, ASTM C478 and Section 7-05.3(1)F of the City of Seattle Standard Specifications.

2. Precast cones shall provide reduction in diameter within a range of height from not less than 18-inches to a maximum 36-inches. Jointing of a cone section to the riser sections shall be similar to jointing between riser sections, but the top surface of the cone section shall be flat and at least 5-inches wide radially, to receive adjustment bricks of precast risers. Handholds (steps) installed in leveling bricks or precast risers shall be modified to allow a minimum clear opening of 21-inches, measured at the shortest dimension, but the handhold shall be not less than 3-inches from the inside face of the wall. An additional handhold shall be provided in all concrete cones on the side opposite the ladder steps at mid-height of the cone section.

D. Top Slab:

1. Top slabs shall be per the City of Seattle Standard Plans, including details of opening location and reinforcing.

E. Preformed Plastic Gaskets or Rubber O-Ring:

1. Use only pipe primer furnished by gasket manufacturer.

2. Install gasket material in accordance with manufacturer’s instructions.


4. Completed Joints shall show no visible leakage and shall conform to the dimensions of ASTM 478.

F. Mortar Placement:

1. Thoroughly wet surface with water prior to placing mortar.


3. Prevent mortar from drying out and cure by applying approved curing compound or comparable approved method.

4. Do not use mortar mixed for longer than 30 minutes.
5. Chip out and replace cracked or defective mortar.

G. Concrete Precast Risers/Leveling Bricks/Grade Rings:
   1. Refer to City of Seattle Standard Plans for maintenance hole types called out in Contract Drawings.
   2. Provide on maintenance holes in streets or other locations where change in existing grade may be likely.
   3. Match diameter/dimensions of opening unless otherwise noted on Contract Drawings.
   4. Lay grade rings in mortar with sides plumb and tops level.
   5. Seal joints with mortar as specified for sections.
   6. Rebuild brick structures per City of Seattle Standard Plan no. 220.

3.04 MAINTENANCE HOLE INVERT
A. Construct with smooth transitions to ensure unobstructed flow through maintenance hole. Remove sharp edges or rough sections that tend to obstruct flow.
B. Where full section of pipe is laid through maintenance hole, break out or cleanly cut top section and cover exposed edge of pipe completely with mortar. Trowel mortar surfaces smooth.

3.05 MAINTENANCE HOLE FRAMES AND COVERS
A. Install concrete grade rings as required to set covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.
B. Set frames and adjust frames using mortar as specified in Section 7-05.3(1)P of the City of Seattle Standard Specifications.
C. Install maintenance hole frame to structure seals in accordance with manufacturer’s instructions. Seal shall cover grade rings.
D. The casting shall be as shown on City of Seattle Standard Plan no. 230. Where City of Seattle Standard Plan no. 230 casting is located within the concrete pavement or within the rigid concrete pavement base, reinforcing in the concrete pavement slab shall be installed as specified in Section 5-05.3(9) of the City of Seattle Standard Specifications and per City of Seattle Standard Plan no. 406. City of Seattle Standard Plan no. 230 casting located across or located within 18-inch of a concrete pavement joint as measured from the casting barrel (not the flange), does not require Section 5-05.3(9) of the City of Seattle Standard Specification pavement reinforcing. Total height of casting and leveling brick shall not exceed 26 inches.

3.06 MAINTENANCE HOLES OVER EXISTING PIPING
A. Cast in place over existing pipes only. Utilize precast sections as detailing on drawings for MH-3.
B. Maintain flow through existing pipelines at all times.

C. Concrete Pipe: Apply bonding agent on surfaces in contact with concrete.

D. Construct base under existing piping.

E. Construct maintenance hole as detailed in Drawings.

F. Apply minimum of two complete wraps of hydrophilic waterstop centered on pipe in wall.

G. Place a minimum of 24-inches of concrete around each pipe penetration outside maintenance hole against undisturbed soil or compacted aggregate unless otherwise detailed.

H. Grout channel through maintenance hole.

I. Saw cut out or demolish existing pipe within new maintenance hole using method approved by Engineer.

J. Protect new concrete or grout for seven (7) days after placing concrete.

3.07 CLEANING

A. Upon completion, clean each structure of all silt, debris, and foreign matter. No debris shall flow to the river.

END OF SECTION 33 05 16
PART 1 - GENERAL

1.01 SUMMARY

A. Scope:
1. This section specifies reinforced concrete pipe, gaskets, and PVC lining. This section contains specifications for maintenance holes and appurtenances.

B. Pipe Designations:
1. Reinforced concrete pipe designations shall be as follows:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP</td>
<td>Reinforced Concrete Pipe</td>
</tr>
</tbody>
</table>

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C76</td>
<td>Reinforced Concrete Culvert, Storm Drain and Sewer Pipe</td>
</tr>
<tr>
<td>ASTM C139</td>
<td>Concrete Masonry Units for Construction of Catch Basins and Manholes</td>
</tr>
<tr>
<td>ASTM C150</td>
<td>Portland Cement</td>
</tr>
<tr>
<td>ASTM C361</td>
<td>Reinforced Concrete Low-Head Pressure Pipe</td>
</tr>
<tr>
<td>ASTM C443</td>
<td>Joints for Concrete Pipe and Manholes, Using Rubber Gaskets</td>
</tr>
<tr>
<td>ASTM C478</td>
<td>Precast Reinforced Concrete Manhole Sections</td>
</tr>
<tr>
<td>ASTM C497</td>
<td>Testing Concrete Pipe, Sections, or Tile</td>
</tr>
</tbody>
</table>
1.03 DEFINITIONS

A. Definitions:

1. Pipe Joint: The area approximately 12 inches each way from the centerline of the visible gap between pipe lengths.
2. Pipe Length: The pipe between two joints; part of a pipe section.
3. Pipe Section: The reach of pipeline between two successive maintenance holes.

1.04 SUBMITTALS

A. Procedures: The following information shall be provided in accordance with Section 01 33 10.

B. Shop drawings: Show profiles, accessories, location, and dimensions.

C. Product Data: Provide manufacturer’s product data for all materials in this specification.

1. Fabrication Drawings: Drawings shall illustrate details of wall thickness, pipe joint, joint gasket, and reinforcement. Reinforcement details shall include the type of cage, the location of the cages in the pipe wall, the size and spacing of circumferential and longitudinal reinforcing steel, and the cross-sectional area of reinforcing steel in each cage per lineal foot of pipe. The gasket details shall include the diameter of the cross section and the circumferential length.

2. Layout Drawings: Layout drawings shall illustrate placement of each pipe length including fittings. Pipe lengths and joints shall be identified with a numbering system.

3. Test Results: The Contractor shall provide results of the following tests as specified in this specification:

4. Certification: The Contractor shall provide certified copies of laboratory reports from his gasket supplier indicating conformance with the requirements of ASTM C443, Section 40 05 12 and this specification for each shipment of gaskets.

D. Television Inspection:

1. Submit USB flash drive with CCTV recordings in a format compatible with SPU’s granite system.

2. Submit PACP qualifications for personnel conducting television inspection.

1.05 QUALITY ASSURANCE

A. General: The Construction Manager shall be notified of the place and time of testing 1 week prior to the commencement of testing.

B. Concrete Compression Tests: Compression tests shall be as specified in ASTM C76, Section 11.4.1.
C. D-Load Tests:
   1. Pipe shall be tested in accordance with ASTM C76, Section 11.3 and ASTM C497. Loads used for testing shall be the load to produce the 0.01 inch crack or the design test load, whichever is less.
      a. One percent of the total number of pipes, with a minimum of three pipe lengths, of each class, size and wall type shall be tested.

D. Absorption Tests:
   1. 4 inch diameter cores from pipe sections selected by the Engineer shall be tested in accordance with ASTM C497.

E. Permeability Tests: Permeability tests shall be conducted as follows:
   1. The pipe selected by the Engineer for testing shall be placed plumb with either end down on a soft rubber impermeable pad and filled with water. The pipe shall be kept full of water for a period of 20 minutes. At the end of 20 minutes, the outer surface of the pipe will be examined for leaks. A leak is herein defined as a moist spot as determined by the Engineer.
   2. The Engineer may test up to 2 percent of all sections in a size and class of pipe; however, no less than 5 pipe sections of any pipe size and class will be tested.

F. Rebar Placement: The Engineer shall be notified 1 week prior to the placement of concrete in the precast pipe forms. The Engineer will schedule an inspection to witness the placement of rebar in the forms.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Pipe: Unless otherwise specified, pipe shall conform to the following specifications:
   1. RCP: ASTM C76, Class IV, Wall C.
   2. Cement shall be ASTM C150, Type II.

B. Gaskets: Gaskets shall conform to Section 40 05 12 and the following specifications:
   1. RCP: ASTM C443, Section 5

2.02 MANUFACTURE

A. Pipe:
   1. General: Pipe manufactured by the vertically wet cast method shall be cast with the spigot end down. Reinforcing steel for each length of pipe shall be held in place throughout the casting operation. Lift holes are not acceptable.
   2. RCP: Pipe shall be manufactured in conformance with ASTM C76. Joints shall be rubber gasket conforming to ASTM C443, unless otherwise specified.
B. Rubber Gasket Joints: Joints shall be concrete bell and spigot.

C. Length And Bevels: Pipe shall be fabricated in nominal lengths of at least 8 feet except where shorter lengths are required to meet special conditions. Pipe ends may be beveled a maximum of 5 degrees to accommodate changes in alignment or curved alignments of the pipeline.

PART 3 - EXECUTION

3.01 PIPE LAYING

A. RCP:

1. Preparation of bedding and backfill shall be as specified in Section 31 05 00, Common Work Results for Earth Work, and the drawing details. Pipe shall be laid with uniform bearing under the full length of the barrel of the pipe.

2. The interior of the pipeline shall be cleaned as the work progresses.

3. The line and grade of any one pipe shall not deviate more than that specified in the following table. The allowable deviation is not cumulative.

<table>
<thead>
<tr>
<th>Pipe length, feet</th>
<th>Maximum deviation per pipe length, feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>0.06</td>
</tr>
</tbody>
</table>

4. Assembled pipe joints shall be kept in compression until the placement of the initial backfill is complete.

B. Jointing: During jointing, neither mortar nor buttering compound is acceptable on either the exterior or interior of the joints. Joints with gaps over 3/4 inch shall be replaced.

3.02 PIPELINE ACCEPTANCE

A. RCP: After backfilling and restoration of surfaces, pipelines shall be cleaned.

B. RCP Leakage Tests: Conform to COS standard 7-17.3(4).

1. General: Leakage tests shall be completed after pipelines have been cleaned of obstructions and inspected by the Engineer, per COS standard 7-17.3(4)A.

C. Air Pressure Joint Test:

1. Pipelines joints shall be tested with low pressure air by the pressure drop method, in lieu of water infiltration or exfiltration. The pressure drop shall be from 3-1/2 to 2-1/2 psi greater than the average back pressure of groundwater above the springline of the pipe. At the Contractor's option, pipe may be tested without pre-wetting; however, the test allowances herein assume pre-wetted pipe.

2. The allowable rate of air loss shall be .003 cubic feet per minute (cfm) per square foot of internal pipe surface; however, the total air loss shall not exceed 3.50 cfm.

3. The test equipment to be used shall be furnished by the Contractor and shall be inspected and approved by the Engineer prior to use. The Engineer may at any time require a calibration test of gauges, other instrumentation, and equipment that is used for this test.
4. Safety Provisions. Plugs used to close the Sewer pipe for the air test shall be securely braced to prevent the unintentional release or loosening of a plug. Gauges, air piping manifolds, and valves shall be located at the ground surface. No person shall be permitted to enter a maintenance hole where a plugged pipe is pressurized. (Four pounds per square inch gauge (psig) air pressure develops a force against the plug in a 12 inch diameter pipe of approximately 450 pounds, and a plug failure may result in injury.) Air testing apparatus shall be equipped with a pressure release device designed to relieve pressure in the pipe at a pressure recommended by the pipe manufacturer. The Contractor shall submit the pipe manufacturer's recommendations to the Engineer including the safety precautions for pipe testing.

5. Pipe 36 inches in diameter and over shall have all joints tested individually and in consecutive order along the entire line. The void volume around the joint shall be pressurized to 3.5 psi above that of the average groundwater pressure above the springline of the pipe. The Contractor shall allow the air pressure and temperature to stabilize before shutting off the air supply and start of test timing. Joint or joints will be determined acceptable if a pressure loss not exceeding 1.0 psi occurs over a 30 second test interval.

6. If a pipe joint fails to pass this pressure test or also fails a retest, it shall be repaired in a manner acceptable to the Engineer. If not repairable, the damaged pipe section shall be replaced with a new one and the joints tested as specified above.

D. Television Inspection with Audio Assessment:

1. During the final inspection process and after all maintenance hole (MH) have been channeled, backfilled and before paving, the Contractor in the presence of the Engineer, shall perform television inspection of the interior of all mainline Sewer and Storm Drain pipe smaller than 48 inches in diameter and all catch basin connection pipe. Seattle Public Utilities will review the television inspection to determine acceptance of this portion of the Work. Pipe larger than 48 inches in diameter will be inspected visually by Seattle Public Utilities after cleaning and successful testing by the Contractor. Side Sewer and inlet connection pipe will not require television inspection.

2. Television inspections not meeting the requirements of this Specification will be determined to be defective work. Upon written notice by the Engineer, the Contractor shall promptly conduct a second television inspection meeting specified requirements, and shall submit a second recording at no additional or separate cost to SPU.

3. Personnel Qualifications: Personnel performing television inspection shall have completed the Pipeline Assessment and Certification Program (PACP), and shall have adequate experience and working knowledge of the entire television inspection systems and processes. Contractor shall submit said certification to the Engineer at least 3 Working days in advance of the first television inspection.
4. Camera Equipment: The camera shall be a 360-degree radial view color television camera (also known as "pan and tilt") with a mechanical footage counter calibrated to indicate video footage consistent with distance traveled in the pipe. Footage shall be zeroed at centerline structure (maintenance hole, vault, etc.) where the video begins and footage shall increase as it travels forward, and decrease when backward camera movement is required. Footage shall be displayed on the video recording and be mentioned on the audio portion (see "audio commentary on recording"). Correct adjustment of the recording apparatus and monitor shall be demonstrated by use of the test video or other device approved by the Contractor. Satisfactory performance of the camera shall be demonstrated by the recording of the appropriate test device at the commencement of each day for a minimum period of 30 seconds.

5. Light Source: The camera shall have a light source providing adequate illumination to clearly identify invert, crown, joints, sides, connections, and infiltration/exfiltration. Illumination shall be capable of providing adequate illumination to at least 15 feet in front of the camera.

6. Camera travel in the pipe: All mainline inspections shall be from the downstream MH (DSMH) to the upstream MH (USMH). The camera shall be positioned to reduce the risk of picture distortion. In circular pipes the camera lens head shall be positioned centrally within the pipe. The camera shall travel along pipe invert to provide the best view of the crown, invert, connections and sides of the pipe, and shall travel at a speed no faster than 25 feet per minute.

7. Audio commentary on recording: Commentary shall be objective and shall be based on PACP defined assessment conditions. Audio shall be intelligible and shall be as free from interference and background noise as can reasonably be done. Subjective comments (such as "the fault of", "caused by", and opinion, etc.) shall not be used. Comment shall include the footage location of the comment, each connection, the starting and ending structure, indicated flaws, areas of infiltration/exfiltration, open joints, outfall, and other features as may be necessary.

8. Required labeling on recording and in audio commentary: Each recording shall have audio accompaniment and shall address a single run of pipe between two (2) structures (maintenance holes, vaults, catch basin, tee, or ending in an outfall, etc.) on a USB flash drive. The recording shall contain a legible label that clearly states the following, and the audio commentary shall begin with the following:
   a. Date and time of day television inspection performed;
   b. Names of television inspection crew members;
   c. Project name, vault plan number listed on Drawings, and Drawing sheet number;
   d. Location with structure labels (for example – maintenance hole 25, vault 2, outfall, etc.), camera travel direction, size of pipe, pipe material (such as "Broad Street, 5th Ave west to midblock, maintenance holes 24 to 25, going upstream, 24 inch reinforced concrete pipe"); and
   e. A unique identification number, with these numbers being in consecutive sequence on all USB flash drive of Project pipe.
9. Recording quality and characteristics: Television inspections shall be submitted on USB flash drive. All inspections should be done in a PACP format, with uploadable capability to the SPU database.
   a. At the start of each pipe length being surveyed or inspected and each reverse set-up, the length of pipeline from zero footage, the entrance to the pipe, up to the cable calibration point shall be recorded and reported in order to obtain a full record of the pipe length. Only one survey shall be indicated in the final report. All reverse set-ups, blind maintenances, and buried maintenance holes shall be logged on a separate log. Surveys must not extend over 1 USB flash drive.
   b. The footage reading entered on to the data display at the cable calibration point must allow for the distance from the start of the survey/inspection to the cable calibration point such that the footage at the start of the survey is zero.
   c. At the start of each pipe, a data generator shall electronically generate and clearly display on the viewing monitor and subsequently on the USB flash drive recording a record of data in alphanumeric form containing all fields required by the PACP information standard including MH depths.
   d. The size and position of the data display shall be such as not to interfere with the main subject of the picture and centered on the viewing screen with white lettering against a black background.
   e. Once the survey of the pipe is under way, the following minimum information shall be continually displayed:
      1) Automatic update of the camera’s footage position in the pipe line from adjusted zero.
      2) Pipe dimensions in inches
      3) MH-to-MH reference numbers.
      4) Direction of survey, i.e., downstream (D) or upstream (U).
      5) Date
   f. Footage and corresponding time elapsed video read out shall be given throughout survey/inspection for all relevant defects and construction features encountered unless otherwise agreed. All continuous defects shall incorporate a start and finish abbreviation in the log report.
   g. Recording of a single segment of pipe shall not extend over more than one USB flash drive. A completed inspection shall be continuous between MH’s. An inspection from different directions and overlapping shall not be acceptable.

10. Required Pre-Notification: The Contractor shall notify the Engineer at least 3 Working Days in advance of the first television inspection.
11. Pre television inspection preparation: Unless the Contract specifies otherwise, the pipeline system to be inspected shall be successfully pressure tested and then flushed clean prior to beginning inspection. Television inspection shall be performed prior to allowing mainline flow into the pipe from upstream sources. Upstream bypass, when used, shall accommodate television inspection to afford full visibility of pipe inverts (see COS standard 7-17.3(2)K).

12. Required Extra Inspection: At all lateral connections, areas of indicated infiltration/exfiltration, open joints, indicated pipe deflection, defects of any kind, and as the Engineer may request, shall require the camera to slow down and fully focus on such areas including having the camera slowly travel backward and forward for multi-directional views. Said areas shall require focused video inspection of not less than 5 seconds. Cameras with telescoping ability shall view the area by telescoping in and out as appropriate for the Engineer to evaluate the condition with certainty.

13. Reinspection:
   a. Should television inspection reveal defective work, the Contractor shall, upon written notice from the Engineer, correct said defects. An additional television inspection ("reinspection") shall then be taken of the corrected pipe run to verify the corrected pipe meets Specifications. The audio portion on this recording shall indicate the same information as specified in "Required labeling on recording and in audio commentary" also stating “this is an additional television inspection to verify corrections at_____ footage location”. Such reinspection shall be considered in accordance with Section 1-05.7.
   b. In addition, SPU will conduct a television inspection during the one year warranty period and the Contractor shall, upon written notice from the Engineer, correct any defects identified.

14. Temporary breakdowns: Should an occurrence such as camera breakdown or inability to perform as specified, or other condition arise where no camera or television or audio progress can be made, after the initial 30 seconds of such condition, the operator shall make comment on the audio of such condition and the footage location, then shall shut down the camera and the audio. Upon fixing such a condition, the video and audio shall be restarted and the audio shall include a comment to the effect “_______ condition fixed and video and audio restarting at _____ footage location”.
15. Contractor to provide:
   a. USB flash drives of specific pipe lengths shall be furnished to the
      Engineer within 5 Working Days of each television inspection for
      acceptance by SPU. All USB flash drives shall become the property
      of the Engineer. Not more than 6 USB flash drives shall be sent to Seattle
      Public Utilities on any one day at the following address:

      Seattle Public Utilities
      Pipe Asset Manager
      Utility Systems Management Branch
      Drainage and Wastewater Division
      Seattle Municipal Tower
      700 5th Ave, 44th floor
      P.O. Box 34018
      Seattle, WA 98124-4018

   b. Seattle Public Utilities will accept or reject the video recording within 10
      Working Days of receipt.

E. Pipe Not Passing Testing

1. If any pipeline installation fails to meet the requirements of the test method used,
   or is indicated as defective by television inspection, see COS standard
   7-17.3(4)A1.

2. All lateral or side sewer branches included in the test section shall be taken into
   account in computing allowable leakage.

3. Upon final acceptance of the Work, all sewers, side sewers and fittings shall be
   open, clean, and free draining, see COS standard 7-17.3(4).

END OF SECTION 33 05 40
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes: This section includes installation of water lines and appurtenances.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.
D. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
E. The Contractor shall have at least one copy of the Standard Specifications at the job site.
F. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.03 DEFINITIONS
(NOT USED)

1.04 SUBMITTALS
A. Submit the following according to Standard Specification 1-05.3 Submittals.
   1. Material cut sheets for each of the products listed in Part 2.
   2. Verification of backflow testing by Washington certified backflow tester.

PART 2 - PRODUCTS

2.01 WATER SERVICE PIPING AND FITTINGS
A. Pipe and fittings for domestic water services on-site that are less than 4 inches shall be installed per City of Seattle Standard Specification 9-30.5.
B. Water service piping shall conform to Standard Specification 9-30.5(4). Water service piping shall be as shown on the Drawings. New water service piping shall be installed on the backside of the meter.
C. Install 2-inch water service lines, in locations of building footings, within 3-inch PVC schedule 40 casing pipe.

2.02 METER AND METER BOX
A. Domestic meter shall be 2-inch and be provided and installed by SPU.
B. Meter box and lid shall conform to Standard Specification 9-30.5(7).
2.03 BACKFLOW PREVENTION AND ENCLOSURE

A. Backflow prevention shall be a Reduced Pressure Backflow Assembly (RPBA) conforming to Standard Specification 9-30.13(5).

B. The RPBA enclosure shall be large enough to handle the discharge of a full relief valve opening.

PART 3 - EXECUTION

3.01 GENERAL

A. Installation of water utilities and appurtenances shall be in accordance with COS Standard Specification 7-15.

3.02 TRENCHES

A. Trenches shall be excavated and backfilled and the pipe shall be bedded in conformance with Standard Specification 7-11.3.

3.03 PIPE AND FITTINGS

A. Pipe location shall be verified in accordance with Standard Specification 7-11.3(4)B.

B. Pipe minimum depth of cover shall be in accordance with Standard Specification 7-11.3(4)C.

C. Domestic water services shall be installed in conformance with Section 7-15.3 of the 2017 COS Standard Specifications.

3.04 METER BOX AND LID

A. Meter box and lid shall be installed per manufacturer’s recommendation. Lid shall be adjusted to finished grade.

3.05 BACKFLOW PREVENTION AND ENCLOSURE


B. RPBA enclosure shall be installed per manufacturer’s recommendations and as shown on the contract plans.

C. All internal backflow assemblies and air gaps must be installed per Washington State’s Uniform Plumbing Code (UPC), as adopted by the City of Seattle.

END OF SECTION 33 10 00
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes: This section includes information related to the stormwater system such as drainage pipe, maintenance holes, catch basin, and cleanouts.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM), versions current at time of bid.
C. Whenever the words “Standard Specifications” are referred to, the reference is to the City of Seattle, Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition.
D. The Contractor shall have at least one copy of the Standard Specifications at the job site.
E. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and measurement and payment sections do not apply to this document.

1.03 DEFINITIONS
(NOT USED)

1.04 SUBMITTALS
A. Submit the following according to Standard Specification 1-05.3 Submittals.
   1. Material cut sheets for each of the products listed in Part 2 Products.
   2. Manufacturer’s Certificate of Compliance meeting the requirements of Standard Specification 1-06.3 for each of the products listed in Part 2 Products.
   3. Testing schedule and plan and results.
   4. Buoyancy calculations and shop drawings for anti-buoyancy measures proposed for drainage structures, such as catch basins, cleanouts and maintenance holes.

PART 2 - PRODUCTS

2.01 PIPE AND APPURTENANCES
A. Pipe and appurtenances shall conform to Standard Specification 9-05.
B. Yard pipe for conveyance from the diversion structure to the pump station and from the pump station to the saddle maintenance hole shall be in accordance with Section 33 05 40.
C. Drainage pipe for site drainage shall be ductile iron and conform to Standard Specification 9-05.3.
D. Drainage pipe for slotted subsurface storm drains shall conform to Standard Specification 9-05.4(1).
E. Drainage pipe for stormwater bioretention systems shall be PVC and conform to Standard Specification 9-05.4.
2.02 CATCH BASINS, CLEANOUTS AND MAINTENANCE HOLES
A. Catch basins and all related appurtenances shall conform to Standard Specification 7-05.2 and 9-12.
B. Maintenance holes shall be in accordance with Section 33 05 16.
C. Cleanouts shall conform to Standard Specification 7-19
D. Anti-buoyancy measures shall be constructed to counter buoyancy forces acting on drainage structures. The anti-buoyancy measures shall assume a groundwater elevation equal to the rim of the drainage structure, and have a safety factor of 1.0.

PART 3 - EXECUTION
3.01 PIPE
A. Pipe shall be installed in conformance with Standard Specification 7-17.3.
B. Pipe connections shall be in accordance with Standard Specification 7-08.

3.02 STRUCTURES
A. Catch basins shall be installed in accordance with Standard Specification 7-05.
B. Cleanouts shall be installed in accordance with Standard Specification 7-19.
C. Maintenance holes and all related appurtenances shall be installed in accordance with Standard Specification 7-05.3(1).
D. Existing structures including the existing tide gate valve shall be cleaned as first order of work to enhance drainage off and through the project site, in accordance with Standard Specification Section 7-07. The facilities shall be kept clean up to the Physical Completion date.
E. Anti-buoyancy measures shall be installed in a manner that does not cause drainage structures or pipes to shift or become buoyant.

END OF SECTION 33 40 00
PART 1 - GENERAL

1.01 SUMMARY
A. The extent and location of “Stormwater Bioretention System” Work is shown in the Contract Documents. This Section includes the requirements for furnishing and installing all items and components of a completed bioretention system with vertical walls or a bioretention system with geotextile liner in conformance with these specifications and the dimensions and sections indicated on the drawings or as established by the Engineer.

1.02 REFERENCES
A. Construct bioretention systems with related appurtenances in strict conformity with City of Seattle Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition (COS) and City of Seattle Standard Plans For Municipal Construction, 2017 Edition (COS Standard Plans). In addition, the following references apply:

1. American Association of State Highway and Transportation Officials (AASHTO)
2. AASHTO M105 – Gray Iron Castings
3. American Society for Testing and Materials (ASTM)
4. ASTM A48, CL.30B – Gray Iron Castings
5. ASTM A82 – Steel Wire, Plain, for Concrete Reinforcement
6. ASTM A185 – Steel Welded Wire Reinforcement, Plain for Concrete
7. ASTM A496 – Steel Wire, Deformed, for Concrete Reinforcement
8. ASTM A497 – Steel Welded Wire Reinforcement, Deformed for Concrete
9. ASTM A615 – Deformed & Plain, Carbon-Steel Bars for Concrete Reinforcement
10. ASTM B209 – Aluminum & Aluminum Alloy Sheet and Plate
11. ASTM C32 – Sewer and Manhole Brick (Made from Clay or Shale)
12. ASTM C139 – Concrete Masonry Units for Construction of Catch Basins and Manholes
13. ASTM C150 – Portland Cement
14. ASTM C478 – Precast Reinforced Concrete Manhole Sections
15. ASTM C595 – Blended Hydraulic Cement
16. ASTM C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
17. ASTM C858 – Underground Precast Concrete Utility Structures
18. ASTM C891 – Installation of Underground Precast Utility Structures
19. ASTM C990 – Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
20. ASTM C1107 – Packaged Dry, Hydraulic Cement Grout (Non-Shrink)
1.03 DEFINITIONS
A. COS: City of Seattle
B. ASTM: American Society for Testing and Materials

1.04 SUBMITTALS
A. Stormwater Bioretention System with Vertical Sides:
   1. Submit materials data in accordance with Section 01 33 10 – Submittals and COS Standard Specifications 1-05.3. Furnish manufacturers’ technical literature, standard details, product specifications, and installation instructions for all products.
   2. Submit the following:
      a. Shop and erection drawings showing compliance with the plan with layout of bioretention system with dimensions, location, elevations and other related details.
      b. Manufacturers product information demonstrating compliance with the specifications and plans.
      c. Installation and maintenance procedures from manufacturer.
      d. Buoyancy calculations and shop drawings for anti-buoyancy measures proposed for Stormwater Bioretention Systems with vertical walls.

B. Stormwater Bioretention System with geotextile liner and slopes sides:
   1. Refer to Standard Specification 1-05.3 for submittal requirements and procedures.

1.05 DELIVERY, STORAGE AND HANDLING
A. All stormwater bioretention system with vertical walls shall have components delivered to the site and unloaded with handling that conforms to the manufacturer’s instructions for reasonable care. Concrete and internal components shall not be rolled or dragged over gravel or rock during handling. The Contractor shall take necessary precautions to ensure the method used in lifting or placing the system components does not induce stress fatigue in the concrete.

PART 2 - PRODUCTS
2.01 DESCRIPTION
A. The Contractor, and/or a manufacturer selected by the Contractor and approved by the Engineer, shall furnish all labor, materials, equipment and incidentals required and install all Stormwater bioretention system with vertical walls and appurtenances in accordance with the contract drawings and these Specifications. The stormwater bioretention system shall consist of modular precast concrete trench sections that house region specific bioretention media, under drain and peak flow conveyance appurtenances. The bioretention systems shall be sized and installed per contract plans.

B. The Contractor shall furnish and install the Stormwater Bioretention Systems complete and operable as shown and as specified herein in accordance with the requirements of the plans and contract documents.
2.02 MATERIALS AND DESIGN

A. Materials shall comply with requirements in the City of Seattle Standard Specification 7-21 and as stated below:


2. Slotted PVC Subsurface Drain Pipe per specification 33 40 00

3. COS Mineral Aggregate shall be Type 26 per COS Standard Specification 9-0.3 and 9-03.10(6).

4. Mulch shall be bark mulch conforming to landscaping per Specification Section 32 93 00.

5. Plant Materials shall conform to landscaping per Specification Section 33 40 00.

6. PVC Storm Drain Pipe for overflow riser shall conform to Specification Section 33 40 00.

7. Streambed aggregate Type 4 per COS Standard Specification 9-03.3(2).

8. Geotextile liner fabric for Stormwater bioretention system with sloped sides, shall be Moderate Survivability Woven/Nonwoven Geotextile meeting the property requirements of Table 3, conforming to COS Standard Specification 9-37.

9. Beehive Grate shall be a locking metal dome grate such as Nyloplast 8 In Dome Grate Assembly or approved substitute that fits the overflow riser.

10. Stormwater bioretention system with vertical walls shall be Washington Department of Ecology (DOE) GULD approved.

2.03 PERFORMANCE

A. The Stormwater Bioretention System soil media performance shall be as required by the City of Seattle Standard Specifications 7-21.

2.04 QUALITY ASSURANCE

A. The materials, process and finished Stormwater Bioretention System shall be subject to inspection by the Engineer. Acceptance or rejection of the system shall be based on the Specifications contained in this section. Imperfections may be repaired but subject to the acceptance of the Engineer.

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall submit shop drawings of that must be approved by the Engineer prior to fabrication or installation.

B. Excavation, trenching and backfilling shall be as specified in Division 31, “Earthwork”.

C. All stormwater bioretention systems shall be identified at the surface level with markings indicating that they are treatment devices.

D. All other construction requirements shall be per City of Seattle Standard Specification 7-21.3.
3.02 **INSPECTION**

A. Systems and accessories, shall be inspected prior to installation and any defective or damaged product shall be replaced.

3.03 **INSTALLATION**

A. General:

1. General Locations and Arrangements: Drawing Plans and Details indicate general location and arrangement of Stormwater Bioretention Systems. Install Stormwater Bioretention System with vertical walls as directed by the product manufacturer. Install Stormwater bioretention system with sloped sides per contract plans.

2. All other installation requirements for Stormwater Bioretention system shall be per City of Seattle Standard Specification 7-21.3 (1)A and 7-21.3(2).

3. Anti-buoyancy measures for stormwater bioretention systems shall be installed in a manner that does not cause the BMP to shift or become buoyant.

B. Trench Excavation and Dewatering:

1. Refer to Specification **Section 31 00 00** for trenching and Seattle Standard Specification 2-08 for dewatering.

C. Bedding:

1. Refer to Storm Drainage Specification **Section 33 40 00**.

D. Setting Structures:

1. Each structure section shall be thoroughly examined before being placed; defective or damaged sections shall not be used. Structures shall be placed to the elevations as indicated on the plans. Proper facilities shall be provided for lowering structure sections into trenches. Sections shall not be laid in water, and the sections shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches shall be provided as directed by the engineer; see dewatering section.

E. Jointing for Stormwater Bioretention with Vertical Walls:

1. Joints shall be constructed as described herein and in accordance with manufacturer’s installation instructions.

2. All joints shall be thoroughly cleaned. The supplied gasket or mastic shall be installed on the spigot end with the angled surface facing toward the mating surface. Joint lubricant, supplied by the manufacturer, shall be liberally applied to entire interior of bell and gasket on spigot prior to assembly. Sections shall be mated with sections level and plumb to prevent rolling the gasket.

3. All Tongue-and-Groove joints shall be thoroughly cleaned. Sections shall be mated and Hydraulic Cement Grout (Non-Shrink) complying with ASTM C1107 shall be applied liberally to the interior and exterior of the joint ensuring all voids are filled completely.
F. Backfilling:
   1. Backfill placement and compaction shall be constructed in accordance with the specifications herein and the product manufacturer’s published installation guides.
   2. Backfilling the exterior of the bioretention planter shall conform to COS standard Specification 2-10 and 2-11.
   3. Movement of construction machinery over a bioretention system at any stage of construction shall be prohibited. Any damaged structure shall be repaired or replaced.

G. Activation of Stormwater Bioretention System with Vertical Walls:
   1. The Stormwater Bioretention System shall be delivered and installed per manufacturer, as applicable. The Contractor shall take any and all necessary actions to protect the Bioretention Cells and pre-treatment structures from sediment, debris and other pollutants during construction. The manufacturer shall be contacted a minimum of three weeks prior to completion of construction to schedule activation of the Bioretention Systems.

END OF SECTION 33 47 50
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. This section specifies general requirements which are applicable to all mechanical equipment. The Contractor is responsible for ensuring that all mechanical equipment meets the requirements of this section in addition to the specific requirements of each individual equipment specification section.

B. Equipment Lists:

1. Equipment lists, presented in these specifications and as specified on the drawings, are included for the convenience of the Engineer and Contractor and are not complete listings of all equipment, devices and material required to be provided under this contract. The Contractor shall prepare his own material and equipment takeoff lists as necessary to meet the requirements of this project manual.

1.02 REFERENCES

A. This section contains references to the documents listed below. They are a part of this section as specified and modified. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, has been discontinued or has been replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABMA Std 9</td>
<td>Load Ratings and Fatigue Life for Ball Bearings</td>
</tr>
<tr>
<td>ABMA Std 11</td>
<td>Load Ratings and Fatigue Life for Roller Bearings</td>
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<td>ANSI B1.1</td>
<td>Unified Inch Screw Threads (UN and UNR Thread Form)</td>
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<td>Pipe Threads, General Purpose (Inch)</td>
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<tr>
<td>ANSI B16.1</td>
<td>Gray Iron Pipe Flanges and Flanged Fittings, (Classes 25, 125, and 250)</td>
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<tr>
<td>ANSI B18.2.1</td>
<td>Square and Hex Bolts and Screws (Inch Series)</td>
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<td>ANSI B18.2.2</td>
<td>Square and Hex Nuts (Inch Series)</td>
</tr>
<tr>
<td>ANSI S2.19</td>
<td>Mechanical Vibration – Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Unbalance, Including Marine Applications</td>
</tr>
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</table>
1.03 **DEFINITIONS**

(NOT USED)

1.04 **ADMINISTRATIVE REQUIREMENTS**

A. Unit Responsibility:

1. The Contractor shall cause equipment assemblies made up of two or more components to be provided as a working unit by the unit responsibility manufacturer, where specified. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance requirements. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement. The requirement for unit responsibility shall in no way relieve the Contractor of his responsibility to SPU for performance of all systems as provided in the General Conditions of the Contract Documents.

B. The Contractor shall ensure that all equipment assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Contractor to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, form and style specified in **Section 00 60 00, Sample Forms**, shall be signed by an officer of the unit responsibility manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.
1.05 QUALITY ASSURANCE

A. Arrangement:

1. The arrangement of equipment shown on the drawings is based upon information available to SPU at the time of design and is not intended to show exact dimensions conforming to a specific manufacturer. The drawings are, in part, diagrammatic, and some features of the illustrated equipment installation may require revision to meet actual submitted equipment installation requirements; these may vary significantly from manufacturer to manufacturer. The contractor shall, in determining the cost of installation, include these differences as part of his bid proposal. Structural supports, foundations, connected piping, valves, and electrical conduit specified may have to be altered to accommodate the equipment actually provided. No additional payment shall be made for such revisions and alterations.

B. Balance:

1. Unless specified otherwise, for all machines 10 HP and greater, all rotating elements in motors, pumps, blowers and centrifugal compressors shall be fully assembled, including coupling hubs, before being statically and dynamically balanced. All rotating elements shall be balanced to the following criteria:

\[
U_{\text{per}} = 6.015 \frac{GW}{N}
\]

a. Where:

1) \( U_{\text{per}} \) = permissible imbalance, ounce-inches, maximum
2) \( G \) = Balance quality grade, millimeters per second
3) \( W \) = Weight of the balanced assembly, pounds mass
4) \( N \) = Maximum operational speed, rpm

2. Where specified, balancing reports, demonstrating compliance with this requirement, shall be submitted as product data. Equipment balance quality grade shall be G 2.5 (G = 2.5 mm/sec) or better in accordance with ANSI S2.19.

C. Testing Agency Listing for Electrified Equipment:

1. Any equipment that utilizes electrical power shall be listed for such use by a third party testing agency such as Underwriters Laboratories (UL) or the Canadian Standards Association (CSA) acceptable to the Authority Having Jurisdiction (AHJ) as defined in the National Electrical Code. The acceptability of third party testing agencies may vary by electrical product. The electrical authority having jurisdiction for this project will be the City of Seattle. It shall be the Contractor’s responsibility to determine the product safety listing requirements by product type and to insure that such listings are provided for that equipment.
PART 2 - PRODUCTS

2.01 FLANGES AND PIPE THREADS

A. Flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.

B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise specified, flanges shall be flat faced.

C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.02 BEARINGS

A. Unless otherwise specified, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service specified. Each bearing shall be rated in accordance with the latest revisions of ABMA Methods of Evaluating Load Ratings of Ball and Roller Bearings. Unless otherwise specified, equipment bearings shall have a minimum L₁₀ rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.

C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.

D. All bearings accessible to touch, and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures, shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65 degrees C or less for continuous operation at bearing rated load and a 50 degrees C ambient temperature or shall be provided with appropriate shielding shall be provided that will prevent inadvertent human contact.

2.03 V-BELT ASSEMBLIES

A. Unless otherwise specified, V-belt assemblies shall be Dodge Dyna-V belts with matching Dyna-V sheaves and Dodge Taper-lock bushings, Wood's Ultra V-belts with matching Ultra-V sheaves and Wood's Sure-Grip bushings, or approved substitute.

B. Sheaves and bushings shall be statically balanced. Additionally, sheaves and bushings which operate at a peripheral speed of more than 5500 feet per minute shall be dynamically balanced. Sheaves shall be separately mounted on their bushings by means of three pull-up grub or cap tightening screws. Bushings shall be key seated to the drive shaft.
C. Belts shall be selected for not less than 150 percent of rated driver horsepower and, where two sheaves sizes are specified, shall be capable of operating with either set of sheaves. Belts shall be of the antistatic type where explosion proof equipment is specified.

2.04 PUMP SHAFT SEALS

A. General:
1. Seals for water and wastewater pump shafts shall be mechanical seals. Mechanical seals shall conform to the requirements set forth in this paragraph.

B. Mechanical Seals:
1. Unless otherwise specified in the detailed pump specifications, mechanical seals shall be split mechanical seals requiring no field assembly, other than assembly around the shaft and insertion into the pump. They shall be self-aligning, and self-centering, single seals. They shall be of a nondestructive (noffretting) type requiring no wearing sleeve for the shaft. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through the seal area (no shaft sleeve). Where the detailed specifications call for cartridge instead of split seals, all other requirements of this paragraph apply.

2. Metal parts shall be Type 316 or 316L stainless steel. Springs shall be Hastelloy C, Elgiloy, or other Duplex SS selected for resistance to chloride attack. Rotary faces shall be silicon carbide or chrome oxide. Stationary faces shall be silicon carbide for solids bearing fluid service and carbon for clean water service. Elastomers shall be ethylene propylene or fluorocarbon. Mechanical seals shall be suitable for operation between full vacuum (0 psia) up to 200 percent of the maximum specified operating pressure, but in any event not less than 200 psig.

3. Seal chambers shall be provided with vented solids removal restriction bushings except for enclosed line shaft pumps where the seal barrier fluid is used for line shaft bearing lubrication. The bushing shall both control the amount of flushing water flow and restrict solids and gas accumulation from the seal face area.

4. Candidate seals include:
   a. Chesterton 442 seals provided with Chesterton/SpiralTrac solids removal restriction bushings Version N or D, as recommended by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.
   b. AESSEAL RDS seals with Cyclops bushing.
   c. John Crane 3710 seals with Type 24SL bushing.

5. Seals on pumps shall be drilled and tapped for connection of a clean water flushing supply.

6. Seals for all vertical pumps (whether column or volute type) shall be provided with a second flush connection. Vertical pumps shall have a vent valve attached to the mechanical seal to eliminate air from the seal chamber prior to pump start; start-up procedures shall include venting instructions; and for remotely started pumps, the vent system shall be automated. Where specified in the detailed specifications, permissive confirmation automatic vent systems shall be provided.
2.05 COUPLINGS

A. Unless otherwise specified in the particular equipment sections, equipment with a driver greater than 1/2 HP, and where the input shaft of a driven unit is directly connected to the output shaft of the driver, shall have its two shafts connected by a flexible coupling which can accommodate angular misalignment, parallel misalignment and end float, and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of a tire with synthetic tension members bonded together in rubber. The flexible member shall be attached to flanges by means of clamping rings and cap screws, and the flanges shall be attached to the stub shaft by means of taper lock bushings which shall give the equivalent of a shrunk-on fit. There shall be no metal-to-metal contact between the driver and the driven unit. Each coupling shall be sized and provided as recommended by the coupling manufacturer for the specific application, considering horsepower, speed of rotation, and type of service.

B. Where torque or horsepower capacities of couplings of the foregoing type is exceeded, Thomas-Rex, Falk Steel Flex, or approved substitute, couplings will be acceptable provided they are sized in accordance with the equipment manufacturer's recommendations and sizing data are submitted. They shall be installed in conformance to the coupling manufacturer's instructions.

2.06 NAMEPLATES

A. Nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation and equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible and visible location with stainless steel screws or drive pins.

2.07 LUBRICANTS

A. The Contractor shall provide for each item of mechanical equipment a supply of the required lubricant adequate to last through the specified commissioning period. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of SPU's current lubricant supplier. The Contractor shall limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. Not less than 90 days before the date shown in his construction schedule for starting, testing and adjusting equipment (Section 01 75 00) the Contractor shall provide SPU with three copies of a list showing the required lubricants, after consolidation, for each item of mechanical equipment. The list shall show estimated quantity of lubricant needed for a full year's operation, assuming the equipment will be operating continuously.
2.08 ANCHOR BOLTS  
A. Anchor bolts shall be designed for lateral forces for both pullout and shear in accordance with the provisions of Section 05 05 33. Unless otherwise stated in the individual equipment specifications, anchor bolt materials shall conform to the provisions of Section 05 05 33.

2.09 SPARE PARTS  
A. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified by part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

PART 3 - EXECUTION

3.01 INSTALLATION  
A. Installation of equipment accessories included in this section shall be as recommended by the equipment manufacturer unless otherwise specified in the individual equipment specification section.

END OF SECTION 40 05 01
PART 1 - GENERAL

1.01 SUMMARY

A. This section specifies minimum requirements for rigid equipment mounts (baseplates, soleplates, and mounting blocks) and their installation on equipment pads. Completed equipment supports shall consist of equipment pads, equipment anchors, and rigid equipment mounts (baseplates, soleplates, or mounting blocks) set in grout.

B. Unless alternate requirements for equipment mounts are specified in the applicable equipment specification, the requirements of this section shall be applied to rigid mounts for all rotating or reciprocating equipment that is used to mix, convey, or pressurize fluids (gases and liquids). The requirements of this section shall also apply whenever referenced in specifications for other types of equipment. If conflict exists between this section and requirements of individual equipment manufacturers, the more restrictive requirements shall prevail.

C. Equipment Mount Requirements:

1. Unless otherwise specified, equipment and drivers shall be rigidly mounted on a common cast iron or fabricated steel baseplate or soleplate grouted into place on a concrete equipment pad. Under no circumstances shall baseplates, soleplates, or mounting blocks be grouted directly to concrete slabs or floors. Equipment that uses an interdependent equipment and driver mounting configuration (equipment that is bolted onto the driver frame and equipment that supports the driver entirely from the equipment frame) may be bolted directly on concrete or grout surfaces of equipment pads if the driver is less than five horsepower. Bolting equipment directly on concrete or grout surfaces of equipment pads is not acceptable for equipment and drivers that do not have an interdependent equipment and driver mounting configuration.

1.02 REFERENCES

A. This section contains references to the following documents. It is a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed document, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

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1.03 DEFINITIONS

A. Specific equipment mounting terminology used in this section conforms to the following definitions:

1. **Baseplate:**
   a. Fabricated (welded structural steel elements), cast, or plate steel base providing a common mounting element on which the legs, feet, or mounting surfaces of equipment are mounted by means of bolted connections.

2. **Soleplate:**
   a. A machined plate, spanning an opening in the floor or equipment pad, providing a common mounting element on which the legs, feet, or mounting surfaces of equipment are mounted by means of bolted connections.

3. **Mounting Blocks:**
   a. Multiple smaller baseplates on which individual legs, feet or equipment supports are mounted when equipment or drivers are not fastened to a common baseplate or sole plate.

4. **Equipment Pad:**
   a. Concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade.

5. **Mounting Pads:**
   a. Thickened or raised areas of baseplates and soleplates where the feet or mounting surfaces of mounted equipment and drivers are bolted and/or doweled to the baseplate or soleplate.

6. **Leveling Blocks:**
   a. Temporary steel blocks placed under baseplates, soleplates, or a mounting block at leveling positions (at equipment anchors) for the purpose of leveling baseplates, soleplates, or mounting blocks prior to grouting.
7. Shims:
   a. Thin stainless steel plates of a uniform thickness installed on top of Leveling Blocks for fine adjustment of level. Shims may also be used between equipment or drivers and baseplates, soleplates, or mounting blocks for equipment alignment purposes.

8. Wedges:
   a. Pairs of uniformly tapered metal blocks that are stacked with the tapered surfaces reversed (relative to the other wedge) so that the top and bottom surfaces of the wedges are parallel. Wedges are used between equipment pads and baseplates, soleplates, or mounting blocks for the purpose of leveling baseplates, soleplates, or mounting blocks.

9. Mounting Stud:
   a. Threaded rod or bolts anchored to baseplates, soleplates, or mounting blocks for the purpose of mounting equipment or ancillary devices onto baseplates, soleplates, or mounting blocks.

10. Reinforcement Dowels:
   a. Steel reinforcement rods embedded in concrete, across a cold joint, for the purpose of transferring loads or force across the joint.

11. Machine Alignment Dowels:
   a. Tapered diameter rods inserted in tapered diameter holes for the purpose of aligning machinery. The practice of drilling tapered diameter holes through machinery and baseplates so that Machine Alignment Dowels may be inserted to facilitate alignment of machinery is known as Doweling.

12. Leveling Position:
   a. A location on the top of a concrete equipment pad where leveling tools and equipment will be temporarily installed or used for the purpose of leveling baseplates, soleplates, and mounting blocks prior to grouting.

13. Grout Manufacturer:
   a. Refers to the manufacturer of the epoxy grout system used for installation of rigid equipment mounts.

14. Grout Manufacturer’s Technical Representative(s):
   a. Refers to the technical representative(s) of the Grout Manufacturer.

1.04 QUALITY ASSURANCE

A. Quality Control By Contractor:
   1. To demonstrate conformance with the specified requirements for rigid equipment mounts, the Contractor shall provide the services of an independent testing laboratory that complies with the requirements of ASTM E329. The testing laboratory shall sample and test equipment mount related materials as indicated in this section (40 05 02). Costs of testing laboratory services shall be borne by the Contractor.
2. For equipment with drivers 20 horsepower and greater, the Contractor shall furnish the services of a grout manufacturer's technical representative that has been factory trained by the grout manufacturer. The grout manufacturer's technical representative shall perform training and quality control of epoxy grout installation for rigid equipment mounts as indicated in this section (40 05 02).

1.05 SUBMITTALS

A. The following information shall be provided in accordance with the submittal requirements specified in Section 01 33 10.

1. A copy of this specification section, with addendum updates included, (referenced sections need not be included for Section 40 05 02) with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (☑) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration. Copies of this specification section shall be numbered and marked (specification number and equipment number) for inclusion (filing) with the associated equipment submittal requirements.

2. Schedule of rigid equipment mount installations specified in paragraph 2.01.

3. Name, employer and certificates or other information documenting compliance with the journeyman qualifications requirements for millwrights who will install rigid equipment mounts, as specified in paragraph 3.03 Leveling.

4. Certificates or other documentation issued by the epoxy grout manufacturer that demonstrates that the grout manufacturer's technical representative has been factory trained on installation of epoxy grout for equipment mounts, as specified in paragraph 1.02 Quality Control by Contractor.

5. Shop drawings for all equipment pads, equipment anchors, and baseplate, soleplate or mounting block details. Shop drawings shall depict size and location of equipment pads and reinforcement; equipment drains; equipment anchor, size, location, and projection; expansion joint locations; elevation of top of grout and grout thickness; elevation of top of baseplate; soleplate; or mounting block; size and location of electrical conduits; and any other equipment mounting features embedded in equipment pads. Shop drawings for equipment pads, equipment anchors, and baseplate, soleplate, or mounting blocks shall be numbered and marked (specification number and equipment number) for inclusion (filing) with the associated equipment submittal requirements.
PART 2 - PRODUCTS

2.01 GENERAL

A. Prior to initiating any installation efforts, the Contractor shall produce a rigid equipment mount installation schedule containing the expected dates for installing equipment anchors and preparation of equipment pads for leveling, grouting, and final equipment anchor clamping for each item of equipment. The schedule shall list the equipment, by equipment tag number, and shall list applicable equipment specification section, motor horsepower, and name of the Contractor's representative responsible for quality control during installation of rigid equipment mounts. The schedule shall be accompanied by written verification of equipment anchor clamping torque from the manufacturer of each item of equipment to be installed with rigid equipment mounts.

2.02 CONCRETE EQUIPMENT PADS

A. Concrete equipment pads shall be as shown in the structural details for equipment pads and equipment anchors for rigid mounted equipment.

B. The Contractor shall submit equipment anchor calculations for all equipment with drivers 20 horsepower and greater. Equipment anchor calculations shall demonstrate that equipment anchor size, embedment, and edge distance comply with the 2015 IBC with City of Seattle amendments, and are sufficient to resist the maximum lateral and vertical forces specified in Section 40 05 01. Equipment anchor calculations shall be sealed by a registered structural or civil engineer licensed in the State of Washington.

2.03 BASEPLATES, SOLEPLATES, AND MOUNTING BLOCKS

A. General:

1. Unless otherwise specified, Type I baseplates, soleplates, and mounting blocks shall be a minimum of 1 inch thick for equipment with drivers 20 horsepower and larger. All Type I baseplates, soleplates, and mounting blocks shall have edges of surfaces bearing on grout rounded to a radius of not less than 0.25 inch. Horizontal corners of Type I baseplates, soleplates, or mounting blocks shall be rounded to a radius of not less than two inches to avoid producing stress risers on the grouted foundation. Grout pouring holes (minimum 4 inches in diameter for epoxy grout, minimum 2 ½ inches in diameter for cementitious nonshrink grout) shall be provided in all baseplates and soleplates and all baseplates and soleplates shall have grout release holes. Mounting blocks may be grouted without grout pouring holes provided that no dimension of the mounting block (width or length) exceeds 18 inches. Grout relief or vent holes (minimum 1 inch in diameter) shall be provided in all baseplates, soleplates, and mounting blocks. Internal stiffeners shall be provided on all cast and fabricated baseplates and shall be designed to allow free flow of grout from one section of the baseplate to another. The minimum acceptable opening in cross bracing and stiffeners shall be 2-inches high by 6-inches in width. All welds shall be continuous and free from skips, blowholes, laps and pockets.
2. Mounting holes for equipment anchors shall be drilled through baseplates, soleplates, and mounting blocks. Mounting holes for equipment anchors shall not be burned out and they shall not be open slots. All mounting studs shall be Type 316 stainless steel. An anti-seize or anti-galling compound, as specified in paragraph 2.06, shall be applied to all mounting stud threads prior to installing nuts on mounting studs. Terminations requiring connections to baseplates, soleplates, or mounting blocks shall be acorn nuts welded to the under side of the baseplate or nuts welded to the underside of the baseplate and plugged with cork, plastic plugs or grease. In no case shall the fastener terminate only into the metal base. Where baseplates, soleplates, or mounting blocks are leveled using jackscrews, jackscrew threads shall be tapped in thickened pads or otherwise in sufficient metal to provide ease in adjusting level.

3. Mounting pads for equipment shall be machined after all welding and stress relieving and shall be coplanar within 0.002 inch per foot in all directions. Mounting pads shall extend not less than 0.5 inch beyond the perimeter of the foot or mounting surface of the mounted equipment, in any direction.

4. Equipment baseplates shall provide common support for the equipment and driver (and flywheel, if one is specified). Baseplates for equipment with drivers 20 horsepower and greater shall be furnished with eight transverse alignment (horizontal) positioning jackscrews for alignment of equipment drivers on horizontal surfaces of baseplates. Two of the eight transverse alignment/positioning jackscrews shall be installed in perpendicular directions in a horizontal plane at the mounting position for each corner or foot of the equipment driver. (Eight additional jackscrews shall be provided for transverse alignment of the flywheel, if flywheels are specified.)

5. Type I Baseplates:
   a. Type I baseplates shall be plate or fabricated structural steel baseplates with thickened steel mounting pads for doweling and bolting equipment to the baseplate. The baseplates shall be rectangular in shape for equipment other than centrifugal refrigeration machines and pump baseplates, which may be "T" or "L" shaped to accommodate the equipment drive and accessories. Baseplates for split case pumps shall include supports for suction and discharge elbows, if required by the specified configuration. Perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the baseplate. Beam depth need not exceed 14 inches provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.

2.04 **GROUT FOR EQUIPMENT PADS**

A. Epoxy Grout for Equipment Mounting:
   1. Unless otherwise specified, grout for setting bearing surfaces of baseplates, soleplates, and mounting blocks on equipment pads shall be Epoxy Grout for Equipment Mounting as specified in **Section 03 60 00**. Where the term epoxy grout is used in the context of details and specifications for equipment mounting it shall mean Epoxy Grout for Equipment Mounting.
B. Cementitious Nonshrink Grout:
   1. Cementitious Nonshrink Grout, specified in Section 03 60 00, may be used for setting bearing surfaces of baseplates, soleplates, or mounting blocks on equipment pads where equipment drivers are 20 horsepower and smaller and the combined weight of equipment and driver is less than 1000 pounds. Where the term nonshrink grout or cementitious grout is used in the context of details and specifications for equipment mounting it shall mean Cementitious Nonshrink Grout. Training and quality control by the grout manufacturer’s technical representative is not required for rigid equipment mounts installed with cementitious non-shrink grout.

2.05 EPOXY PRIMER
A. Epoxy primer shall be a lead free, chrome free, rust inhibitive, two-component epoxy primer specifically designed for use on metal substrates and in conjunction with epoxy grout. The epoxy primer shall be a product of the epoxy grout manufacturer.

2.06 ANTI-SEIZE/ANTI-GALLING COMPOUND
A. Anti-seize or anti-galling compound shall be a molybdenum disulfide and graphite combination in an aluminum complex base grease conforming to MIL-PRF-907E. Acceptable products include Jet Lube 550 by Jet Lube, Inc., E-Z Break by LA-CO, or approved substitute.

2.07 PRODUCT DATA
A. The following information shall be provided in accordance with the product data requirements specified in Section 01 33 10:
   1. Equipment anchor calculations specified in paragraph 2.02.
   2. Results of grout strength tests, as specified in paragraph 3.03 Grouting.
   3. Completed Rigid Equipment Mount Installation Inspection Checklist Forms (Form A), as specified in paragraph 3.02 Epoxy Grout Quality Control.
   4. List of Contractor’s equipment installation staff that has completed epoxy grout manufacturer’s grout installation training specified in paragraph 3.02 Epoxy Grout Training.

PART 3 - EXECUTION
3.01 GENERAL
A. Grouting for installation of equipment on equipment pads shall take place prior to connecting any field piping or electrical and instrumentation systems. Unless the Engineer accepts an alternate installation procedure in writing, baseplates, soleplates, and mounting blocks shall be leveled and grouted with the equipment removed. Pumps shall be installed in accordance with this section and ANSI/HI 1.4 or ANSI/HI 2.4, as appropriate for the type of pumping equipment installed.

B. Connecting piping with flexible connections and/or expansion joints shall be anchored such that the intended uses of these joints are maintained in the piping system without imposing strain on the equipment connections.
C. Where an equipment manufacturer’s installation requirements include a rigid connection between the machine and connecting piping systems, the Contractor shall delete any flexible coupling (including equipment connection fittings) shown on the drawings and install the equipment in the following manner, in lieu of installing the flexible coupling:

1. The equipment pad shall be prepared as shown on the details for rigid equipment mounts.

2. The baseplate, soleplate, or mounting blocks supporting the equipment shall be installed, leveled, and grouted in place as specified in this section.

3. The equipment shall be installed, aligned and doweled in place as specified in Section 40 05 03.

4. The piping shall be installed and aligned to the equipment connections and the field piping connections without welding one of the joints for one section of pipe between the equipment connection and the field piping and all valving. All flanged joints shall be bolted up and pressure tested.

5. All piping shall be fully supported by supports designed to accept their full weight and thrust forces.

6. The final sections of piping shall be aligned with the equipment and field connections without the use of jacks, chain falls or other devices to force it into alignment.

7. The final piping joints shall be welded only after the previous steps have been completed and accepted by the Engineer.

3.02 EPOXY GROUT TRAINING AND QUALITY CONTROL

A. Epoxy Grout Training:

1. Prior to commencing rigid equipment mount installation work on equipment pads, the Contractor shall furnish the services of a grout manufacturer’s technical representative to conduct a training school for the workers that will be using the epoxy grout for rigid equipment mount installations. The school shall be not less than 4 hours in length and shall cover all aspects of using the products, from mixing to application. This requirement, however, shall not be construed as relieving the Contractor of overall responsibility for this portion of the work. The epoxy grout manufacturer shall furnish a list of school attendees that have been satisfactorily trained to perform epoxy grout installation for equipment mounting.
B. Epoxy Grout Quality Control:

1. For equipment with drivers 20 horsepower and greater, the epoxy grout manufacturer’s technical representative shall provide quality control services for epoxy grout installation in rigid equipment mounts. The epoxy grout manufacturer’s technical representative shall be on site to inspect and verify that the application personnel have successfully performed surface preparation, epoxy grout application, and Quality Control Inspection in accordance with these specifications for a representative portion of the epoxy grout installation work.

   a. Specifically, the epoxy grout manufacturer’s technical representative shall perform the following services for at least one rigid equipment mount installation for each equipment type and size:

      1) Inspect ambient conditions during various phases of epoxy grouting installation for conformance with the epoxy grout manufacturer’s requirements.

      2) Inspect the surface preparation of concrete substrates onto which epoxy grout materials are to be applied, for conformance to the specified application criteria, including but not limited to substrate profile, degree of cleanliness, and moisture.

      3) Inspect the surface preparation of the metallic substrates onto which the epoxy primer is to be applied.

      4) Inspect the epoxy-primed metallic substrate for coverage and adhesion.

      5) Inspect preparation and application of epoxy grout form work for conformance to the specifications.

      6) Inspect and record that the “pot life” of epoxy grout materials is not exceeded during installation.

      7) Inspect epoxy grout for cure.

      8) Inspect and record that localized repairs made to grout voids are in conformance with the specification requirements.

      9) Conduct a final review of completed epoxy grout installation for conformance to these specifications.

     10) Attest to conformance of the Contractor’s work by signing appropriate entries in the “Rigid Equipment Mount Inspection Checklist,” Section 00 60 00.
3.03 INSTALLATION

A. Concrete Equipment Pad Preparation:
   1. After the concrete is fully cured, the top of the equipment pad shall be roughened by chipping the surface. Chipping shall remove all laitance and defective or weak concrete and result in a rough surface profile with a 0.25 inch minimum amplitude. Chipping shall expose broken aggregate without dislodging unbroken aggregate from the cement matrix and shall not cause fractures below the concrete surface. Leveling surfaces of the concrete that have been finished smooth and level for baseplate, soleplate, or mounting block leveling at equipment anchors shall be protected from damage during chipping. A light duty, hand held pneumatic chipper with a chisel type tool shall be used for chipping the equipment pad concrete surface. Abrasive blast, bush-hammer, jack hammers with sharp chisels, heavy chipping tools, or needle gun preparation of concrete surfaces to be grouted is not acceptable.
   2. Prior to leveling activities, satisfactory removal of defective or weak concrete shall be demonstrated in the presence of the Engineer by operating the chipper on the chipped concrete surface at locations identified by the Engineer. The chipped surface of the concrete shall be such that the final baseplate, soleplate, or mounting block elevation results in the grout manufacturer's recommended grout thickness between the surface of the equipment pad and the lower baseplate flange, underside of the soleplate or underside of mounting block.
   3. All dust, dirt, chips, oil, water, and any other contaminants shall be removed and the surface protected with plastic sheeting until grout is installed.
   4. Concrete equipment pad surfaces that have been finished smooth and level for use as leveling positions shall be protected from damage during chipping activities. Alternatively, leveling positions may be restored on chipped surfaces. Leveling positions shall be restored by installing leveling blocks or leveling plates for jackscrews on a high compressive strength epoxy putty (Philadelphia Resins, Phillybond Blue 6A, or approved substitute). Leveling blocks and leveling plates shall be installed level on the epoxy putty.

B. Baseplates, Soleplates, and Mounting Blocks:
   1. All surfaces of baseplates, soleplates, and mounting blocks to be in contact with epoxy grout shall be cleaned to SSPC SP-6 and shall be primed with epoxy primer within 8 hours of cleaning.

C. Leveling:
   1. All machinery shall be mounted and leveled by journeyman millwrights. Precision surveying equipment shall be used for leveling. Machinists' spirit levels will not be permitted for leveling purposes for any baseplate, soleplate, or mounting block with a plan dimension greater than 4 feet. Baseplates and mounting blocks shall be leveled to a maximum tolerance of 0.002 inch per foot or as otherwise required by the equipment manufacturer, if more stringent. Soleplates shall be leveled to 0.0005 inch per foot or as otherwise required by the equipment manufacturer, if more stringent. An anti-seize or anti-galling compound specified in paragraph 2.06 shall be applied to all equipment anchor threads prior to beginning baseplate, soleplate, or mounting block leveling.
2. All baseplates, soleplates, and mounting blocks shall be leveled against steel surfaces (jackscrew plates, leveling blocks, leveling nuts, support plates, or other steel surfaces). Use of other materials for leveling purposes is strictly and specifically prohibited. Unless otherwise specified, baseplates, mounting blocks, and soleplates shall be leveled as indicated in the leveling details. Leveling equipment and tools shall be stainless steel leveling blocks and shims, steel wedges, or jackscrews bearing on leveling plates. Leveling nuts may be used for leveling baseplates and soleplates weighing less than 200 pounds. The use of leveling nuts for leveling mounting blocks is not permitted.

3. After baseplates, soleplates, or mounting blocks have been leveled on the leveling equipment, the Contractor shall clamp the baseplates, soleplates, or mounting blocks in position by installing the equipment anchor nuts and washers. Clamping torque shall be less than the final clamping torque specified in paragraph 2.01, but sufficient to hold the baseplate, soleplate, or mounting block in position. The Contractor shall verify that the correct level and position of the baseplate, soleplate, or mounting block has been maintained after clamping on the leveling equipment.

4. Leveling blocks shall be stainless steel, four inches square and 1-1/2 inches thick with an open-ended slot terminating in the center for the equipment anchor. Leveling blocks shall be machined flat on all horizontal surfaces and placed under the baseplate or soleplate at each equipment anchor. Shims shall be pre-cut stainless steel, slotted for removal after grouting, and shall extend not less than three inches beyond the baseplate, soleplate or mounting block. Leveling blocks and shims shall be coated with a light oil just prior to beginning the leveling and grouting work. Shims shall be placed so the tabs on the shims are easily accessible.

D. Grouting:

1. Grout forms shall be built of minimum 0.75 inch thick waterproof plywood and shall be securely braced (minimum brace size shall be two-by-four lumber). Forms shall be designed for a minimum of 6 inches hydrostatic head above the final elevation of the grout, to assist in flow during installation. Equipment mounting grout shall be furnished with expansion joints installed at four to six foot intervals, perpendicular to the centerline of baseplates.

2. Forms shall be coated with three coats of paste wax on all areas that will come in contact with the grout to prevent the grout from bonding to the forms. Forms shall be waxed before assembly to prevent accidental application of wax to surfaces where the grout is to bond. Before any forms are installed, all concrete surfaces that will contact epoxy grout shall be free from any foreign material, such as oil, sand, water, wax, grease, etc. Forms shall be liquid-tight. Any open spaces or cracks in forms, or at the joint between forms and the foundation, shall be sealed off, using sealant, putty, or caulking compound. All outside vertical and horizontal edges of the grout shall have 45-degree chamfers as indicated in the equipment anchor details for rigid equipment mounts. Match chamfers in concrete portions of the equipment pad. Block outs shall be provided at all shimming and leveling positions to allow removal of leveling equipment and tools after the grout has cured. Jackscrews shall be coated with a light oil or other acceptable bond-breaking compound prior to grouting.
3. The 45-degree perimeter chamfer strip shall be located at the final elevation of the grout. The final elevation of the grout on baseplates with exposed I-beam or C-channel supports shall be at the top of the lower support flange. The top of the grout, on all other baseplates soleplates, and mounting blocks, shall be at least 1.0 inch above the bottom or underside of the baseplate, soleplate, or mounting block and shall not be higher than the top of the baseplate, soleplate, or mounting block. The grout's final elevation shall not be so high as to bond the equipment anchor nut and washer.

4. The resin and hardener for epoxy grout for equipment mounting shall be mixed in accordance with the epoxy grout manufacturer's recommendations. Epoxy grout shall be placed at the center of one end of the baseplate or soleplate and worked toward the ends in such a manner as to force the air out from beneath the baseplate or soleplate and out the vent holes, to eliminate voids. Epoxy grout shall be placed in a manner that avoids air entrapment, using a head box to pour grout into the grout holes. When the head box is moved to the next grout hole, a 6-inch high standpipe shall be placed over the grout hole and filled with grout. Use of vibrating tools and/or jarring (rapping or tapping) forms to facilitate grout flow is not permitted during placement of epoxy grout.

5. The Contractor shall exercise care to never allow the grout to fall below the baseplate level once the grout has made contact with the baseplate. Grout placement shall be continuous until all portions of the space beneath the baseplate, soleplate, or mounting block have been filled. Subsequent batches of grout shall be prepared so as to be ready when the preceding batch has been placed. Under no circumstances shall the grouting operation be halted because of lack of grout mix. After the entire baseplate is full, 6-inch high standpipes shall be maintained over each grout hole, to continue purging of air. When the grout has started to take an initial set (typically this is determined by a noticeable increase in temperature and no flow of grout at the vent holes) the standpipes shall be removed and excess grout cleaned from all surfaces.

6. Where the cavity under a baseplate or mounting block extends above the elevation of the top of the bolting flange for the baseplate or mounting block, grouting may be completed in two pours. Under these circumstances, the first grout pour shall be continuous until the lower face of the bolting flange for the baseplate or mounting block is submerged in grout a minimum of one inch. The second grout pour shall be completed with standpipes and air purges as specified in the previous paragraph.

7. Grout forms shall be checked for leaks throughout grout pours. Leaks shall be repaired immediately to prevent formation of voids. A final check of baseplate, soleplate, or mounting block level and elevation shall be performed before the grout sets.
8. A grout sample shall be taken for each equipment pad that has a baseplate, soleplate, or mounting block set in grout. The sample shall be placed in a cylinder of sufficient size to yield three two-inch cubes as test samples. The samples shall be tagged with project name, date, time, the equipment number and ambient temperature at the time of placement. Once the epoxy grout cylinder has been completely filled, it shall be placed next to the foundation of the equipment being grouted and allowed to cure for 48 hours. After 48 hours, the test cylinder shall be tested in accordance with the grout manufacturer’s recommendations by the independent testing laboratory specified in paragraph 1.02 Quality Control by Contractor. The results shall be reported directly to the Engineer. Forms shall be removed only after the grout has cured sufficiently and upon specific permission from the Engineer.

E. Completion:

1. Upon acceptance by the Engineer and the equipment manufacturer’s representative and after the grout has reached sufficient strength, grout forms and block outs at leveling positions shall be removed. Leveling blocks and shims or wedges and support plates shall be removed, leveling nuts and jack screws shall be backed off to allow the grout to fully support the baseplate, mounting block, or soleplate. Take care not to damage the grout during removal of extended shimming material or leveling equipment and tools.

2. The equipment anchor nuts shall be tightened, using calibrated indicating torque wrenches, to develop the full clamping force required by the equipment manufacturer.

3. Equipment anchor nuts shall be tightened in increments of not more than 25 percent of the final torque value in an alternating pattern to avoid stress concentration on the grout surface. After tightening equipment anchor nuts to final values, apply additional wax, grease, or mastic to all exposed portions of the equipment anchor beneath the baseplate, soleplate, or mounting block.

4. After applying additional wax or mastic to exposed portions of equipment anchors, block outs (pockets) for access to leveling nuts, leveling blocks and shims, or wedges shall be filled with the grout material installed under baseplates, soleplates, or mounting blocks and pointed after the equipment anchor nuts have been tightened to final values. Jackscrews shall be removed and holes in the baseplate, soleplate, or mounting blocks filled with a flexible sealant (silicone rubber) or a short cap screw.

5. Check for baseplate, soleplate, or mounting block movement (soft foot) by individually loosening and re-tightening each equipment anchor. Vertical movement at each equipment anchor shall be measured and recorded during loosening and retightening and shall not exceed 20 micrometers (0.001 inch). Vertical movement shall be measured using a magnetic-based dial indicator on the baseplate, soleplate, or mounting block referenced to the epoxy grout surface of the equipment pad or other approved method. Soft foot conditions shall be sufficient cause for removal and reinstallation of grout and baseplates, soleplates, or mounting blocks.
6. Check for grout voids by tapping along the upper surfaces of the baseplate, soleplate, or mounting block. Grout voids shall be sufficient cause for removal and reinstallation of grout and baseplates, soleplates, or mounting blocks. Grout voids shall be marked. At the discretion of the Engineer, grout voids may be repaired as specified in Chapter 5, Section 3.16 of API 686.

3.04 FINAL INSPECTION

A. The Engineer will conduct a final inspection with the Contractor for conformance to requirements of the contract documents.

END OF SECTION 40 05 02
PART 1 - GENERAL

1.01 SUMMARY
A. This section specifies vibration and critical speed limitations for rotating mechanical equipment. Factory and/or field testing and vibration measurements shall be taken when specified in the individual equipment specification sections.

1.02 REFERENCES
(NOT USED)

1.03 DEFINITIONS
(NOT USED)

1.04 VIBRATION LIMITATIONS
A. General:
   1. Vibration frequencies shall span the range from 5.0 to 5000 Hz. Where specified, measurements shall be obtained while the installed equipment is operating within the specified speed range.

B. Centrifugal:
   1. Machines With Sleeve Bearings:
      a. Unless otherwise specified, centrifugal machines with sleeve bearing shafts shall not exhibit unfiltered RMS readings for vibration displacement in excess of the following:

<table>
<thead>
<tr>
<th>Shaft Speed Range, RPM</th>
<th>Displacement, Peak to Peak, Mils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 900</td>
<td>3.5</td>
</tr>
<tr>
<td>901-1800</td>
<td>3.0</td>
</tr>
<tr>
<td>1801-3000</td>
<td>2.5</td>
</tr>
<tr>
<td>3001-4500</td>
<td>2.0</td>
</tr>
<tr>
<td>Above 4500</td>
<td>1.6</td>
</tr>
</tbody>
</table>

      b. Displacement measurements shall be taken radially on the shaft at two points at each bearing, except for well pumps which shall be measured at top of motor. Measuring points shall be 90 degrees apart.

   2. Machines with Antifriction Bearings:
      a. Unless otherwise specified, centrifugal machines with antifriction bearing shafts shall not exhibit unfiltered RMS readings for vibration velocity in excess of 0.12 inch per second. Velocity measurements shall be taken on one point of each bearing housing.
1.05 CRITICAL SPEED REQUIREMENTS

A. Unless otherwise specified, rotating mechanical equipment shall not exhibit critical speeds within the specified range of operating speeds. Critical speeds for equipment with rigid rotor systems shall be at least 20 percent greater than maximum operating speed. Critical speeds for equipment with flexible shaft-rotor systems shall be at least 15 percent below minimum operating speed and 20 percent above maximum operating speed.

PART 2 - PRODUCTS

2.01 PRODUCT DATA

A. Manufacturer’s certified data showing location of critical speeds in relation to operating speeds shall be provided as product data in accordance with Section 01 33 10.

PART 3 - EXECUTION

(NOT USED)

END OF SECTION 40 05 04
PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section, when referenced in the detailed specification section, provides minimum requirements applicable to centrifugal and axial-flow pumping equipment furnished under this contract. More restrictive requirements, where found in individual pump specifications, supersede requirements of this section.

2. “Detailed pump specification,” “detailed specification,” “individual pump specification,” “referencing section,” or words of similar import in this section, mean the specification section where the requirements for specific pump performance are presented. “Pumping unit,” whenever and wherever used, means the complete pumping assembly, including driver (whether engine, turbine, or motor) and includes accessories such as variable-speed drives required for motor operation, gear reducers, intermediate shafting and bearings, flywheels, and supports for equipment furnished with the pump.

3. For a subset of pumps, a number of provisions of this section are required. These requirements (refer to paragraphs 1.05 and 1.07 in this section) are in addition to requirements applicable to pumps. The subset of pumps is defined as pumping equipment meeting any of the following criteria:
   a. All pumping unit specifications where the words “custom-engineered” appear in the title of the specification section
   b. Where a particular Section 40 05 05 provision is cited in the detailed section

1.02 REFERENCES

A. This section (Section 40 05 05) contains references to the following documents. They are a part of this section and any referencing section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. The following order of precedence prevails in the event of conflict between the requirements of this section or any referencing section and those of the listed documents (in the order of primacy):

1. The referencing section
2. This section
3. The referenced document

B. Unless otherwise specified, references to documents mean the documents in effect at the time of advertisement for bids or invitation to bid (or on the effective date of the agreement if there were no bids). References to documents mean the replacement documents issued or otherwise identified by the organization if referenced documents have been discontinued, or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>ABMA 9</td>
<td>Load Ratings and Fatigue Life for Ball Bearings</td>
</tr>
<tr>
<td>ABMA 11</td>
<td>Load Ratings and Fatigue Life for Roller Bearings</td>
</tr>
<tr>
<td>AISC</td>
<td>American Institute of Steel Construction—Manual of Practice</td>
</tr>
<tr>
<td>ANSI/API 610</td>
<td>Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas</td>
</tr>
<tr>
<td></td>
<td>Industries (also referenced as ISO 13709-2009)</td>
</tr>
<tr>
<td>ANSI/ASME B46.1</td>
<td>Surface Texture, Surface Roughness, Waviness and Lay</td>
</tr>
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<td>ANSI/HI 1.1–1.6</td>
<td>Rotodynamic (Centrifugal) Pumps</td>
</tr>
<tr>
<td>ANSI/HI 2.1–2.4</td>
<td>Rotodynamic (Vertical) Pumps</td>
</tr>
<tr>
<td>ANSI/HI 9.1–9.5</td>
<td>Pumps – General Guidelines for Types, Applications, Definitions,</td>
</tr>
<tr>
<td></td>
<td>Sound Measurements and Documentation</td>
</tr>
<tr>
<td>ANSI/HI 9.6.1</td>
<td>Rotodynamic Pumps—Guideline for NPSH Margin</td>
</tr>
<tr>
<td>ANSI/HI 9.6.2</td>
<td>Centrifugal and Vertical Pumps for Allowable Nozzle Loads</td>
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<td>ANSI/HI 9.6.3</td>
<td>Rotodynamic Pumps (Centrifugal and Vertical) Guideline for</td>
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<td>Allowable Operating Region</td>
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<td>ANSI/HI 9.6.4</td>
<td>Rotodynamic Pumps—Vibration Measurements and Allowable Values</td>
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<td>ANSI/HI 9.6.6</td>
<td>Rotodynamic Pumps for Pump Piping</td>
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<td>ANSI/HI 9.6.8</td>
<td>Rotodynamic Pumps—Guideline for Dynamics of Pumping</td>
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<td>Machinery</td>
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<td>ANSI/HI 9.8</td>
<td>Pump Intake Design</td>
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<tr>
<td>ANSI/HI 11.6</td>
<td>Submersible Pump Tests</td>
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<tr>
<td>ANSI/HI 14.6</td>
<td>Rotodynamic Pumps for Hydraulic Performance Acceptance Tests</td>
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<tr>
<td>API 686/PIP REIE 686</td>
<td>Recommended Practices for Machinery Installation and</td>
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<tr>
<td></td>
<td>Installation Design</td>
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<tr>
<td>ASME B18.8.2</td>
<td>Taper Pins, Dowel Pins, Straight Pins, Grooved Pins, and Spring</td>
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<tr>
<td></td>
<td>Pins (Inch Series)</td>
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<tr>
<td>ASME Code</td>
<td>ASME Boiler and Pressure Vessel Code</td>
</tr>
<tr>
<td>ASTM A27</td>
<td>Steel Castings, Carbon, for General Application</td>
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<tr>
<td>ASTM A36</td>
<td>Carbon Structural Steel</td>
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<td>ASTM A148</td>
<td>Steel Castings, High Strength, for Structural Purposes</td>
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<tr>
<td>ASTM A322</td>
<td>Steel Bars, Alloy, Standard Grades</td>
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<tr>
<td>ASTM A564</td>
<td>Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars</td>
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<td>and Shapes</td>
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<td>ASTM A571</td>
<td>Austenitic Ductile Iron Castings for Pressure-Containing Parts</td>
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<td>Suitable for Low-Temperature Service</td>
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<td>ASTM A995</td>
<td>Standard Specification for Castings, Austenitic-Ferritic (Duplex)</td>
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<td>Stainless Steel, for Pressure-Containing Parts, Grades 2A, 3A, or</td>
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<tr>
<td></td>
<td>6A</td>
</tr>
<tr>
<td>ASTM B148</td>
<td>Aluminum-Bronze Sand Castings</td>
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<tr>
<td>AWWA C213</td>
<td>Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel</td>
</tr>
<tr>
<td></td>
<td>Water Pipelines</td>
</tr>
</tbody>
</table>
## 1.03 DEFINITIONS

A. The following definitions apply for classifying pumps specified in this and referencing sections:

1. **General**: Terminology and definitions in this section follow those established in American National Standards Institute (ANSI)/Hydraulic Institute (HI) 9.1 through 9.5, unless otherwise noted.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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<tbody>
<tr>
<td>AWWA C550</td>
<td>Protective Epoxy Coatings for Valves and Hydrants</td>
</tr>
<tr>
<td>NSF/ANSI 61</td>
<td>Drinking Water System Components – Health Effects</td>
</tr>
<tr>
<td>ISO 10816-3</td>
<td>Mechanical Vibration—Evaluation of Machine Vibration by Measurement on Non-rotating Parts—Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ, Annex A, Table A.1 and A.2. For the purposes of this specification, Annex A of ISO 10816, Part 3 forms a part of this specification and ISO 10816, Part 3.</td>
</tr>
<tr>
<td>MIL STD 167-2</td>
<td>Mechanical Vibrations of Shipboard Equipment (Reciprocating Machinery and Propulsion System and Shafting)</td>
</tr>
</tbody>
</table>
2. **Solids-bearing liquids:** Liquids to be pumped containing, or assumed to contain, solids that require appropriate pump design considerations and/or materials of construction. Solids-bearing liquids are liquids with settleable solids exceeding 50 milligrams per liter (mg/L) and include wastewater, stormwater, primary effluent, return sludge, return activated sludge (RAS), trickling filter circulation, and similar services.

3. **Clear liquids:** Liquids to be pumped mostly free of deleterious solids. Potable water, heat reservoir, raw water, secondary effluent pumping, and similar services are clear liquids.

4. **Efficiency:** For the purposes of this section and sections referencing this section, efficiency, as related to pumps, is the ratio of the pump output power (water horsepower [hp]) divided by the pump input power (brake horsepower) required to deliver the total head, with meanings as defined in ANSI/HI 1.2.3.8 and ANSI/HI 2.2.3.8. For column-type pumps, efficiency is computed inclusive of inlet, bowl, column, and discharge head losses.

5. **Net positive suction head, 3 percent reduction (NPSH3):** For the purposes of this section and sections referencing this section, NPSH3 means the value of net positive suction head (NPSH) resulting in a reduction of 3 percent in the developed pump discharge head when the pump is tested in accordance with procedures established by ANSI/HI. NPSH3 is the successor designation to net positive suction head required (NPSHR). Where NPSHR is used in the contract documents it means NPSH3.

6. **NPSH margin:** For the purposes of this section and sections referencing this section, “NPSH margin,” wherever used, means net positive suction head available (NPSHA) divided by the candidate pump’s NPSH3 for the specific operating condition in question.

7. **POR:** preferred operating region as defined in ANSI/HI 9.6.3.

8. **AOR:** allowable operating region as defined in ANSI/HI 9.6.3.

1.04 **TYPE**

A. Provisions and requirements contained in this section apply specifically to centrifugal and axial-flow pumps, both vertical and horizontal, commonly falling into the generic types covered by ANSI/HI 1.1 through 1.4, and 2.1 through 2.4. This section does not apply, except by specific reference, to positive-displacement pumps of any type.
1.05 DESIGN REQUIREMENTS, ALL PUMPS

A. General:

1. Conform equipment furnished under sections referencing this section to the objective of paragraph 6.1.1, ANSI/API 610, and ensure that the equipment and “auxiliaries” are designed for at least a 20-year service life and 3 years of “uninterrupted operation.” Select all components associated with the rotating elements in the drive train, including equipment supports and supports for rotating elements, that are designed to function without damage or disassembly at reverse rotational speeds up to 130 percent of maximum operational speed during flow reversals through the pump. Ensure that the complete pumping unit operates without overload on any component at any point along the pump’s entire full-speed operating curve. Furnish pumps required by virtue of the specified operating conditions to operate against a closed valve or throttled for any period of time exceeding 5 seconds with drivers sized to operate continuously at the power requirement for that condition even though the power requirements at the rated condition may be less.

2. With the exception of submersible pumps and the inlet connection for pumps designed to operate in open forebays or wetwells, ensure that pump connection nozzles are designed for the loads and moments stipulated in ANSI/HI 9.6.2. Where ANSI/HI 9.6.2 does not cover a specific pump type or category, or where that document is silent on allowable nozzle loads or a particular type of nozzle load (e.g., thermal pipe strain), have the contractor furnish documentation from the manufacturer attesting to the limitations on loads and moment forces that can be tolerated on each connection and recommended connection details to be used.

B. Pump Selection:

1. Proven designs:

a. Ensure that pumps furnished under sections referencing this section are proven designs that have been in similar conditions of service with no objectionable performance characteristics for a period of not less than 5 years. Have the contractor furnish a detailed list of installations with contact information supporting qualification under this requirement with the information required under paragraph 1.08. To satisfy this requirement, ensure that the listed pump is of the same size volute or bowl, discharge case and nozzle size, and impeller design (including number of vanes) and is operating under similar conditions of pumped fluid, head, capacity, speed, rotation, and NPSHA.
b. The contractor may propose alternative equipment that cannot meet the requirement for a proven design under this paragraph, subject to additional documentation requirements and under the following conditions:

1) The proposed design has been in successful operation under similar conditions of volute or bowl, discharge case and nozzle size, impeller design (including number of vanes), pumped fluid, head, capacity, rotation, and NPSHA, but at a higher speed for a period of not less than 3 years.

2) The proposed design has been in operation in designs where both larger and smaller nozzle size pumps have been in service for a period of not less than 5 years, and impeller design (including number of vanes, plus or minus one vane in pumps with four or more vanes), pumped fluid, head, capacity, speed, and NPSHA are similar to that for the proposed installation and within one synchronous speed higher or lower than that indicated in the detailed specification.

3) In addition to the installation list required under this paragraph, provide dimensional drawings, bill of materials, and historical (certified) shop test results for candidate pumps documenting performance including, but not limited to head, capacity, speed, and NPSHR, and limit of stable hydraulic operation based on the onset of suction recirculation, if available. Results should match or bracket the specified performance and two or more candidate pump results may be required.

c. If the proposed pump is not a proven design under either of the above paragraphs, have the contractor demonstrate, by operation of a test pump in a fully equipped hydraulic test facility, that the proposed pump in the size and at the speed proposed with the proposed impeller design will have acceptable operating characteristics under the conditions specified for the proposed installation. Set up the test pump and perform a witnessed demonstration prior to designing, fabrication, and testing of any of the equipment proposed for the specific installation.

2. General performance criteria:

a. Ensure that pumps furnished under this section and any referencing section operate without loss of head due to cavitation or vibration over the entire specified range of flow and head conditions and are specifically selected for NPSH margin requirements detailed in paragraph 1.04 NPSH margin limitations. Pump selections that do not provide the specified margin will be rejected.
3. General design criteria:

a. Select pumps furnished under sections referencing this section that are designed in accordance with applicable portions of ANSI/HI 1.1–1.4, 2.1–2.4, 9.6.2, 9.6.3, 9.6.4, 9.6.6, and 9.6.8 and the requirements of this section. Select pumps that are specifically designed to pump the fluid described in the detailed specification and to operate without clogging or fouling caused by material in the pumped fluid at any operating condition within the range of service specified. Clogging or fouling conditions may be of any cause, demonstrated by a 5 percent or greater capacity drift within 2 hours of sustained operation.

b. Unless otherwise noted or specified, slope pump head capacity curves in one continuous curve within the specified operating conditions. Do not permit points of reverse slope inflection capable of causing unstable operation within the specified zone of continuous-duty operation. Pumps with head/capacity curves with a reverse inflection are specifically prohibited if these characteristics will cause unstable operation within the specified range of operating conditions and where startup/shutdown conditions entail operation against a slow opening/closing valve.

c. Ensure that column-type (vertical-turbine, vertical-column solids-handling, and axial-flow propeller and mixed-flow) pumps have bells selected to provide intake velocity of not less than 3.5 feet per second (ft/s) or more than 4.0 ft/s when operating at the maximum specified flow or the flow resulting from the lowest specified operating head at maximum speed, whichever is greatest (“peak flow”). Select pump discharge column sizes to limit the calculated average velocity at peak flow to no more than 12 ft/s.

d. Ensure that pumps specified to operate at constant-speed function without loss of head or capacity due to cavitation or excessive vibration over the entire specified range of flow and head conditions defined by the region bounded by Condition Points A, B, and C and any other continuous-duty operating condition specified in the detailed specification referencing this section, and select pumps to place Condition Point C in the detailed specification within the POR, or a modified POR if stipulated in the detailed pump specification.

e. Ensure that pumps specified to operate at variable-speed function without loss of head or capacity due to cavitation or excessive vibration over the entire specified range of flow and head conditions defined by the region bounded by Condition Points A, B, and C and any other continuous-duty operating condition specified in the detailed specification referencing this section. Ensure that unless otherwise specified in the section referencing this section, acceptance criteria include the following:

1) Ensure that Operating Condition Point C and any other continuous-duty operating point specifically required in the detailed specification reside within the region defined by the POR, or in a modified POR if stipulated in the detailed pump specification.
2) Unless otherwise noted in the detailed specification referencing this section, Operating Condition Point A may reside in the area outside the POR; Condition Point C will be located within the POR, or in a modified POR if stipulated in the detailed pump specification; and Condition B will preferably be located within the POR, or within 5 BEPQ percentage points (in terms of flow) outside the POR so long as Condition Point C resides in the POR or the stipulated modified range.

4. POR:
   a. Unless otherwise specified, the POR for a given pump is as defined in ANSI/HI 9.6.3.
   b. The detailed specifications may stipulate a narrower POR than indicated in ANSI/HI 9.6.3.
   c. Do not let suction-specific speed (Nss) exceed 8,500, unless otherwise indicated in the detailed specifications.
   d. For high-Nss pumps (greater than 8,500) and other conditions as determined by the engineer, a narrower stable operating region may be defined in the detailed specifications and then identified in ANSI/HI 9.6.3 for the POR. The detailed specifications take precedence over this section.
   e. The detailed specification sections identify the duty points that must be within a pump’s POR and those that may be within the AOR and take precedence over this section.

C. Critical Speeds and Natural Frequencies:

1. General:
   a. The criteria of this paragraph applies to pumps, provided that the foundation and support details provided at the time of pump design are accurate. Repair or replace pumps exhibiting adverse behavior after installation from resonance, vibration, or fatigue at no cost to the owner. The criteria apply to the equipment in “like-new” condition as well as the “as-worn” condition (i.e., when parts, individually and as a composite, reach the manufacturers’ maximum tolerances). Critical speed and natural frequency data submittal requirements depend upon the pump:
      1) For the more critical pumps that are covered under paragraph 1.05, the contractor is required to submit analytical reports confirming requirements on critical speeds and natural frequencies prior to pump fabrication as specified in that paragraph
      2) Unless otherwise specified, for constant-speed pumps and variable-speed pumps with suction size less than 6 inches diameter, no critical speed submittal is required
2. Lateral rotor and structural dynamics:
   a. Ensure that the complete pumping unit, composed of the entire rotating group and related frames, supports, enclosures, housings, and casings, is free from critical speeds from 15 percent below to 25 percent above the operating speeds required to achieve the specified performance characteristics (critical avoidance zone). A critical speed is defined as any damped natural frequency with a logarithmic decrement less than +0.3 that has an interference with a primary excitation order in the critical avoidance zone. Analyze backward rotation for rubber-bearing vertical-column pumps. The critical avoidance zone, interferences, and possible critical speeds can be illustrated on a natural frequency map as presented in the figure below. In the figure, three natural frequencies are shown with forward and backward modes. Only two of those modes, 1F and 2F, have interferences with primary excitation orders. Whether these are critical speeds is determined by the value of log decrement at the intersection. Note that higher order modes, such as 2F, have the same log decrement criterion as the first mode.

![Natural Frequency vs Operating Speed Diagram](image-url)
b. Process sensitivities are such that operation at infinitely variable speed within the specified operational conditions is an absolute requirement. Any remedy imposing a locked-out speed interval or intervals will not be considered an acceptable remedy for identified critical speeds. Acceptable remedies include combinations of adjustments in rotor geometry or materials, and the substitution of energy-absorbing couplings. Other remedies may be considered so long as they are justified in writing and the proposal is sealed and signed by the design professional retained by the manufacturer to perform the system mass elastic system analyses.

3. Torsional rotordynamics and combined shaft stress:
   a. Ensure that the complete rotating group is free from critical speeds from 10 percent below to 20 percent above the operating speeds required to achieve the specified performance characteristics (critical avoidance zone). A critical speed is defined as any damped natural frequency with a logarithmic decrement less than plus 0.3 that has an interference with a primary excitation order in the critical avoidance zone.

   b. If efforts to remove torsional critical speeds are unsuccessful, perform a combined shaft stress analysis to demonstrate that the response does not adversely affect the entire rotating group fatigue life. Ensure that the combined shaft stress analysis considers any speed in the critical avoidance zone and during startup, shutdown, or motor control transients if synchronous motors are specified.

   c. For constant-torque applications, ensure that the pump-rotating group is free from torsional response that produces combined (steady plus alternating torque induced) stresses exceeding 50 percent of the material’s fatigue limit or 30 percent of the material’s elastic limit (but no more than 18 percent of the material’s ultimate tensile strength) if relevant fatigue data for the selected material are not available.

   d. For variable-torque applications (including variable-speed pumps, vertical pumps, and pumps with large overhung loads) ensure that the pump rotating group is free from torsional response that produces combined (torsional steady and alternating) peak shear stresses at points of stress concentration (calculated in accordance with the requirements of paragraph 1.05E.3 Torosional Shaft Stresses) that exceed 50 percent of the material’s fatigue limit or 4 percent of the material’s ultimate tensile strength (as per United States Military Standard [MIL STD] 167-2) if relevant fatigue data for the selected material are not available.

   e. Document the source of fatigue data used in lieu of elastic or ultimate strength ratios in the analysis report submittal.

D. Impeller clearances, vane-passing frequency, and impeller keyways:
   1. Ensure that the radial clearance between the tip of the impeller vane and diffuser or volute vanes is not less than 3 percent and 6 percent, respectively, of impeller diameter. Select a pump that is designed so that internal geometry does not cause uneven flow distribution at impeller vane inlets.
2. Ensure that impeller vane combinations are not an even multiple of diffuser vanes in column-type pumps.

3. Cut impeller keyways for multistage column-type pumps at differing positions and provide equal angular spacing on the impeller shaft to avoid multiple simultaneous vane-passing pulses.

E. Component design criteria:

1. General:
   a. Unless otherwise specified, ensure that combined stresses in steel frames and supports does not exceed those permitted by the American Institute of Steel Construction (AISC) Manual of Practice. Ensure that combined stresses in cast, forged, rolled, or fabricated pressure-retaining components, frames, and supports does not exceed that allowed for the given material in Section VIII, Division 1 of the American Society of Mechanical Engineers (ASME) Code. Ensure that design pressures for pressure-retaining parts are not less than 50 percent greater than the pump’s shutoff head at the manufacturer’s listed maximum operating speed. Ensure that the pump casing strain at any head on the full-speed operating curve (including allowances for increases caused by specified multistage applications) do not result in distortions at the bearing housings greater than the maximum allowable by the bearing manufacturer to provide the specified bearing life.

   b. The term “combined stresses” in this section means the sum of operating stresses, including stresses induced by dynamic and static forces as developed via the analysis procedures stipulated in this section. Static forces (x, y, z, and moments in planes) include the relevant maximum nozzle loads specified in ANSI/HI 9.6.2 or as stipulated by the pump manufacturer. Dynamic forces include both steady-state and transient stresses induced by operating conditions within the zone of operation established by the specified operating conditions.

2. Anchorage and equipment mounts:
   a. Have the contractor hold the pump manufacturer responsible for the design of the anchor-bolting system and equipment supports for each separately mounted component furnished under the detailed specification. Conform anchorage and equipment support requirements for pumps to the requirements of Section 40 05 02.

   b. BC’s structural staff now maintain and update seismic and anchorage requirements in Section 01 73 23. Include Section 01 73 23 in the document set. Select anchor bolts and connecting bolts for pumps and assemblies supported by other assemblies furnished under this section, or sections referencing this section, that are designed in accordance with Section 01 73 23. Ensure that all operation and maintenance (O&M) manuals for pumps and assemblies contain criteria for anchor and baseplate bolt torque values.
c. Ensure that equipment mounts for vertical (column- and volute-type) pumps weighing more than 1,000 pounds, with discharge nozzles 6 inches in diameter and greater, employ soleplates conforming to the requirements of Section 40 05 02. Provide soleplate mounting conforming to Section 40 05 02 for separately supported components in the pump drive system. Fabricated steel supports regardless of design, and the nature of the structural shapes used for such proposed supports, will not be accepted.

d. Select soleplates that are designed to span openings for equipment connections and provide access to maintenance points. Ensure that soleplates are of sufficient section to key, not less than 1 inch, into the supporting grout provided for bonding the soleplate to the structure. Provide soleplates of sufficient size to bolt the pump base to the soleplate [and allow doweling the pump base to the soleplate] without encumbering the anchor bolts required for clamping the soleplate to the structure.

e. Select equipment mounts for horizontal pumps that are designed in accordance with Section 40 05 02 and ANSI/HI 1.3.8-2013, and ensure that they provide common support for the pump and motor (and flywheel, if one is specified). Conform baseplate bolting to assumptions contained in ANSI/HI 9.6.2. [Drill and dowel pin the pump base to the baseplate in addition to bolting.]

f. Use tapered dowel pins when required in the detailed specification to record the final position of machine bases on soleplates or pump baseplates. Where specified, harden and machine-ground dowel pins, conforming to the requirements of ANSI/ASME B18.8.2. Conform holes for tapered dowels to the requirements set forth in Appendix A of ANSI/HI B18.8.2.

3. Torsional shaft stresses:
   a. Calculate shaft stresses using the following equation and the stress concentration factors in the tables below:

   \[ S = S_{cf} \times \frac{G \times D \times \Delta \Theta}{2 \times L} \]

   where:

   - \( S \) = stress, pounds per square inch (psi)
   - \( S_{cf} \) = stress concentration factor, dimensionless
   - \( D \) = minimum shaft diameter at point of concentration, inches
   - \( \Delta \Theta \) = twist in shaft between adjacent masses, radians
   - \( L \) = effective length between masses, inches
   - \( G \) = shear modulus of shaft material, psi
b. Ensure that the $S_{cf}$ to be applied at changes in shaft diameter is as follows:

```
<table>
<thead>
<tr>
<th>Shaft diameter ratio D/d = 1.05</th>
<th>Shaft diameter ratio D/d = 1.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r/d$</td>
<td>$S_{cf}$</td>
</tr>
<tr>
<td>0.0025</td>
<td>2.67</td>
</tr>
<tr>
<td>0.0100</td>
<td>1.84</td>
</tr>
<tr>
<td>0.0200</td>
<td>1.58</td>
</tr>
<tr>
<td>0.0300</td>
<td>1.47</td>
</tr>
<tr>
<td>0.0400</td>
<td>1.39</td>
</tr>
<tr>
<td>0.0500</td>
<td>1.34</td>
</tr>
<tr>
<td>0.1000 and greater</td>
<td>1.22</td>
</tr>
</tbody>
</table>
```

c. Ensure that the $S_{cf}$ to be applied at circumferential shaft grooves is as follows:

```
<table>
<thead>
<tr>
<th>Shaft diameter ratio D/d = 1.05</th>
<th>Shaft diameter ratio D/d = 1.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r/d$</td>
<td>$S_{cf}$</td>
</tr>
<tr>
<td>0.0025</td>
<td>3.73</td>
</tr>
<tr>
<td>0.0100</td>
<td>2.34</td>
</tr>
<tr>
<td>0.0200</td>
<td>1.92</td>
</tr>
<tr>
<td>0.0300</td>
<td>1.74</td>
</tr>
<tr>
<td>0.0400</td>
<td>1.64</td>
</tr>
<tr>
<td>0.0500</td>
<td>1.57</td>
</tr>
<tr>
<td>0.1000 and greater</td>
<td>1.39</td>
</tr>
</tbody>
</table>
```
d. Ensure that the $S_{cf}$ to be applied at the roots of keyways is as follows:

\[
\begin{array}{|c|c|}
\hline
\text{r/D} & \text{$S_{cf}$} \\
\hline
0.0025 & 4.35 \\
0.0100 & 3.20 \\
0.0200 & 2.64 \\
0.0300 & 2.43 \\
0.0400 & 2.32 \\
0.0500 & 2.25 \\
0.1000 & 2.12 \\
\hline
\end{array}
\]

\(a.\) Base values of $S_{cf}$ between data points in the tables above upon a straight line interpolation.

4. Shaft deflection:

a. Select pump shafts installed on volute-type pumps to provide sufficient stiffness to operate without distortion or damaging vibration throughout the range of service specified. Limit shaft deflection at the face (impeller side) of the shaft seal to no more than 2 mils at any operating condition within the zone described by the specified continuous-duty operating conditions. Calculate deflection at the shaft seal as required by provisions set forth in ANSI/HI 1.3.

5. Bearings:

a. Unless otherwise specified, select anti-friction bearings for pumps for a minimum L–10 life of 50,000 hours in accordance with ABMA 9 or 11. Ensure that anti-friction bearings for custom-engineered pumps have bearings selected for an L–10 life of 100,000 hours in accordance with ABMA 9 or 11. Select bearings for other elements in the rotating system such as motors, intermediate shaft bearings, and flywheel bearings using the same criteria as specified for the pump. Base bearing selection upon the worst combination of continuous-duty operating conditions specified, and include both steady-state and transient loads. Provide calculations supporting the selection of bearing sizes as Product Data.

6. Bearing isolators:

a. Unless otherwise specified, fit pump and motor bearings with bearing isolators, specifically selected for the size and type of bearing. Provide bearing isolators that are the labyrinth, non-fretting type designed to expel contaminants by centrifugal force and prevent the escape of lubricants. Provide vapor-block capability. Ensure that the bearing seals are Inpro/Seal, or an approved substitute.
7. Pump shaft seals:
   a. Unless otherwise specified in the detailed specification, pump shaft seals must be mechanical seals as specified in Section 40 05 01.

F. NPSH margin limitations:
   1. General:
      a. Select pumps furnished under this section and sections referencing this section for NPSH margin limitations using the criteria set forth in this section. Base NPSH3 characteristics for the candidate pump upon documented test data not more than 5 years old. Perform testing on a pump not more than two nominal pump diameters larger or smaller than the proposed pump with an impeller of the same geometry as that proposed for the pump to be used for the subject application, and operating at either the same speed as the pump for the proposed application or a speed that provides plus or minus 10 percent of the impeller inlet velocity if reduced-speed testing is used. For very large pumps that cannot be accommodated in the manufacturer's test pit, the use of a model pump, sized in accordance with ANSI/HI 14.6, Appendix K, is acceptable. Have the contractor document the basis for pump selection based upon NPSH margin limitations as set forth in this paragraph.

      b. The detailed specification sections provide NPSHA information for anticipated operating conditions for each application. This information is generally referenced to a specific elevation, stated in terms of project datum. The contractor is responsible for requiring the pump manufacturer to adjust the NPSHA information in the specification section to the elevation of the pump impeller eye for the specific pump model and size proposed for the application. NPSH3, as used in the following paragraphs, means the NPSH3 at the impeller eye, determined in accordance with ANSI/HI 11.6 or 14.6, as applicable for the proposed pump. Have the contractor require the pump manufacturer to document the method used to determine NPSH3 for the proposed pump and justifying compliance with the NPSH margin limitations established under this paragraph for each specified operating condition in material submitted under paragraph 1.08. Include in the documentation justification of the NPSH3 tests used to develop NPSH3 characteristics, including the following:

         1) Date, test procedure, and test logs of original NPSH3 information used to project requirements for the pump selected for the application
         2) Test pump size, impeller diameter, impeller model, eye diameter, and speed
         3) Calculations projecting NPSH3 test information to NPSH3 curve information for the pump proposed for the application
         4) Calculations demonstrating compliance with the NPSH margin requirements established in this paragraph
c. Have the contractor submit the manufacturer’s margin calculations justifying the proposed pump selection with the material required under paragraph 1.08. The NPSH margin ratios specified in this paragraph are the minimum acceptable margin ratios. If the proposed pump requires greater margin ratios to operate within the specified operating conditions without loss of head due to cavitation, then it is the responsibility of the contractor to bear costs associated with achieving the required margin ratio by lowering the elevation of the pump setting, lowering the elevation of the structure, or through other means. Subject any such adjustments to review and acceptance by the construction manager if necessary.

d. Individual restrictions are applicable to NPSH margin depending upon the type of pumping equipment and the fluid to be pumped as set forth in ANSI/HI 9.6.1, Table 9.6.1.4.5. Under no circumstances may the absolute value of the NPSH3 margin be less than 3.5 feet.

G. Electric Motors:

1. General:
   a. Pumps must be electric-motor driven unless otherwise specified. Select all motors to be non-overloading at any operating point along the pump’s full-speed operating curve, including points located beyond specified operating conditions. Ensure that all vertical motors are solid-shaft construction. Hollow-shaft motors will not be accepted. Ensure that motors furnished with pumps specified for operation at variable-speed inverter-duty types conform to the requirements of Section 40 05 06, and are compatible with the variable-speed equipment furnished with the pump.
   b. Protect motor bearings with bearing isolators as specified in paragraph 1.04.

2. Motors for custom-engineered pumps:
   a. In addition to the information submitted under the requirements of Section 40 05 06, have the contractor provide certified reed-frequency calculations for both the motor rotor and frame for vertical motors driving custom-engineered pumps with the data to be submitted under paragraph 1.08. Upon completion of construction of motors for custom-engineered pumps, give each rotor and frame and the completed assembly a pump test to confirm reed-frequency calculations in the dynamic analysis modeling work performed under paragraph 1.05. Provide the results of the bump test, certified by the chief engineer or individual in responsible charge of the test facility, as an information submittal under paragraph 1.08.
b. Ensure that all vertical motors meet motor face dimension tolerances as follows:

<table>
<thead>
<tr>
<th>Motor Face Bolt Circle Diameter, Inches</th>
<th>Motor Face Runout, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0.002</td>
</tr>
<tr>
<td>16.5–24.5</td>
<td>0.002</td>
</tr>
<tr>
<td>30–42</td>
<td>0.003</td>
</tr>
<tr>
<td>42 and larger</td>
<td>0.005</td>
</tr>
</tbody>
</table>

c. Ensure that the motor face register concentricity, referenced to the shaft centerline, is not greater than 0.002 inch if the motor is furnished without jack screws. Ensure that the motor shaft total indicated runout (TIR) does not exceed 0.002 inch.

3. Balance:
   a. Ensure that motors rated 50 hp or greater and motors driving custom-engineered pumps are precision-balanced, conforming to a balance grade of G2.5 per International Organization for Standardization (ISO) 1940-1.
   b. Have the contractor provide certified balance logs attesting to achieving these requirements and submitted as required by paragraph 1.08. Have the chief engineer or person in charge of the test facility sign the balance logs.

4. Custom electric motors:
   a. Provide custom motors in accordance with Section 43 05 23. Provide custom motors for pumps to be supplied under the following sections:
      1) Section [section number and titles]
      2) Section [section number and titles]
      3) Section [section number and titles]
      4) Section [add section number and titles as necessary]

1.06 ADDITIONAL DESIGN REQUIREMENTS

A. Scope: The following paragraphs present requirements that apply to only some pumps on the project. In each of the paragraphs, the first sub-paragraph titled “General” explains when the paragraph applies.
B. Critical Speed Analysis and System Design:

1. General:
   a. The requirements of this paragraph apply to pumping equipment in detailed specifications where the words “custom-engineered” appear in the title of the specification section, and elsewhere when the referencing specification section stipulates. Apply the analyses to the equipment in “like-new” condition, as well as the “as-worn” condition (i.e., when parts, individually and as a composite, reach the manufacturers’ maximum tolerances). For the purpose of these analyses, define worn conditions as two times the new condition clearance unless specified less by the manufacturer and specifically accepted by the construction manager.

2. Requirements:
   a. Subject the complete pumping unit (including rotating elements, frames, and supports) and related structural elements (including pump, motor, and bearing supports) to structural, lateral, and torsional dynamic analyses to identify and eliminate critical speeds as defined in paragraphs 1.05C.2.a Lateral rotor and structural dynamics and 1.05C.3.a Torosional rotordynamics and combined shaft stress.
   b. Select the complete pumping unit rotating group including pump, motor, intermediate shafting and flywheel rotors (if specified), and other elements in the power train (or powered via the power train) that are designed and manufactured to limit torsional stresses.
   c. Overhung shaft pumps and between bearings pumps operating in single-volute casings shall be subject to analysis for shaft deflection in accordance with the terms of this section.
   d. Ensure that the structural, lateral, and torsional dynamic analyses are together termed the pumping equipment’s “mass elastic design.” Ensure that no fabrication work on any component for the equipment specified under this section and any referencing section are started until the mass elastic design has been completed and has been reviewed by the construction manager.
   e. If the contractor proposes the use of alternative methods for the required analyses, submit documentation justifying the substitution. Include in the documentation justification that product results will be equivalent to that specified and with an equivalent level of accuracy. Also include the location and description of projects of an equivalent size where the procedure has been employed and the length of time these projects have been in actual service.
3. Professional qualifications:
   a. Have the contractor require the manufacturer of the pumping equipment to retain the services of an independent professional engineering firm, employing a qualified design professional who has been engaged in performance of the required mass elastic design analyses for not less than 10 years on equipment of similar size and complexity. Ensure that the design professional has not been in the employ of any pump manufacturer for a period of not less than 10 years from the date of the request for proposals for the project. Have the design professional's firm submit a notarized certification attesting to having no contractual arrangements with the proposed pump manufacturer. The pump manufacturer's internal engineering organizations, regardless of qualifications, are specifically prohibited from doing this work. This provision, however, is not to be construed as relieving the contractor of overall responsibility for this portion of the work.

   b. Ensure that the mass elastic design is the product of a design professional, registered to practice mechanical engineering in at least one of the states composing the United States, who has been responsible for the design of not less than five systems similar to that specified in the detailed specification section. Ensure that the design professional has been engaged in this type of analysis for not less than 10 years, and directly supervise the performance of the work and be responsible for analysis of results and recommendations for any corrections to the specific rotating system and the associated frames and supports. Have the contractor submit the design professional's qualifications as a part of the initial submittal information required under this section.

   c. SPU and construction manager believe that the following firms are capable of providing services that will satisfy the requirements of this paragraph. This statement, however, is not to be construed as an endorsement of a particular firm; do not assume that a named firm's standard service will comply with the requirements of this section. Candidate firms performing these analyses satisfactorily in the past include:

   1) DynaTech Engineering Incorporated, Auburn, California
   2) Engineering Dynamics Incorporated, Houston, Texas
   3) No Bull Engineering (Corbo, Malanoski & Associates), Brandon, Vermont

   d. The contractor may propose a firm other than those listed. However, before a substitute firm can perform the analyses, submit the proposed firm's qualifications, the qualifications of personnel proposed for assignment to this project, along with examples of analyses performed on similar pumping equipment using procedures similar to those specified in this section, for review by the construction manager. Examples include the types of graphical displays required under this section as well as a complete report describing the analyses performed and the recommendations arising out of the analysis results. The construction manager retains the right to reject any proposed firm with justification.
4. Reports, calculations, and recommendations: Ensure that all reports, calculations, and recommendations resulting from the required analyses bear the design professional's original signature and professional registration seal. Submit all reports, recommendations, and calculations produced under this paragraph under the requirements of this section, as follows:

   a. Following completion of the pumping equipment's mass elastic design, have the contractor require the design professional to prepare a plain-English “Executive Summary” report with a narrative including a description and assumptions about the proposed operating system, detailed description of the analysis process, results of analyses and findings, detailed recommendations for modification of the pumping unit (defined in paragraph 1.01A Scope), if any, and sufficient graphical depictions to describe the information to a lay reader. Detailed calculations and extensive data reports are not to be submitted at this time and will cause the entire report to be rejected, if included. Submit this Executive Summary for review and acceptance prior to pump or component fabrication. Have the Executive Summary report state that analysis procedures have complied fully with the requirements of this section and that the proposed system will meet of the requirements set forth herein for limitations in stresses, deflection, and fatigue limits. Have the design professional affirm in writing that requirements of this section have been achieved or specifically state where exceptions have been taken, with justification citing recognized authorities for taking such exceptions. Ensure that the reports are signed and sealed by the design professional, as specified, and that they are notarized.

   b. Following review and approval of the Executive Summary report, have the contractor require the design professional to review and address any comments from the construction manager and incorporate changes that may be required. Subsequently, have the contractor direct the design professional to issue a complete “Final Report” with a revised Executive Summary report, recommendations binding on the manufacturer, calculations, data, and other supporting information. Have the format and documentation for this report follow the requirements of ANSI/HI 9.6.8 Appendix G Level 3 as indicated in the detailed specifications. Have the contractor submit this report as an information submittal.

   c. Upon completion and receipt of certified results of the bump tests required for the motor rotor, frame, and assembly specified under paragraph 1.05G.2, have the design professional review the data and submit a “Supplemental Report,” as product data, either accepting the test results or recommending alterations to assembly structures to adjust for differences between calculated values used for the original analyses and actual values determined subsequent to motor fabrication.
d. Upon completion of installation and as a part of the initial test procedures specified under Section 01 75 00, have the design professional responsible for the mass elastic design visit the site and inspect the installed equipment. Prior to the initiation of any field tests, have the design professional issue a report attesting that the equipment, as installed, conforms to the recommendations contained in the report setting forth the results of the mass elastic system design or recommendations for remedies should the supplied equipment contain features or characteristics deviating from the original recommendations and calculations.

e. During initial testing of the equipment, ensure that the design professional is prepared with necessary monitors, instruments, and recorders, and have him/her conduct an in situ torsional vibration test on one of the installed pumping units, to be selected by the construction manager, to confirm the torsional natural frequency results of the original mass elastic system design. Conduct the torsional vibration test with transducers suitable for narrow-band spectrum analysis, including strain gauges, magnetic or optical pulse demodulation, or shaft position encoders. If the torsional vibration test should reveal any anomalies that cause the equipment to be out of compliance with the requirements of this section, have the design professional conduct torsional vibration tests on other like pumping units and submit a comprehensive report, sealed and signed as specified above, detailing the reasons for failure to comply with these specifications and recommendations for attaining compliance. Have the design professional consider feasible options for compliance and provide detailed descriptions of the modifications required to achieve the required performance. Have the contractor implement those recommendations accepted by the construction manager at no cost to SPU.

5. Methodology:

a. Lateral rotor and structural dynamic analyses:

1) Include in the analyses procedure the following features based on a Level 3 analysis prescribed in ANSI/HI 9.6.8-2014:

   a) The procedure considers speeds required to operate the equipment within the envelope of continuous-duty operating conditions specified in paragraph 1.05C.2.a Lateral rotor and structural dynamics.

   b) The procedure includes liquid influences (wet conditions) including Lomakin effects, impeller-diffuser destabilizing forces, and added mass due to entrained fluid in the calculation of natural frequencies and forced response for pump types.
c) The procedure produces Campbell diagrams for the proposed operating conditions depicting potential sources of excitation to check interference with relevant natural frequencies from both lateral and structural analyses. Primary excitation orders to be considered during the analysis include 1 and 2 times running speed, vane-passing frequencies for the pump impeller/cutwater-diffuser vane combinations, and any unique harmonic of running speed produced by the pumping system, up to, and including, not less than 6 times operating speed.

d) For pump types except column pumps, the procedure considers the effect of support stiffness on natural frequencies. The range of stiffness to be considered is not to be less than 4 orders of magnitude. Results are provided in a critical-speed map (graph of natural frequencies versus stiffness similar to Figure 9.6.8.6.2.1.3 in ANSI/HI 9.6.8-2014) and indicate the expected values of stiffness.

e) For column-type pumps only, the procedure considers the effect on critical speeds subject to variations in assumed coefficients from new values for seal and wearing ring clearances, bearing clearances, and impeller destabilizing forces. Unless specifically accepted by the construction manager, the range in variation of component characteristics (either clearances or forces) is 2 times as-new values. Forced response is also calculated at new and 2 times as-new values (or approved deviation) using rotor unbalance (10 percent of weight at each impeller position) and hydraulic unbalance at not less than five operating conditions within the envelope of continuous-duty operating conditions specified in (a). Response to unbalance is assessed by the design professional relative to acceptable bearing loads and deflections of the rotating group.

f) Ensure that the mathematical calculation tools to be employed for the analyses and the procedures to be used are as follows:

(1) Build the mathematical model of the rotating group on a dedicated rotodynamics code employing finite-element beam theory. Do not use general-purpose finite-element, transfer matrix, or lumped-parameter program for this purpose. Construct the model specifically to contain axisymmetric models of the rotor and, with column-type pumps only, the casing. Use this model to determine the damped natural frequencies and, if required, the forced response of the rotating group.
(2) Use a general-purpose finite-element code such as NASTRAN or ANSYS to construct three-dimensional models of the casing and housing structures supporting the rotating group. Use this model to determine the natural frequencies of the support structures and casing as well as the pump-bearing frames. Include representative sections of piping and structural supports such as piers and baseplates in the model.

(3) Adjust the rotating group axisymmetric model, preferably by changing component materials or sizes, or by changing component type, until the output frequencies or static deflections agree with the models constructed under (2).

(4) Use the three-dimensional models constructed under (2) to determine if the foundation of the pumping unit is rigid or flexible as per Figures 9.6.8.3.1a, 9.6.8.3.1b, and 9.6.8.3.1c in ANSI/HI 9.6.8-2014.

2) Include in the Final Report graphic presentations, preferably in three dimensions, of frame and shaft distortion and rotor group performance at any identified critical speeds within the pump’s operating range.

b. Torsional dynamic analysis:

1) The methodology used for the torsional rotordynamic analysis of the rotating group and evaluation of shaft combined stresses is based on a Level 2/3 analysis in ANSI/HI 9.6.8-2014 and includes the following features:

a) The procedure considers speeds required to operate the equipment within the envelope of continuous-duty operating conditions specified in paragraph 1.05C.3.aTorsional rotodynamics and combined shaft stress.

b) The mathematical model of the rotating group is built on a dedicated rotordynamics code employing finite-element beam theory or a general-purpose finite-element program. Do not use a transfer matrix or lumped-parameter code for this purpose. The computer program used for the torsional analysis must be field-calibrated at not less than five similar installations.

c) Verify the computer analysis results by hand calculations for the fundamental frequency and mode shape.
d) Ensure that primary excitation orders to be considered in the analysis are 1 and 2 times running speed, vane-passing frequencies for the pump impeller/cutwater-diffuser vane combinations, line- and twice-line frequency, motor-pole frequency, torsional harmonics from reciprocating engine drivers (up to, and including, 6 times operating speed), and harmonics as defined in (f) if variable-frequency drives (VFDs) are specified.

e) Produce a Campbell-type interference diagram showing the relationship between operating range, natural frequencies, and primary excitation orders, with any critical speeds clearly identified.

f) If critical speeds are predicted to occur in the critical avoidance zone specified in paragraph 1.05C.3.a Torosional rotordynamics and combined shaft stress, perform a damped, steady-state forced-response analysis to demonstrate satisfactory fatigue life as defined further in that paragraph, as applicable. Ensure that forcing function magnitudes used for the analysis are not less than 1 percent of the maximum transmitted torque at the speed of intersection. Justification of the source and magnitude of any damping incorporated in the analysis is required. Include in the analysis evaluation of control pulse frequencies induced by VFDs or engine power-stroke frequencies, if provided as part of the specified system. Include in the analysis report a statement produced by the VFD manufacturer detailing control-pulse frequencies generated by the equipment between 1 and 24 times motor running speed. Consider any torque harmonic greater than 1 percent of steady torque a primary excitation order.

2) Physical adjustments to obtain the required characteristics must be preferably by changes in component dimensions, and secondarily by providing torsionally resilient dampening devices such as fluid-damped couplings or metallic couplings such as manufactured by Bibby and Holset. Do not use couplings or dampeners using rubber or similar elastic materials.

3) If synchronous drives are specified in the mass-elastic design, include in the analysis a time-integration study showing transient peak stresses resulting from startup, shutdown, and motor control transients. Provide tomographic diagrams, colorimetrically displaying stresses at positions in the rotating group shafting, including roots at changes in section and keyways or other stress concentrating locations, with the analysis report. Indicate in the diagrams the operating speeds identified that produce the peak stresses, specific for speeds inducing identified peak stresses at keyways, changes in section, and at connections to other components. Combine the reported stresses incorporating identified loads from torsional, lateral, and hydraulic sources.
1.07 QUALITY ASSURANCE: ALL PUMPS

A. Quality Certification:
   1. Ensure that all manufacturers and manufacturing sites proposed by the contractor for supply of equipment furnished under this section and sections referencing this section hold current certification under ISO 9001. Application for certification under ISO 9001 is not deemed as an acceptable substitute for current certification. Provide documentation of the manufacturer’s ISO 9001 certification and the manufacturer’s written quality assurance/quality control (QA/QC) program.

B. Unit Responsibility:
   1. Have the contractor assign unit responsibility to the pump manufacturer in conformance with the requirements of Section 40 05 01.

C. Performance Confirmation:
   1. Hydrostatic tests:
      a. Subject all pressure-sustaining parts to factory hydrostatic tests. Unless otherwise specified, conform hydrostatic tests to the requirements of ANSI/HI 11.6 for submersible pumps and ANSI/HI 14.6 for dry pit pumps. Unless otherwise indicated in the detailed specifications, hold castings at the test pressure for the duration indicated in ANSI/HI 11.6 and 14.6. For process pumps designed in accordance with ANSI/API 610, hydrostatic testing must comply with the requirements of paragraph 8.3.2 of ANSI/ANSI/API 610. Ensure that test results are certified correct by the chief engineer or individual in responsible charge of the manufacturing facility.

   2. Performance guarantee:
      a. Unless specified otherwise in the detailed specification, have pump performance (flow and head, efficiency, and NPSH3) guaranteed by the pump manufacturer to the criteria specified under this paragraph.
      b. Ensure that equipment performance documentation, including test data, where tests are specified, includes sufficient test points (not less than eight) to document hydraulic performance along the complete head/capacity curve from shutoff to maximum capacity, and covers full-speed operating points specified in the detailed specification section referencing this section. Ensure that tests conducted at specified operating conditions are the inlet throttled to produce the NPSHA indicated for that specific condition in the detailed specification. Perform NPSH3 tests for not less than four full-speed operating conditions, but not less than specified operating conditions and at the best efficiency point (BEPQ).
c. Conform test procedures to those set forth in ANSI/HI 14.6 acceptance grade 1U, and as specifically detailed in these specifications. However, any increase in flow or head permitted under acceptance grade 1U cannot result in overload (nameplate basis, S. F. = 1.0) of the specified motor power rating at any location on the pump’s head/capacity curve. Conduct performance tests at the specified maximum speed. Affinity relationship-predicted test results will not be accepted. For column-type pumps, include in the performance documentation curves showing both bowl efficiency and overall efficiency (including inlet, bowl, column, and discharge head losses) at maximum operating speed for the application.

d. Ensure that acceptance criteria for head and capacity test results, based upon the rated condition specified in the detailed specification, are as required in ANSI/HI 11.6 and 14.6, acceptance grade 1U, with the above-stated limitation with respect to motor power overload.

e. Ensure that acceptance criteria for NPSH3 at any specified operating condition are the values proposed by the contractor in the curves submitted under paragraph 1.09, and duly accepted by the construction manager, with a tolerance of plus 0, minus unlimited, with the exception that Nss, as calculated for the specific pump, does not exceed the limitation established under paragraph 1.05B. If the NPSH3 data result in an increase in Nss, have the manufacturer confirm that the stable operating region for the pump corresponds to the POR as defined in ANSI/HI 9.6.3, and that the operating conditions specified to be within the POR are within the stable operating region for the pump. In addition, have the manufacturer identify the onset of suction recirculation and confirm that the onset of suction recirculation is outside of the specified operating range.

f. Include in the guarantee a statement to the effect that the pump will operate within the operating regions specified in the detailed specification. Put the guarantee in writing, and have the chief engineer or individual in responsible charge of the test facility sign it. Under no circumstances should deviations from specified operating conditions result in overload of the driver furnished with the equipment, nor should such deviations result in power requirements greater than the driver’s nameplate (1.0 service factor) rating.
3. Non-witnessed tests:

a. Unless specified otherwise, performance-test pumps in accordance with ANSI/HI 14.6, Acceptance Grade 1U, with the above restrictions on motor power overload. Include in the factory tests test data for each full-speed performance requirement (Condition Points A and B specified in the detailed specification) and any other points stipulated for this test procedure in the detailed specification. Conduct these tests with the pump inlet throttled to provide the specified NPSHA. For large-column pumps, model performance testing with reduced NPSHA, pursuant to paragraph 1.08B.4, may be used. If specified in the detailed specification, include shaft vibration and case noise in the test data at the full-speed operating conditions.

b. Duplicate the test setup in the manufacturer’s test facility as closely as possible to the inlet conditions in the proposed installation, using temporary baffles and other means, within the limitations of the test facility. Where centrifugal pumps are furnished with inlet elbows, inlet adapters or inlet reducers as a part of the manufacturer’s scope of supply, test the pumps with the elbow, adapter, or reducer fitted to the pump and apply specified performance criteria to the complete pump assembly, including losses through any elbow, adapter, or reducer. Where submersible pumps are to be furnished with inlet nozzles and/or discharge elbows or adapters, test the pumps with these components fitted to the pumps. Apply the specified performance requirements to the complete pumping assembly including any inlet nozzles, and discharge elbows or adapters. Include in the certified test data separate readings for inlet and discharge head for each data point.

c. Take not less than eight test points, including not less than three within plus or minus 8 percent (in terms of rated flow) of the rated condition (Condition Point A) and not less than two test points within plus or minus 4 percent of the pump’s BEP at the test speed. In addition, one test point is sufficient to define head and power requirements at shutoff head.
d. Perform NPSH3 tests in accordance with ANSI/HI 14.6, paragraph 14.6.5.8.2.1, Type 1 Test except that not less than four tests should be performed at the test motor speed to completely cover the range of operating conditions specified in the detailed specification. Ensure that one of the test points is at BEP flow to confirm the test pump’s Nss. Ensure that translation of test results to specified operating conditions is in accordance with ANSI/HI 14.6, paragraph 14.6.6.1.1 so long as the exponent used can be supported by certified test data performed on a pump of the same type, size, speed, and specific speed as that of the proposed pump. Include NPSH3 tests at both the proposed and test speeds in test data justifying the exponent, test points at BEP, and at least three other points on the test pump head/capacity curve at least 15 percentage points removed from the BEP. Use the results of the NPSH3 tests to confirm the NPSH margins for each specified operating condition as specified in paragraph 1.05F. Perform NPSH3 tests for column type (axial, mixed-flow, and vertical-turbine) pumps using the open sump/water level or closed tank/tank pressure methods described in ANSI/HI 14.6, Table 14.6.5.8.2.1. Perform NPSH3 tests for submersible wastewater pumps using the method described in Figure 11.6.8 in ANSI/HI 11.6. Extend all NPSH3 tests from 50 percent to 140 percent of best efficiency flow at full speed, or to not less than 10 percent (in terms of flow) past the flow at Operating Condition B, whichever is greater. For a given pump, if the manufacturer can provide documentation that the upper flow limit of the AOR on the right side of the pump curve is less than 140 percent of best efficiency flow, the AOR may be used as the limit for the NPSH3 test. Cause for rejection is failure to achieve specified performance or performance proposed in accepted submittal documents (capacity and head, efficiency, or NPSH3), whichever is more restrictive. Acceptance tolerances are as set forth in paragraph 1.07C.2 Performance Confirmation; Performance guarantee.

e. Ensure that all test procedures are in strict conformance with the referenced standards. However, prediction of performance of a trimmed impeller from test data of the larger impeller will not be permitted. If trimming is required, re-test the pump. Do not allow deviations from specified operating conditions, though allowed by the referenced standards, to result in overload of the driver furnished with the equipment, nor allow such deviations to result in power requirements greater than the driver’s nameplate (1.0 service factor) rating.

f. Have the contractor furnish the construction manager with not less than 2 weeks’ advance written notice of the date and place of the non-witnessed tests.

g. Have all test results, including test logs and generated curves, certified correct by the chief engineer or individual in responsible charge of the manufacturer’s test facility, and submit in accordance with paragraph 1.09.
1.08 QUALITY ASSURANCE: ADDITIONAL REQUIREMENTS

A. Scope:
   1. In addition to the requirements under paragraph 1.06 applicable to pumps, the following are required for the subset of larger and custom-engineered pumps defined in paragraph 1.01A Scope. Contractors are advised that the results of NPSH3 will be used by the construction manager to determine if the tested pumps conform to the POR requirements set forth in paragraph 1.04. Failure to meet these requirements will likely require remanufacture of the pumps or rework of one or more of the pump components to achieve the required and necessary pump stability characteristics. Ensure that all costs associated with such remanufacture or rework and retesting are borne by the contractor.

      2. Ensure that performance curves submitted under paragraph 1.09, once accepted by the construction manager, become a warranty on the part of the contractor to provide equipment that will provide performance characteristics that accurately duplicate the characteristics presented in the submitted and accepted curves. Ensure that factory test results confirm performance within the tolerances set forth in ANSI/HI 14.6.3, Acceptance Grade 1U for the specified rated condition and Grade 2B for other specified full-speed operating conditions. Ensure that NPSH3, as determined by certified factory test results, does not cause the pump’s Nss to exceed the limit specified in this section or the detailed specification. The manufacturer may propose a pump with a higher Nss, provided that documentation showing that the onset of suction recirculation is to the left of the pumps specified operating region. Submit documentation of the procedures used to determine the onset of suction recirculation.

B. Performance Testing:
   1. Witnessed tests:
      a. Subject all custom-engineered pumps, and other pumps where required by the detailed specification, to a witnessed factory performance test and NPSH3 tests in accordance with the provisions of this portion of the specifications.
      b. Have the contractor furnish the construction manager with not less than 2 weeks’ advance written notice of the date and place of the witnessed tests.

   2. Performance tests:
      a. Conform factory performance tests to the requirements of ANSI/HI 14.6, Acceptance Grade 1U. Include in the factory tests test data for each full-speed performance requirement (Condition Points A and B specified in the detailed specification) and any other points stipulated for this test procedure in the detailed specification. Conduct these tests with the pump inlet throttled to provide the specified NPSHA or as otherwise detailed in the accepted test plan. For large-column pumps, model performance testing with reduced NPSHA, pursuant to paragraph 1.08B.4 Performance Testing; Model tests, may be used. Include shaft vibration and case noise at full speed in the test data.
b. Duplicate the test setup in the manufacturer’s test facility as closely as possible the inlet conditions in the proposed installation, using temporary baffles and other means. Where centrifugal pumps are furnished with inlet elbows, inlet adapters, or inlet reducers as a part of the manufacturer’s scope of supply, test the pumps with the elbow, adapter, or reducer fitted to the pump. Ensure that specified performance criteria apply to the complete pump assembly, including losses through any elbow, adapter, or reducer. Where submersible pumps are to be furnished with inlet nozzles and/or discharge elbows or adapters, test the pumps with the inlet nozzles or adapters. Ensure that the specified performance requirements apply to the complete pumping assembly, including any inlet nozzles, discharge elbows, or adapters. Ensure that NPSHA does not exceed that specified in the detailed specification during any performance test. Include separate readings for inlet and discharge head for each data point in certified test data.

c. Take not less than eight test points, including not less than four within plus or minus 8 percent (on the basis of rated flow) of the rated condition (Condition Point A) and not less than two test points within plus or minus 4 percent of the pump’s BEP at the test speed. In addition, one test point is sufficient to define head and power requirements at shutoff head, and one test point is sufficient to define flow at Condition Point B.

3. NPSH3 tests:

a. Perform NPSH3 tests to confirm the data used to establish NPSHA margin for each specified operating condition as specified in paragraph 1.05F. Perform NPSH3 tests for submersible wastewater pumps using the method described in Figure 11.6.8 in ANSI/HI 11.6. Extend all NPSH3 tests from 30 percent to 140 percent of best efficiency flow at full speed, or to the upper limit of the AOR as defined by the manufacturer, whichever is less. Cause for rejection is failure to achieve guaranteed performance or performance proposed in accepted submittal documents, whichever is the more restrictive (capacity and head, efficiency or NPSH3). Ensure that tolerances and restrictions are as set forth in paragraph 1.07C.3 Performance Confirmation; Non-witnessed tests, above, for non-witnessed tests.
4. Model tests:
   a. Where allowed in the detailed specification or upon specific application with adequate justification by the manufacturer, confirmation of performance of large pumps may be demonstrated by testing the prototype at reduced speed or by testing a model of the prototype pump. Perform NPSH3 tests to confirm the data used to establish NPSHA margin for each specified operating condition as specified in paragraph 1.05F. Cause for rejection is failure to achieve guaranteed performance (capacity and head, efficiency or NPSH3). Perform physical model testing at qualified, commercial facilities, with at least 10 years of continuous-duty operation. Conduct all tests in accordance with ANSI/HI 1.6 or 2.6, with the following restrictions:
      1) Ensure that if the prototype is tested at reduced speed, the ratio of test speed to prototype speed is not less than 0.66:1.
      2) Ensure that model test ratios are not less than 0.33:1, model to prototype.
      3) Ensure that impellers for model tests are not less than 12 inches in diameter.
      4) Subject impellers for prototype pumps to a model-to-prototype profile comparison using templates ratioed from the impeller used for the completed and accepted model test. Compare impeller profiles for the x, y, and z planes. If model testing is proposed for any or of the specified tests, have the contractor include the proposed methodology for profile confirmation as a part of the submittal material required under paragraph 1.08. Perform impeller profile comparison with a representative of the construction manager present. Ensure that all costs associated with travel and subsistence of the construction manager’s representative are borne by the contractor.
      5) Ensure that acceptance criteria, based upon projected prototype performance from model test results using ANSI/HI-approved affinity relationships, areas set forth above under paragraph 1.07C.3 Performance Confirmation; Non-witnessed tests.
      6) Apply the restrictions set forth above for witnessed tests.
   b. Have the contractor furnish the construction manager with not less than 2 weeks’ advance written notice of the date and place of the model tests.

5. Test certification and reporting:
   a. Certify correct and have notarized by an officer of the pump manufacturer all test results, including test logs and generated curves. Have the contractor submit test results as product data.
C. **Confirmation of passage geometry:**

1. For solids-handling pumps, subject the design waterway passages and mating passages between rotating and stationary portions of such passages to confirmation that no mismatch of exiting and entering angles or angular discontinuities exist in pumps furnished under specification sections containing the words “custom-engineered” in the title, and that are not proven designs in accordance with paragraph 1.05B. Ensure that the confirmation process employs CFD modeling techniques in which mesh generation is optimized and mesh size is reduced in the regions of flow attachment, detachment, and separation regions of the impeller and cutwater to detect angular mismatches of 0.25 degree or greater.

2. Use a number of different convergence criteria to assess whether a solution is converged. These criteria may include the residuals given by the software; global imbalances in momentum, energy, etc.; whether key global quantities have reached an equilibrium value; and whether information from various solution monitoring points have stabilized. Note that these monitoring points should be in areas where the flow could be much weaker, and not where the flow could be converged easily. Use high-convergence criteria, and repeat runs with different monitoring points to ensure proper convergence.

3. Provide modeling software that is professionally customized and optimized for the determination of pump fluid dynamics, especially flow attachment, detachment, and separation. Verify the mathematical model and software accuracy by experimental data from test cases including similar dynamics. Ensure that the individual conducting the modeling effort is a CFD specialist with graduate-level education in the subject and over 5 years of relevant experience. Submit the model graphic outputs, signed and notarized by the pump manufacturer’s officer in charge of engineering, as a part of the documentation required under paragraph 1.08.

### 1.09 **SUBMITTALS**

A. **Action Submittals:**

1. Procedures: **Section 01 33 10.**

2. In addition to the material listed in the detailed specification, provide the following submittals:

   a. Documentation of successful pump designs or proposed alternatives as specified under paragraph 1.05B.1 Pump Selection. If included as part of the design, include in the documentation applications where pump cans of a similar size have been provided as part of the design.

   b. A Certificate of Unit Responsibility attesting that the contractor has assigned unit responsibility in accordance with the requirements of this section and **Section 40 05 01-1.02** Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
c. A copy of this specification section and the specification sections listed for submittal in the detailed specification sections. Ensure that the specification copies are complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore, requested by the contractor, underline each deviation and denote by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the contractor with the specifications. Accompany the submittal with a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal is sufficient cause for rejection of the entire submittal with no further consideration.

d. A copy of the contract document control diagrams and process and instrumentation diagrams (P&IDs) relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings as "no changes required." Failure to include copies of the relevant drawings with the submittal is cause for rejection of the entire submittal with no further review.

e. Documentation of certification in accordance with ISO 9001 as specified under paragraph 1.07A.

f. Predicted pump performance curves for each condition point specified showing head, power, efficiency, and NPSH on the ordinate plotted against capacity (in million gallons per day [mgd]) on the abscissa, along with the contractor’s warranty to meet the requirements specified in paragraph 1.07 Scope. Provide curves for variable-speed pumps to demonstrate operation at speeds required to achieve the specified reduced-speed operating conditions. Ensure that all curves clearly display the specified operating conditions and conformance with POR and AOR limits in the individual specification sections. Provide variable-speed plots showing specified operating conditions and POR limits. Plot curves at increments of not more than 5 percent speed or 50 rpm increments, whichever is less, from full speed to the lowest speed required to meet specified operating conditions. Ensure that curves for column-type pumps show bowl efficiency and allowances for inlet, column, and discharge head losses separately.

g. NPSH margin calculations performed for each specified operating condition in accordance with paragraph 1.04 as applicable and including the information required under paragraph 1.05F.

h. Motor submittal information as specified in Section 40 05 06. In addition, include in this information certified calculations for motor rotor and frame reed frequencies, as specified under paragraph 1.05G.
i. Complete description and sketch of proposed test setup for factory test if a factory test has been required under the detailed specification section or as required by the provisions of this section. Include in submittal material sample calculations and proposed test log format. If the contractor proposes a model test for a part or all of the specified performance tests, include in the submittal information the proposed model details and a complete description of the proposed method for comparing the model impeller profiles with the impeller profiles for the prototype pumps.

j. Drawings showing general dimensions and confirming the size of pumps, motors, drives, and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; and weight of equipment.

k. Variable-speed drive information as required under Section 26 29 23 if the equipment specified includes variable-speed capability.

l. Driver unit support calculations and data if the driver is separately supported and if the analysis under the requirements of paragraph 1.06B have been required by the terms of these specifications.

m. Shaft deflection calculations for volute-type pumps: provide calculations to demonstrate compliance with paragraph 1.05E, per the methodology set forth as required by paragraph 1.06B.

n. Detail drawings of the pump and driver unit foundation demonstrating conformance to this section and Section 40 05 02. Include in the submittal drawings depicting type, size, number, projection, and arrangement of anchor bolts; dimensional drawings of the sole and baseplates; and dimensional drawings for the concrete supports for both the pump and motor, if applicable. Ensure that drawings also depict other pertinent information, including location of equipment pads and reinforcement; equipment drains; expansion joint locations; elevation of top of grout and grout thickness; elevation of top of baseplate, soleplate, or mounting block; size and location of electrical conduits; and any other equipment-mounting features embedded in equipment pads.

o. Limiting nozzle loading criteria, if different from that established by ANSI/HI 9.6.2.

p. The qualifications of the independent testing laboratory and individual personnel proposed by the contractor to perform field vibration testing, analysis, and reporting in accordance with the requirements of paragraph 3.06.

q. The qualifications of the personnel proposed by the contractor to perform field alignment procedures in accordance with the requirements of paragraph 3.04.
3. The following are applicable for pumps specified to meet ANSI/HI 9.6.8 Analysis Level 2 or 3:
   a. Qualifications of the design professional, and firm name, proposed to perform the mass elastic design analyses specified under paragraph 1.06B if the subject analyses are required by the terms of these specifications.
   b. Descriptive material outlining the methodology and software to be used in the analyses required under paragraph 1.06B.
   c. “Executive Summary” report of the mass elastic design analyses for pumps as specified in paragraph 1.06B.
   d. The proposed instrumentation setup for the in situ torsional vibration test specified under paragraph 1.06B.
   e. Can design documentation specified under paragraph 1.01, including bolt patterns for the pump base and soleplate on can.
   f. “Final Report” of the model study specified under paragraph 1.01.
   g. Model graphic outputs specified in paragraph 1.08C.

B. Information Submittals
   1. Procedures: Section 01 33 10:
      a. Performance guarantee as specified in paragraph 1.07C.
      b. Equipment anchor calculations specified in paragraph 1.05E.
      c. O&M information specified in Section 01 78 23.
      d. Motor product data as specified in Section 40 05 06.
      e. Bearing L-10 life calculations.
      f. Critical speed calculations demonstrating compliance with paragraph 1.06B if a lateral rotordynamic analysis is required. Otherwise, provide critical speed calculations demonstrating compliance with paragraph 1.05C.
      g. Nozzle loading information required under paragraph 3.01.
      h. Motor balance logs, certified and notarized as specified in paragraph 1.05G.
      i. Certified balance logs and worksheets, as specified in paragraph 2.05.
      j. Installation certification Section 40 05 01-Form A as specified in paragraph 3.01.
      k. Training certification Section 40 05 01-Form B as specified in paragraph 3.08.
      l. If factory tests are specified in the detail specification section, certification of satisfactory testing of each unit as specified. Include in the certified material copies of test logs and resulting performance curves.
      m. Field vibration test reports in accordance with paragraph 1.01.
C. The following are applicable for pumps specified to meet ANSI/HI 9.6.8 Analysis Level 2 or 3:

1. Results of model tests for pump cans if model tests are required by the provisions for paragraph 1.01.

2. "Final Report" of mass elastic systems analyses for pumps as specified in paragraph 1.06B.

3. Results of motor rotor, frame, and assembly bump tests, certified as specified under paragraph 1.05G Electric Motors, along with the design professional's "Supplemental Report" as specified under paragraph 1.06B.

4. Pump can installation acceptance certification, as specified in paragraph 3.03, if applicable.

5. Results of field vibration tests as specified under paragraph 3.06.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General:

1. Where this section and sections referencing this section are silent with respect to materials of construction on any component, have material selection follow the requirements of Table H.1, ANSI/API 610, Materials Class I-1, with the exception that shafts for vertical column-type pumps be 12 percent chromium stainless steel. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Pumps:

1. Finish for surfaces in contact with pumped fluid:

   a. Conform all pump components in contact with the pumped fluid to the following requirements.

   b. Indicate surfaces to be machine-finished on the shop drawings by symbols that conform to ANSI B46.1, Surface Texture, Surface Roughness, Waviness, and Lay. Ensure that machine surfaces are finished to at least the following tolerances:
c. Nominal roughness:

<table>
<thead>
<tr>
<th>Surface</th>
<th>Grade, Ref: ANSI B46.1 (SI units microns) (Ra: micro inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General machine work</td>
<td>3.2 or better (125 Ra)</td>
</tr>
<tr>
<td>Flange faces</td>
<td>3.2 or better (125 Ra)</td>
</tr>
<tr>
<td>Journal surfaces at sleeve bearings</td>
<td>0.4 or better (16 Ra)</td>
</tr>
<tr>
<td>Hydraulic surfaces</td>
<td></td>
</tr>
<tr>
<td>Impeller</td>
<td>4.5 or better (177 Ra)</td>
</tr>
<tr>
<td>Impeller bowl and diffuser</td>
<td>6.3 or better (250 Ra)</td>
</tr>
<tr>
<td>All other wetted surfaces</td>
<td>6.3 or better (250 Ra)</td>
</tr>
</tbody>
</table>

d. Flaws such as scratches, ridges, holes, peaks, cracks, or checks that will make the part unsuitable will be cause for rejection. Ensure that machine-finished surfaces are thoroughly cleaned and coated with a protective layer of rust preventive. Oil and wrap small pieces, unassembled pipe, or finished bolts with moisture-resistant paper.

2. Materials:

a. Unless otherwise specified, ensure that wetted cast-iron parts for pumps for solids-bearing liquid services have 2 to 3 percent nickel added to the cast iron.

b. Provide stainless-steel impellers for the first stage of custom-engineered pumps, pumps intended for pumping screened or unscreened wastewater, and elsewhere when specified. Ensure that stainless-steel impellers are ASTM A743, Grade CA6NM. Where cast-nickel aluminum bronze impellers are specified, ensure that the materials conform to ASTM B148, Alloy C95500.

c. Ensure that materials for shaft sleeves for packed boxes, fretting seals, and interstage seals conform to ANSI/API 610, Annex H 12 percent chromium-hardened or hard-faced 316 austenitic stainless steel. Ensure that materials for seal glands for packed boxes and shaft sleeves are AISI 316 stainless steel. Ensure that fastener parts of all types in wetted areas conform to ANSI/API 610, Materials Class S-5 requirements. Regardless of the seal construction, adequately size seal chambers to accommodate specified mechanical seals.
C. **Flywheels:**

1. Where flywheel assemblies are to be provided with the pumping equipment, ensure that pump pressure-containing parts are of ductile iron conforming to ASTM A571. Ensure that materials of construction for the flywheels are as follows:

<table>
<thead>
<tr>
<th>Frame</th>
<th>Steel, ASTM A-36, welded and stress relieved.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft</td>
<td>Alloy Steel, ASTM A322, Grade 4142 HT, ST, BHN 375-388 for shafts 3.5 inches in diameter and less; stainless steel, ASTM A564, Type 630 HT, Condition H1150 for shafts larger than 3.5 inches in diameter.</td>
</tr>
<tr>
<td>Rotor</td>
<td>Steel, ASTM A36, or cast steel, ASTM A27 for flywheels 3 feet in diameter or less; cast steel, ASTM A148 for flywheels greater in diameter than 3 feet. All stress relieved after machining.</td>
</tr>
</tbody>
</table>

2.02 **GENERAL QUALITY**

A. Ensure that details of manufacture and assembly of equipment furnished under this section and referencing sections follow the requirements of ANSI/API 610 with respect to the following features (paragraph references, ANSI/API 610):

1. Alignment aids (paragraph 6.1.24)
2. Removal of rotating element (paragraph 6.1.25)
3. Jackscrews for assistance in alignment on baseplates and equipment supports (paragraph 9.3.8.3.2)
4. Castings (paragraph 6.12.2)

B. Provide all components or subassemblies weighing 50 pounds or more with at least one lifting eye or a provision for threading in a lifting eye. Provide components 250 pounds or greater with lifting eyes or provisions for at least two lifting eyes. Provide components 1,000 pounds or greater with at least three lifting eyes or provisions for inserting lifting eyes.

2.03 **BASEPLATES AND SOLEPLATES**

A. Unless otherwise noted in the detailed specification, have the pump manufacturer furnish pumps with baseplates or soleplates conforming to the requirements of Section 40 05 02. Design baseplates and soleplates to be installed in the housekeeping curb shown, and ensure that they are machined flat and co-planar to within 0.002 inch per foot in all directions on the face mating with the pump and motor or driver support. Ensure that soleplates have the words “THIS SIDE DOWN” permanently affixed to the underside using a welding rod material or stamped prior to milling. Alternative marking methods, using heavy scribing or machining, are acceptable provided that they may be observed following blasting in preparation for coating.
2.04 WEARING RINGS
A. Where specified, fit pumps with both stationary and rotating wearing rings. Except for the difference in hardness between stationary and rotating rings, ensure that wearing rings are stainless steel and conform to the requirements of ANSI/API 610, paragraph 6.7 and material class S-8 (Table H.1, Annex H). Ensure that maximum wearing ring clearances do not exceed 150 percent of the values stated in Table 6, ANSI/API 610. Ensure that minimum wearing ring hardness on the rotating ring is 350 Brinell Hardness Number (BHN), with the stationary ring not less than 100 hardness points greater.

B. L-form wearing rings [are/are not] acceptable for wastewater, sewage, stormwater, thickener overflow, mixed sludge, digester circulation, digested sludge, waste activated sludge (WAS), RAS, or primary effluent pumping service.

2.05 BALANCE
A. Ensure that balancing for pumps with suction nozzle sizes 6 inches in diameter and greater and associated components conform to the requirements set forth in ANSI/API 610, paragraph 6.9.4.1 (equivalent to ISO 1940 or ANSI 2.19 Grade 2.5), unless other portions of this project manual impose more restrictive requirements. It is the intent that the components be balanced as an assembly (“rotor”) in accordance with ANSI/API 610 definitions. For extended-shaft pumps, balance impeller(s) and shaft up to the first coupling with the line-shaft.

B. For separately balanced components, perform a residual unbalance inspection after rotor assembly per ANSI/API 610 requirements, as described in Annex J of that document. Provide copies of worksheets and demonstrate that tolerances are in compliance (i.e., rotor has passed) in addition to other reporting requirements of this paragraph.

C. Furnish all balance logs, certified correct and signed by the chief engineer or individual in responsible charge of the manufacturing facility, in accordance with paragraph 1.09.

2.06 DRIVE UNIT SUPPORTS FOR SEPARATELY SUPPORTED MACHINES AND INTERMEDIATE SHAFT SUPPORTS
A. Ensure that supports for separately mounted vertical pump drivers and intermediate shaft bearings are composite structures of fabricated steel, ASTM A36. Unless otherwise specified, design the supports to span an opening in the floor sufficient to allow removal for the complete pump. Provide rolled steel beams to stiffen the support and mount a fabricated steel driver unit support pedestal on the support plate. Ensure that the support pedestal top plate and portions of the support plate assembly intended to join with surfaces in the installation structure are milled flat and parallel to 0.002 inch per foot. Provide pedestals with access provisions to adjust or assemble/disassemble couplings. Select a support that is designed to be supported on a soleplate or soleplates embedded in a housekeeping pad at the edges of the floor opening or as indicated. Ensure that other details for the driver unit support are as indicated.
2.07 MACHINING

A. Unless otherwise specified, provide machined surfaces with a 125 Ra (micro-inch) finish without any grooves, surface imperfections, or machining marks. Ensure that mating surfaces are coplanar within a maximum of 0.002 inch. Ensure that bearing housings and seals have collinear centerlines within less than 0.001 inch total difference. Provide shafts with a 63 Ra (1.6-micron) finish at fit areas (coupling, sleeves, impeller) and 125 Ra (3.2-micron) finish at the clear spans.

PART 3 - EXECUTION

3.01 GENERAL

A. With the exception of submersible pumps and the inlet connection for column-type pumps installed in open forebays or wetwells, connect pump inlet and discharge nozzles to field piping using equipment connection fittings conforming to the requirements of Section 40 05 06.16. Select restraining rods on equipment connection fittings that is designed specifically to restrain the unbalanced hydraulic thrust developed by the pump when operating at full speed against a closed valve. Torque all restraining rod nuts to ensure that any moment or shear transmitted to the pump nozzles is within the values permitted under ANSI/HI 9.6.2, or that permitted by the equipment manufacturer, whichever is greatest. Where ANSI/HI 9.6.2 is silent with respect to any particular aspect of allowable nozzle loads, have the contractor follow the written requirements provided by the equipment manufacturer. Install all pumps furnished under specification sections containing the words “custom-engineered” in the title under the presence of a factory-authorized installation specialist or specialists. Ensure that under no circumstances does any installation procedure take place without the installation specialists present. Ensure that equipment installation procedures conform to the requirements of Section 40 05 02. Upon completion of installation work, have the contractor submit a complete, properly signed certification statement. Demonstrate system in accordance with Section 01 75 00.

3.02 SOLEPLATES

A. Level soleplates, if provided pursuant to this section or any section referencing this section, or where required by the equipment manufacturer’s recommendation, in the presence of a factory-authorized installation specialist to a maximum tolerance of 0.002 inch per foot in all directions. Where the equipment manufacturer requires more stringent tolerances, those tolerances prevail.

3.03 ALIGNMENT

A. Ensure that journeymen millwrights perform alignment of equipment furnished under this section and any referencing section. Carpenters, laborers, or any other trades are specifically excluded from performing this work. In locations where such trades are not available, have the contractor retain the services of a firm specializing in this type of work to perform the setting and alignment work. Have the contractor submit the qualifications of the proposed firm to the construction manager for acceptance prior to performing the work. Ensure that the construction manager personally witnesses final alignment procedures for each item of equipment as a condition precedent to beginning any work required under Section 01 75 00.
3.04 FIELD TESTING

A. Ensure that field testing conforms to the requirements of Section 01 75 00. For pumps furnished under specification sections containing the words “custom-engineered” in the title, ensure that the testing procedure is a plan developed jointly by the contractor and equipment manufacturer to demonstrate performance of each item of equipment at specified operating conditions.

B. Unless otherwise specified in the detailed specifications, field-test centrifugal pumps for lateral vibration in accordance with paragraph 3.05B. Ensure that “custom-engineered” pumps additionally undergo field torsional vibration testing (paragraph 3.06A).

3.05 FIELD VIBRATION TESTS

| Reference Table: Previous Vibration Limits in Section 40 05 05 |
|---|---|---|---|
| Component | Standard | Applicable range | Notes | Inside POR (in./sec-RMS) | Outside POR (in./sec-RMS) |
| Motors | None | | | |
| Recip engines | None | | | |
| Pumps | API 610 | Horizontal | | 0.120 | 0.156 |
| Pumps | ANSI/HI 9.6.4 | Horizontal | Range based on hp | 0.22–0.30 | 0.29–0.39 |
| Support bearings, flywheels | None | Vertical | | 0.26–0.34 | 0.34–0.44 |

A. Qualifications:

1. Ensure that the contractor retains the services of an independent testing laboratory to conduct the testing work specified under this paragraph. Ensure that the work is directed by a professional mechanical engineer, registered to practice in any one of the 50 states composing the United States. Ensure that the engineer (hereinafter termed “professional vibration analysis specialist”) is a graduate of a college holding Accreditation Board for Engineering and Technology Inc. (ABET) accreditation in mechanical engineering and has been engaged in the practice of providing the type of monitoring services required under this paragraph for rotating machinery for a period of not less than 10 years. Submit the professional vibration analyst’s qualifications and references, certified and notarized, for review and acceptance by the construction manager not less than 6 weeks prior to the date scheduled for the field vibration test work specified herein. Ensure that the construction manager reviews the required documentation and references and indicates acceptance or rejection of the proposed analyst’s qualifications within 14 days of submission. If the analyst proposed by the contractor is rejected, have the contractor propose an alternative choice with appropriate documentation.
2. Ensure that the independent testing laboratory’s testing team (comprising the professional vibration analysis specialist and any technicians required to complete the specified tasks) is fully equipped to provide continuous pressure, velocity, and displacement values for rotating equipment installed under the requirements of this section. Ensure that vibration testing equipment includes sufficient calibrated pressure and flow monitoring devices to determine pump operating conditions as well as vibration levels.

B. Vibration Tests:

1. Ensure that the RMS vibration velocity does not exceed the limits established in ISO 10816-3 for electric motors (Table A.1 or A.2, Zone Boundary B/C, with flexible or rigid support determined by paragraph 1.06B.5.a.1)f)(4) Critical Speed Analysis and System Design; Methodology; Lateral rotor and structural dynamic analyses), ISO 10816-6 for reciprocating engine drives (Table A.1, classification number 3, Zone B), ISO 10816-7 Category II for pumps (Table A.1 or A.2, Zone B), and ISO 10816-1 for other rotating components such as support bearings and flywheels (Annex B, Table B.1, Class I, II, or III, Zone B) at any specified continuous-duty operating condition when the pump is operating within the POR. Ensure that measurement locations correspond to guidelines provided in the specific ISO 10816 section for the machine being evaluated (motor, engine, pump, or other component). When operating at any combination of conditions outside the POR for any pump, regardless of type, ensure that limiting values are 30 percent greater than the above limits, as indicated in the following table.

### Pumping System Component Vibration Limits

<table>
<thead>
<tr>
<th>Component</th>
<th>Standard</th>
<th>Applicable range</th>
<th>Notes</th>
<th>Inside POR (in./sec-RMS)</th>
<th>Outside POR (in./sec-RMS)</th>
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</thead>
<tbody>
<tr>
<td>Motors</td>
<td>ISO 10816-3 Table A.2</td>
<td>15 kilowatts (kW) to 300 kW &gt;300 kW</td>
<td>Rigid base*</td>
<td>0.110</td>
<td>0.177</td>
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<tr>
<td>Motors</td>
<td>ISO 10816-3 Table A.2</td>
<td>15 kW to 300 kW &gt;300 kW</td>
<td>Flexible base*</td>
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<td>Recip engines</td>
<td>ISO 10816-6 Table A.1, Class 3</td>
<td>&gt;100 kW &gt;134 hp</td>
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<td>0.441</td>
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<tr>
<td>Pumps (2 or more vanes)</td>
<td>ISO 10816-7 Table A.1</td>
<td>&lt;268 hp &gt;268 hp</td>
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<td>0.201 0.240 0.261 0.312</td>
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<tr>
<td>Additional for pumps 600 rpm or less</td>
<td>ISO 10816-7 Table A.2</td>
<td>Filtered amplitudes at 1/2X, 1X and 2X</td>
<td>Values are displacement (not velocity)</td>
<td>3.15 mils p-p 3.94 mils p-p</td>
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<tr>
<td>Single vane pumps</td>
<td>ISO 10816-7 Table A.1</td>
<td>&lt;268 hp &gt;268 hp</td>
<td>Increase 2 or more vane values by 50%</td>
<td>0.302 0.360 0.392 0.468</td>
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</tbody>
</table>
Pumping System Component Vibration Limits

<table>
<thead>
<tr>
<th>Component</th>
<th>Standard</th>
<th>Applicable range</th>
<th>Notes</th>
<th>Inside POR (in./sec-RMS)</th>
<th>Outside POR (in./sec-RMS)</th>
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</thead>
<tbody>
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<td>Support bearings, flywheels</td>
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<td>Class III: &gt;75 kW</td>
<td>0.177</td>
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</table>

*Rigid or flexible base determined by analysis using ANSI/HI 9.6.8 methodology.

2. Provide vibration test reports as an information submittal in accordance with paragraph 1.09, and provide the signature of the responsible professional vibration analysis specialist. Ensure that the vibration spectra is of sufficient resolution for legibility of magnitude and frequency data to be properly reviewed by the construction manager. Cascade diagrams are not sufficient for variable-speed drive application unless supported by the required data in a format suitable for more detailed analyses. Provide separate spectra at the maximum and minimum operating speeds and any potential resonant frequencies.

3.06 FIELD TORSIONAL VIBRATION TESTING

A. As required in paragraph 1.06 for custom-engineered pumps, perform field torsional vibration tests under the direct supervision of the design professional responsible for the mass elastic system design on an installed pumping unit selected by the construction manager.

3.07 TRAINING

A. Ensure that training conforms to the requirements of Section 01 79 00 and includes separate training sessions for each operator shift maintained by SPU and a separate session for maintenance personnel. Unless otherwise specified in the referencing section, the training requirement is waived for constant-speed pumping equipment with suction nozzle sizes 6 inches in diameter and smaller and for pumps with connected power requirements 10 hp and less. Ensure that the training session for maintenance personnel includes a comprehensive presentation, employing cut-away models or comparable graphics, and documentation on the step-by-step disassembly and subsequent reassembly of a pumping unit. Upon completion of training requirements, ensure that the contractor submits certified Form 40 05 01-B as specified in Section 01 99 90.

END OF SECTION 40 05 05
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Squirrel cage type, AC induction motors, up to 500 HP, for up to 4 poles (3600 or 1800 rpm nominal), or up to 250 HP for over 6 poles (1200 rpm or slower) shall be per NEMA MG1, Small or Medium.

2. Special purpose motors with features or ratings which are not specified herein, are specified in the particular equipment specifications.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>ABMA 9</td>
<td>Load Ratings and Fatigue Life for Ball Bearings</td>
</tr>
<tr>
<td>ABMA 11</td>
<td>Load Ratings and Fatigue Life for Roller Bearings</td>
</tr>
<tr>
<td>IEEE 112</td>
<td>Standard Test Procedures for Polyphase Induction Motors and Generators</td>
</tr>
<tr>
<td>IEEE 841</td>
<td>Standard for Petroleum and Chemical Industry- Premium-Efficiency, Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500 HP</td>
</tr>
<tr>
<td>NEMA ICS 2</td>
<td>Industrial Control and Systems Controllers, Contactors and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC</td>
</tr>
<tr>
<td>NEMA 250</td>
<td>Enclosures for Electrical Equipment (1000 volts maximum)</td>
</tr>
<tr>
<td>NEMA MG 1</td>
<td>Motors and Generators</td>
</tr>
<tr>
<td>UL 674</td>
<td>Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations</td>
</tr>
<tr>
<td>UL 1004</td>
<td>Electric Motors</td>
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</tbody>
</table>

1.03 DEFINITIONS

A. Terminology used in this Section conforms with NEMA MG-1. Motors covered in this specification are those defined in NEMA MG1 as Small (Fractional) and Medium (Integral) AC induction motors.
1.04 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility: Where Unit Responsibility is specified in the driven equipment sections of these specifications, the motor supplier shall coordinate with the provider of the driven equipment to verify that the motor provided under this section is fully compatible with and meets the specified performance requirements for that equipment.

1.05 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 10.
   a. Copy of this Section, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   b. Check-marks (✓) to denote full compliance with a paragraph as a whole. Underline deviations and denote by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance. Include a detailed, written justification for each deviation.
   c. Failure to include a copy of the marked-up specification sections with justification(s) for any requested deviation will cause rejection of the entire submittal with no further consideration.

2. Motor Data Sheets specified in this Section and Division 01.
   a. Motors in conformance with IEEE 841: Manufacturers to complete IEEE Standard 841 Data Sheet for AC Induction Motors.
   b. Motors not in conformance with IEEE 841: Motor supplier to complete Form 43 05 21-A in Section 00 66 00 with required factory data.
   c. Motor Speed-Torque curve, where specified.

   a. High-potential test.

4. Factory test data, from required dynamometer tests, where specified.

5. Vibration level when measured in accordance with NEMA MG 1, for all IEEE 841 motors, and where elsewhere specified.

6. Motor heating curve, where specified,

7. Motor mounting, outline, dimensions, and weight.

8. Motor bearing and winding RTDs (resistance temperature detector), where specified.

9. Motor winding thermostat or thermistor, where specified.

10. Motor winding space heaters, where specified.

11. Motor nameplate data.
B.  Informational Submittals:
   1.  Procedures: Section 01 33 10 and 01 77 19.
   2.  Submittal requirements for operation and maintenance manuals as per requirements of Section 01 77 19.

1.06 QUALITY ASSURANCE

A.  Factory Testing:
   1.  All polyphase motors shall be factory tested in conformance with routine tests per NEMA MG1 and IEEE 112. Provide the following tests:
      b.  No-load readings of current and speed at normal voltage and frequency.
      c.  Current input at rated frequency with rotor at standstill.
      d.  High potential test.
   B.  Where specified for use in corrosive or hazardous locations, motor testing shall additionally be per IEEE 841. Test report shall be certified by the motor manufacturer’s test personnel and submitted to the Engineer.
      1.  For motors larger than 100 horsepower, test and submit results for the following:
         a.  Routine tests per NEMA MG1 and IEEE 112. Provide tests as noted in paragraph 1.07 Factory Testing. Test report shall be certified by the motor manufacturer’s test personnel and submitted to the Engineer.
         b.  For motors larger than 200 horsepower, efficiency and power factor by Test Method B, IEEE 112. Submit Form B and B-2.

1.07 SPECIAL WARRANTY

A.  In addition to the guarantee requirements specified in Section 01 77 19, General Conditions, all motors ½ horsepower and greater shall be warranted against defects in materials and workmanship for a period of 5 years under the specified uses and with normal operation and service.
   B.  This warranty shall be delivered, in writing, to SPU and shall include, as a minimum, 100 percent full payment coverage for parts and labor during the first 60 months of operation. Submit warranties in writing to include 100 percent full payment coverage for parts and labor for repair or replacement of the motor (s) during the warranty period.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A.  The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer’s standard product may require modification to conform to specified requirements:
   1.  Baldor
   2.  General Electric
   3.  Siemens
   4.  US Motors
5. WEG
6. Approved substitute

2.02 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:
1. Temperature: -25-degree C to [+40] [+50] degree C.
2. Altitude: 0 to 3300 feet above sea level minimum.
3. Derate motors for higher ambient temperature and for higher altitude with motor size based on brake-horsepower.

B. Design Requirements:
1. Operation: Continuous.
3. Tolerance: +/- 10-percent of rated voltage at rated frequency; +/- 5-percent of rated frequency at rated voltage.
4. Standard design: NEMA Design B.

C. Service Factor (percent of additional horsepower):
1. 1.15 for Sine-wave motors.
2. Dual rating: 1.15 Sine-wave and 1.0 Inverter Duty for Inverter Duty motors.

D. Motor Efficiency:
1. NEMA Premium™ efficiency electric motor, single-speed, polyphase, 1-500 horsepower, 3600-rpm 2-pole, 1800-rpm 4-pole, and 1200-rpm 6-pole (1-250 HP), squirrel cage induction motors, NEMA Design B, continuous rated. NEMA Standards Publication MG 1 2011, in Table 12-12.

<table>
<thead>
<tr>
<th>HP</th>
<th>2 Pole</th>
<th>4 Pole</th>
<th>6 Pole</th>
<th>8 Pole</th>
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Table 12-12
Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors
Rated 600 Volts or Less (Random Wound)
### Table 12-12
Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors
Rated 600 Volts or Less (Random Wound)

#### Open Motors

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<tr>
<th>HP</th>
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<th>4 Pole</th>
<th></th>
<th>6 Pole</th>
<th></th>
<th>8 Pole</th>
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<tr>
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#### Enclosed Motors

<table>
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### Table 12-12
Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors
Rated 600 Volts or Less (Random Wound)

<table>
<thead>
<tr>
<th>HP</th>
<th>2 Pole</th>
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<th>8 Pole</th>
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<td>95.0</td>
<td>96.2</td>
<td>95.4</td>
</tr>
</tbody>
</table>

#### 2.03 MATERIALS

A. Motor frames:
   1. TEFC motors shall be cast iron.
   2. Aluminum frame motors are not permitted.

B. Stator windings:
   1. Shall be copper with Class F minimum insulation not to exceed Class B temperature rise of 80-degree C at rated load and with Design B torque /current characteristics for all Medium (Integral) motors.
   2. Small (fractional) motors shall be supplied with Class F insulation where available.

C. Rotor material shall be aluminum or copper.

D. Fans shall be non-sparking fan blades.

E. Motor leads shall be non-hygroscopic.
2.04 MOTOR TYPES

A. General Requirements for motors 1/2 horsepower through 500 horsepower:
   1. Three phase, squirrel cage, with copper windings.
   2. Rated for full voltage starting and continuous duty.
   3. Rating shall be:
      a. 460/230 volts, three-phase, 60-Hertz, as shown on the contract drawings.
   4. General Purpose Type motors, which may also be called Type 1 per the project equipment specifications shall be:
      a. Open Drip Proof Motors, shall be as defined per NEMA MG1, self-cooled by convection air.
      b. Weather-Protected Type I Motors (WP-I), shall be as defined per NEMA MG1, similar to ODP construction with addition of screens to prevent entry of rain, snow, and particles, or objects into the motor. Suitable for clean indoor and protected outdoor installations.
      c. Weather Protected Type II Motors (WP-II) shall be as defined per NEMA MG1, with maximum protection from entry of airborne particles, moisture and high velocity air. Suitable for unprotected outdoor installations.
   5. Severe Duty Type Motors, which may also be called Type 2 per the project equipment specifications, shall be in accordance with IEEE 841.
      a. Totally Enclosed Fan-Cooled Motors (TEFC) shall be defined per NEMA MG1.
      b. Enclosure: totally enclosed, fan cooled, with external fan blowing air to the motor frame cooling fins for cooling.
      c. Applications: severe duty and most outdoor installations.
   6. Explosion Proof Type Motors, which may also be called Type 3 per the project equipment specifications.
      a. Enclosures: UL listed explosion proof
      b. Applications: hazardous locations including Class I and Class II (Division 1 and 2), and Class III classified areas.

B. Motors Less Than 1/2 Horsepower:
   1. Type shall be:
      a. Squirrel cage, capacitor start with Class F insulation and copper windings.
      b. Fan motors rated 1/8 horsepower or less: split-phase or shaded-pole type.
   2. Rating shall be:
      a. 115Volts, single phase, 60 Hz.
      b. 208 Volts, single phase, 60 Hz.
      c. 230 Volts, single phase, 60 Hz.
2.05 COMPONENTS

A. Inverter-Fed Polyphase Motors per NEMA MG1 Part 31:
   1. Applications: variable torque or constant torque loads, for vertical or horizontal motors with variable frequency drive controllers (VFD).
   2. Features shall include:
      a. Insulation design to meet 2000-Volt peak at a minimum of 0.1 micro-second rise time.
      b. Built-in motor winding protection as specified.
      c. Electrically insulated bearings or,
      d. Provide Electro Static Technology's AEGIS Shaft Grounding Ring for Bearing Protection or approved substitute. The shaft grounding ring shall be solidly bonded per manufacturer's recommendations.

B. Vertical Motors:
   1. Features: Inverter duty or non-inverter duty with solid shaft P-base and high thrust bearing compatible with loads imposed by the driven equipment.

C. Thermal Protection:
   1. Inverter duty motors:
      a. Motors up to 50 horsepower:
         1) Protection to be NEMA Type 2 bi-metallic thermal switch (Klixon) type.
         2) Motor Nameplate: Marked "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.43.
      b. Motors larger than 50 horsepower up to and including 250 horsepower:
         a. Unless another form of thermal protection is specified in the driven equipment specification, provide a NEMA Type 1 temperature sensing device embedded in the motor winding which is sensitive to motor running over temperature.
         b. Sensor: Wired to a temperature relay in a NEMA 4 box located near or on the motor, or to the variable frequency drive controller.
         c. Motor Nameplate: Marked "OVER TEMP PROT 1" in accordance with NEMA MG 1 12.43.
      2. Motors larger than 250 horsepower:
         a. Unless another form of thermal protection is specified in the driven equipment specification, provide 100 ohm platinum RTDs, two per phase embedded in each winding phase.
         b. RTDs shall be brought out to a separate control terminal box mounted on the motor.
         c. Motor Nameplate: Marked "OVER TEMP PROT 1" in accordance with NEMA MG 1 12.43.
4. Explosion proof motors:
   a. Protection to be NEMA Type 2 bi-metallic thermal switch (Klixon) type:
      1) Constant speed motors (non-explosion proof).
   b. Motors up to 50 horsepower:
      1) Where thermal protection is specified in the driven equipment specifications, provide NEMA Type 2 bi-metallic thermal switch (Klixon) type.
      2) Motor Nameplate: Marked "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.43.
   c. Motors larger than 50 horsepower up to 250 horsepower:
      1) Where thermal protection is specified in the driven equipment specifications, provide a NEMA Type 1 temperature sensing device embedded in the motor winding which is sensitive to both motor running over temperature and with fast response to rate of temperature rise for locked rotor protection.
      2) Sensor: Wired to a NEMA 4 temperature monitor box located near or on the motor.
      3) Temperature Sensing System: Automatic reset, normally closed contact, rated 2A at 115 VAC.
      4) Motor Nameplate: Marked "OVER TEMP PROT 1" in accordance with NEMA MG 1 12.43.
   d. Motors larger than 250 horsepower:
      1) Unless another form of thermal protection is specified in the driven equipment specification, provide 100 ohm platinum RTDs, two per phase embedded in each winding phase.
      2) RTDs shall be brought out to a separate control terminal box mounted on the motor.
      3) Motor Nameplate: Marked "OVER TEMP PROT 1" in accordance with NEMA MG 1 12.43.

D. Motor Nameplates:
   1. Materials: Engraved or stamped stainless steel.
   2. Features shall be as follows:
      a. NEMA Standard MG 1 motor data.
      b. Permanently fastened to the motor frame.
      c. ABMA bearing identification number for motors meeting IEEE 841.
      d. NEMA nominal efficiency for all motors.
      e. NEMA nominal and minimum efficiency for motors meeting IEEE 841.
      f. UL frame temperature limit code for explosion proof motors.
      g. Space heater data.
h. Over Temperature Protection Type Number.
i. Temperature device rating and alarm and shutdown setpoint.
j. Provide motor nameplates for motors with space heaters located in Class I, Division 2, Groups C, and D areas in accordance with NEC 501.125(B).

E. Conduit Boxes:
1. Provide oversized boxes, with split construction with threaded hubs and petroleum-resistant gaskets.
2. Conduit boxes can be rotated in order to permit installation in any of four positions 90 degrees apart.
3. Provide grounding lug located within the conduit box for ground connection.
4. Provide separate conduit boxes for temperature devices and space heaters.
5. Separate terminal box for any signal leads (RTD, thermistor, vibration transmitter, etc.).

F. Bearings:
1. Provide oil or grease lubricated ball bearings, angle contact roller bearings for axial thrust loads, and cylindrical bearings for radial-only loads.
2. Rated for a minimum L-10 life of 50,000 hours for direct-connected loads.
3. Cartridge type bearings will not be accepted.
4. Fitted with lubricant fill and drain or relief fittings.
5. Belt loads not to exceed forces calculated from NEMA MG 1 Table 14-1 and 14-1A.

G. Bearing lubrication shall be either grease or oil as per the requirements in either 1 or 2:
1. Grease lubricated bearings:
   a. Shall be for electric motor use only.
   b. Grease shall be capable of higher temperatures associated with electric motors and shall be compatible with Polyurea-based greases.
   c. Provide grease fittings, similar to Alemite™ type (or equivalent).
   d. Shielded bearings with regreasable provisions are permissible.
2. Provide oil lubricated bearings with externally visible sight glass to view oil level.

H. Lifting Eyes:
1. Provide lifting eyes with a safety factor of 5.
2. Provide one lifting eye for motors more than 50 pounds.
3. Provide two lifting eyes for motors over 150 pounds.

I. Winding Space Heaters when specified or shown:
1. Provide winding space heaters to prevent condensation.
2. Rating: 120 volts, single phase, 60 Hertz.
3. Motor nameplate to show space heater rating in watts and volts.
4. Provide terminal block in motor conduit box for heater leads termination.

2.06 FINISHES
A. Paint Finish:
   1. Provide standard manufacturer paint finish.
   2. Provide motors with semi-gloss finish, scratch and heat resistance electric motor paint.

PART 3 - EXECUTION
3.01 EXAMINATION
A. Delivery Inspection:
   1. Inspect driven equipment-motor assembly and components immediately upon delivery and unloading at the job site for damages.
   2. Take photos of damage(s) if any, to substantiate the delivery inspection report.

3.02 INSTALLATION
A. Grounding of Motors:
   1. Connect the motor feeder ground cable (green) to the grounding lug terminal in the conduit terminal box.
B. Supplemental Grounding of Motors: Provide for motors fed from VFDs, all motors above 100 horsepower, and all motors in classified areas, where feasible.
   1. Bond the motor frame to the grounding grid/electrode system to provide supplemental grounding.
C. Field Coating of Motors:
   1. Refer to the driven equipment specification section and Section 09 90 00 for coating requirements.

3.03 FIELD QUALITY CONTROL
A. Field Testing:
   1. Measure winding insulation resistance of motors to no less than 10-megohm with a 1000-Vac megohmmeter.
   2. Perform motor phases current imbalance testing for motors 20 horsepower and larger.
   3. Test motors for proper rotation prior to connection to the driven equipment.
   4. Perform thermographic survey per NETA ATS, for motors over 100 horsepower.
B. Field Inspection:
   1. Compare equipment nameplate data with drawings and specifications.
   2. Inspect physical and mechanical condition.
   3. Inspect anchorage, alignment, and grounding.
4. Verify the installation of breather/drain fittings as specified herein.
5. Check for proper connections of space heaters, winding and RTDs and or thermostats.
6. Visually check for correct phase and ground connections:

C. Manufacturer Services: Provide where specified or shown on the drawings.
   1. Provide services to the driven equipment manufacturer for the inspection and certification of the installation of the motor driven equipment.
   2. Provide assistance in the start up and operational testing of the motor driven equipment.

3.04 SYSTEM START UP
A. Commissioning Test: Provide where specified or shown on the drawings, in accordance with the provisions of Section 01 75 00.
   1. Provide assistance during the commissioning test of the motor driven equipment.

3.05 CLOSEOUT ACTIVITIES
A. Operation and Maintenance:
   1. Provide the operation and maintenance manual of the motor(s). Include testing result information in the O&M manual.

END OF SECTION 40 05 06
PART 1 - GENERAL

1.01 SUMMARY

A. Scope: This section specifies stainless steel slide gates for pump station isolation.

B. Type: Slide gates shall be of stainless steel construction with gates and guides provided by one manufacturer. Gates shall meet the leakage requirements of AWWA C513 and C561 as applicable, unless otherwise specified.

C. Design Conditions:
   1. Slide gates shall be designed for continuous exposure to Stormwater runoff.
   2. Slide gates will be installed outdoors in a municipal stormwater pump station.

D. Operating Requirements:

<table>
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<th>Equipment No.</th>
<th>Gate Opening Size, Inch&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Gate Type&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Opening Direction&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Bottom Seating&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Design head, feet Seating</th>
<th>Unseating</th>
<th>Operator Type&lt;sup&gt;e&lt;/sup&gt;</th>
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<tbody>
<tr>
<td>SLG-0116</td>
<td>60x60</td>
<td>W</td>
<td>U</td>
<td>S</td>
<td>5</td>
<td>15</td>
<td>Powered</td>
</tr>
</tbody>
</table>

Notes:
1. <sup>a</sup> Width by height
2. <sup>b</sup> W = wall-mounted
3. <sup>c</sup> U = upward
4. <sup>d</sup> S = standard
5. <sup>e</sup> Powered = electric powered, ref. Section 40 05 62, Power Actuated Valve and Gate Actuators

E. Component Sizing:
   1. Operating forces used for determining the strength of gate components comprising of yokes, frames, discs, stems, disc nut pockets, and other load-bearing members shall be based on the sum of the guide friction force (computed using an opening breakaway friction factor of 0.70) and the weight of disc and stem.
   2. When the gate is in motion, the operating forces shall be based on the sum of the frictional force (using a guide friction factor of 0.35) and the weight of disc and stem.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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<tr>
<td>ASTM A167</td>
<td>Stainless and Heat-Resisting Chromium Nickel Steel Plate, Sheet, and Strip</td>
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<td>ASTM A240</td>
<td>Heat-Resisting Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels</td>
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<tr>
<td>ASTM A269</td>
<td>Seamless and Welded Austenitic Stainless Steel Tubing for General Service</td>
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<tr>
<td>ASTM A276</td>
<td>Stainless Steel Bars and Shapes</td>
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<tr>
<td>ASTM D2000</td>
<td>Rubber Products in Automotive Applications</td>
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<tr>
<td>ASTM D4020</td>
<td>Ultra-High-Molecular-Weight Polyethylene Molding and Extrusion Materials</td>
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<tr>
<td>ASTM F593</td>
<td>Stainless Steel Bolts, Hex Cap Screws, and Studs</td>
</tr>
<tr>
<td>ASTM F594</td>
<td>Stainless Steel Nuts</td>
</tr>
<tr>
<td>AWWA C513</td>
<td>Open-Channel, Fabricated Metal Slide Gates</td>
</tr>
<tr>
<td>AWWA C561</td>
<td>Fabricated Stainless Steel Slide Gates</td>
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</tbody>
</table>

1.03 DEFINITIONS

(NOT USED)
1.04 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 10:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (☑) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and paragraph 1.04 B of Section 40 05 01, General Requirements for Equipment. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.

3. Fabrication drawings with full dimensions.

4. Plan, cross section, and details showing proposed mounting for gate and actuator.

5. Product Data:
   a. Product information, calculations, charts, or graphs to verify that the product provided meets the requirements set forth in this specification.
   b. Affidavits of compliance in accordance with AWWA C561, Section 6.3 and AWWA C513.
   c. Applicable operation and maintenance information as specified in Section 01 77 19, General Conditions.

6. Operations and maintenance data in conformance with Section 01 73 00, Operation and Maintenance Information.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. SPU and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed that named manufacturers’ standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Golden Harvest, Waterman, Whipps, or approved substitute, modified to meet specified requirements.
2.02 MATERIALS

A. Materials for components shall be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate, guides, and frame</td>
<td>ASTM A240 Type 304 or 304L stainless steel</td>
</tr>
<tr>
<td>Stem, stem couplings, and stem guide</td>
<td>ASTM A276 Type 304 stainless steel</td>
</tr>
<tr>
<td>Seat and stem guide bushings</td>
<td>ASTM D4020 UHMW Polyethylene</td>
</tr>
<tr>
<td>Seal</td>
<td>ASTM D4020 UHMW Polyethylene</td>
</tr>
<tr>
<td>Fasteners and adjusting hardware</td>
<td>ASTM F593/F594, Type 304 stainless steel</td>
</tr>
<tr>
<td>Yoke</td>
<td>ASTM 269 Type 304 stainless steel</td>
</tr>
</tbody>
</table>

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 EQUIPMENT

A. Slide gates

1. Slide gates shall meet the requirements of AWWA C561 except as otherwise specified. Slide gates shall be of the heavy-duty type. Frames shall be flat back.

2. Stems and stem guides shall be provided in accordance with AWWA C561, Sections 4.4.11 and 4.4.12. Gates shall have non-rising stems. Stems shall have 29-degree Acme threads and be turned straight and true and honed to a smooth 63 micro-inch or better finish.

2.04 EQUIPMENT FEATURES

A. Frame and Guides:

1. The gate frame shall be a rigid, welded unit, composed of the guide rails, cross bars, and deadrails, with a clear opening the same size as the waterway, unless otherwise specified. They shall be flatback or embedded type. The guides shall be of sufficient length to support two-thirds (2/3) the height of the slide, when the gate is fully open.

2. On wall mounted gates, compressible gaskets or grout shall be provided between frame and wall as needed to ensure full mating of surfaces and no leakage.

3. The yoke shall be sufficiently strong to support the lift forces when subjected to a load of 100 pounds pull on the operator. The yoke shall be designed so that its deflection under full operating load will not exceed 1/360 of the gate width or ¼ inch under maximum load, whichever is less.
B. Slide:
   1. The slide shall be plate reinforced with structural shapes welded to the plate. The slide shall not deflect more than 1/1000 of the span of the gate, or 1/16 inch whichever is greater, under maximum design head. The stem connection shall be either the Clevis type, with structural members welded to the slide and a bolt to act as pivot pin, or a threaded and bolted (or keyed) thrust nut supported in welded nut pocket. The pocket and yoke of the gate shall withstand at least 2.5 times the rated thrust output of the operator at 40 pounds pull.

C. Stem:
   1. Stems shall be manufactured of solid bar. The stem diameter shall be capable of withstanding twice the rated output of the operator at 40 pounds pull for manual operators, or 1.25 times the output thrust of operator for powered actuators (the hydraulic cylinder or the electric motor in stalled condition), and shall be supported such that 1/r ratio for the unsupported part of the stem shall not exceed 200. Stem threads shall be of cut ACME type.

   2. Stems shall be non-rising type.

D. Sealing System:
   1. Flush bottom seal shall be of compressible neoprene shall be located on the slide. With the slide open, the invert of the gate shall be flush with the opening, with no pockets or cavities for the accumulation of solids.

   2. Top and side seals shall be able to be replaced without removing the gate frame from the concrete or wall thimble.

   3. Gates shall use a sealing system of neoprene to achieve the leakage rates specified and to provide a durable sealing system as follows:
      a. Upward Opening Gates for Submerged Service: The seating face of the frame shall be oriented at an angle to the plane of the mounting flange to effect a wedging action upon closure. Seals shall be UHMW polyethylene and be fully adjustable. Invert seal shall be mounted on the slide. Side and top seals shall be frame mounted.

2.05 OPERATORS

A. Operators shall be the powered type. Operators shall meet AWWA C561 specifications and shall be designed to meet the operating requirements specified in paragraph 1.04 A of this section.

   1. See Section 40 05 62, for specification of electric powered operators.

B. Mounting Bracket: Operators shall be mounted on a manufacturer-provided stainless-steel bracket installed on top of wetwell wall. Bracket shall mount flush with top and interior faces of wetwell wall. Bracket shall align the slide gate shaft with the powered actuator.
2.06 PRODUCT DATA
A. The following information shall be provided in accordance with Section 01 33 10:
   1. Product information, charts, or graphs to verify that the product provided meets the requirements set forth in the specification.
   2. Affidavits of compliance in accordance with AWWA C561.
   3. Operating and maintenance information as specified in Section 01 77 19.

PART 3 - EXECUTION

3.01 INSTALLATION
A. Unless otherwise specified, slide gates shall be installed in accordance with manufacturer's instructions.

3.02 TESTING
A. Shop seat clearance and operating tests and field operating and leakage tests shall be performed as per Section 5.2 of the AWWA C561.

B. For purpose of this specification, field leakage tests shall be performed as specified in AWWA C513/C561 as applicable. Field leakage tests shall be conducted with no head on one side of the gate being tested. Prior to testing and commissioning a test plan procedure shall be submitted and approved.

C. The maximum leakage rate for submerged upward opening gates shall be 0.02 gallons per minute per foot of seating perimeter for the seating and unseating heads specified.

D. The maximum leakage rate for downward opening gates shall be 0.10 gallons per minute per foot of seating perimeter for the seating and unseating heads specified.

E. Gate shall be operated through a minimum of two cycles, to confirm operation. Limit switches and other stops shall be adjusted per the manufacturer’s recommendations.

F. Installation, testing, and training in accordance with Section 01 75 00.

END OF SECTION 40 05 07
PART 1 - GENERAL

1.01 SUMMARY

A. Scope:

1. This section specifies systems of process piping and general requirements for piping systems. Detailed specifications for the components listed on the Piping System Specification Sheets are found in other sections of Division 33 and Division 40. This section shall be used in conjunction with those sections.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
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<td>AASHTO M36/M36M</td>
<td>Metallic (Zinc or Aluminum) Coated Corrugated Steel Culverts and Underdrains</td>
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<td>Scheme for the Identification of Piping Systems</td>
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<td>Pipe Threads, General Purpose (Inch)</td>
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<td>ASTM A312/A312M</td>
<td>Seamless and Welded Austenitic Stainless Steel Pipe</td>
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<td>Thermoplastic Gas Pressure Pipe, Tubing, and Fittings</td>
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<td>ASTM F441</td>
<td>Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80</td>
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<td>Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids</td>
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<td>AWWA C110</td>
<td>Ductile-Iron and Gray-Iron Fittings, 3 Inch Through 48 Inch, for Water and Other Liquids</td>
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<td>AWWA C111</td>
<td>Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings</td>
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<td>AWWA C115</td>
<td>Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges</td>
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<td>AWWA C151</td>
<td>Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids</td>
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<td>AWWA C200</td>
<td>Steel Water Pipe 6 Inches and Larger</td>
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<td>AWWA C205</td>
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<td>AWWA C301</td>
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</tr>
<tr>
<td>UPC</td>
<td>Uniform Plumbing Code</td>
</tr>
</tbody>
</table>
1.03 **DEFINITIONS**

A. Pressure terms used in Section 40 05 01 and elsewhere in Division 40 are defined as follows:

1. **Maximum:** The greatest continuous pressure at which the piping system operates.

2. **Test:** The hydrostatic pressure used to determine system acceptance.

1.04 **QUALITY ASSURANCE**

A. Fittings and Coupling Compatibility:

1. To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturers.

1.05 **SUBMITTALS**

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Piping layout drawings shall be transmitted to the Engineer a minimum of 6 weeks prior to construction. Drawings shall be original layouts by the Contractor; photocopies of contract drawings are not acceptable.

D. Product data on piping materials.

**PART 2 - PRODUCTS**

2.01 **PIPING MATERIALS**

A. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, shall be selected from those listed on the piping system specification sheets. Piping materials shall conform to detailed specifications for each type of pipe and piping appurtenance specified in other sections of Division 40.
2.02 PIPING IDENTIFICATION

A. Plastic Coding Markers:
   1. Plastic markers for coding pipe shall conform to ANSI A13.1 and shall be as manufactured by W. H. Brady Company, Seton Name Plate Corporation, Marking Services Inc., or approved substitute. Markers shall be the mechanically attached type that are easily removable; they shall not be the adhesive applied type. Markers shall consist of pressure sensitive legends applied to plastic backing which is strapped or otherwise mechanically attached to the pipe. Legend and backing shall be resistant to petroleum based oils and grease and shall meet criteria for humidity, solar radiation, rain, salt, fog and leakage fungus, as specified by MIL-STD-810C. Markers shall withstand a continuous operating temperature range of -40 degrees F to 180 degrees F. Plastic coding markers shall not be the individual letter type but shall be manufactured and applied in one continuous length of plastic.
   2. Markers bearing the legends on the background colors specified in the PIPESPEC shall be provided in the following letter heights:

<table>
<thead>
<tr>
<th>Outside Pipe Diameter,(^{1}) Inches</th>
<th>Letter Height, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1-1/2</td>
<td>1/2</td>
</tr>
<tr>
<td>1-1/2 through 3</td>
<td>1-1/8</td>
</tr>
<tr>
<td>Greater than 3</td>
<td>2-1/4</td>
</tr>
</tbody>
</table>

\(^{1}\) Outside pipe diameter shall include insulation and jacketing.

3. In addition, pipe markers shall include uni- and bi-directional arrows in the same sizes as the legend. Legends and arrows shall be white on blue or red backgrounds and black on other specified backgrounds.

B. Plastic Tracer Tape:
   1. Tracer tape shall be 6 inches wide, colored the same as the background colors as specified in Table A, paragraph 3.06, and made of inert plastic material suitable for direct burial. Tape shall be capable of stretching to twice its original length and shall be as manufactured by Allen Systems, W. H. Brady Co., Seton Name Plate Corporation, Marking Services Inc., or approved substitute.
   2. Two messages shall be printed on the tape. The first message shall read "CAUTION CAUTION CAUTION PIPE BURIED BELOW" with bold letters approximately 2 inches high. The blank shall be filled with the particular system fluid such as chlorine, oxygen or sulfur dioxide. The second message shall read "CALL ____" with letters approximately 3/4 inch high. Both messages shall be printed at maximum intervals of 2 feet.

2.03 VALVES

A. Valves of the same size and service shall be provided by a single valve manufacturer. Packing shall be nonasbestos material. Actual length of valves shall be within 1/16 inch (plus or minus) of the manufacturer's specified length. Flanges shall meet the requirement of ANSI B16.5. Push-on and mechanical joints shall meet the requirements of AWWA C111.
2.04 PRODUCT DATA
A. Product data on piping materials shall be provided in accordance with Section 01 33 10 where specified.
B. Piping layout drawings shall be transmitted to the Engineer a minimum of 2 weeks prior to construction. Drawings shall be original layouts by the Contractor; photocopies of contract drawings are not acceptable.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Location:
   1. Piping shall be provided as specified except for adjustments to avoid architectural and structural features and shall be coordinated with electrical construction
B. Piping Sizes:
   1. Where the size of piping is not specified, the Contractor shall provide piping of the sizes required by UPC. Unless specified otherwise, small piping (less than 1 inch in diameter) required for services not described by UPC shall be 1/2 inch.
C. Pipe Support, Anchorage and Seismic Bracing:
   1. General: Piping shall be supported by anchor brackets, guides, saddles or hangers. Acceptable types of supports, guides, saddles, hangers and structure attachments for general pipe support, expansion/contraction and for seismic bracing, as well as anchorage details, are shown on the drawings. Minimum spacing shall be as specified for supports and for seismic bracing. Where a specific type of support or anchorage is indicated on the drawings, then only that type shall be used there. Piping shall be vertically supported by anchor brackets, guides, saddles or hangers and shall be seismically braced where indicated to resist lateral load. Supports shall be provided on each run at each change of direction. Pipe supports shall be hot-dip or mechanically galvanized. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.
   2. Piping Connections to Machines: Piping at machine connections shall be aligned in all planes to permit insertion of bolts at bolted connections or coupling screwed connections without using jacks, come-a-longs or other mechanical means to align field piping with the connections at the machines. Bolts shall not be forced into mating flange bolt holes and shall be capable being withdrawn using finger pressure alone. The use of ‘dutchmen’ mitered sections or similar specials to achieve the required alignment with machine connections is strictly prohibited.
D. Anchorage for Buried Piping:
   1. All plugs, caps, tees and bends in buried pressure piping systems shall be anchored by means of reaction backing or restrained joints as specified.
E. Bedding and Backfill:
   1. Bedding and backfill for buried piping shall be as specified.
F. Equipment Connection Fittings:
   1. Where shown, equipment connection fittings as specified in Section 40 05 12 shall be provided between field piping systems and equipment inlet and outlet connections.

G. Flexibility
   1. Unless otherwise specified, piping passing from concrete to earth shall be provided with two pipe couplings or flexible joints as specified in Section 40 05 12.

3.02 PIPING IDENTIFICATION

A. Pipe Coding:
   1. After application of the specified coating and insulation systems, exposed piping, interior and exterior, and piping in ceiling spaces, pipe trenches, pipe chases and valve boxes shall be identified with plastic markers as specified in paragraph 2.02 Plastic Coding Markers. Legend markers and directional arrows shall be located at each side of walls, floors and ceilings, at one side of each piece of equipment, at piping intersections, and at approximately 50-foot centers.

B. Plastic Tracer Tape:
   1. A single line of tape as specified in paragraph 2.02 Plastic Tracer Tape shall be provided 2.5 feet above the centerline of buried System 7 pipe. For System 7 pipelines buried 8 feet or greater below finished grade, contractor shall provide a second line of tape 12 inches below finished grade, above and parallel to each buried pipe. Tape shall be spread flat with message side up before backfilling.

C. Magnetic Tracer Tape:
   1. Polyethylene magnetic tracer tape shall be buried 12 to 18 inches below ground and shall be above and parallel to buried plastic and RCP pipe (systems 13 and 24). For pipelines buried 8 feet or greater below final grade, the Contractor shall provide a second line of tape 2.5 feet above and parallel to the buried pipe.

3.03 TESTING

A. General:
   1. Upon completion of piping, but prior to application of insulation on exposed piping, the Contractor shall test the piping systems. Pressures, media and test durations shall be as specified in the PIPESPEC. Equipment which may be damaged by the specified test conditions shall be isolated. Testing shall be performed using calibrated test gages and calibrated volumetric measuring equipment to determine leakage rates. Each test gage shall be selected so that the specified test pressure falls within the upper half of the gage’s range. Unless otherwise specified, the Contractor shall notify the Engineer 24 hours prior to each test.

   2. Unless otherwise specified, testing, as specified herein, shall include existing piping systems which connect with new pipe systems. Existing pipe shall be tested to the nearest existing valve. Any piping which fails the test shall be repaired. Repair of existing piping will be considered and paid for as extra work.
3. Where testing existing chlorine and sulfur dioxide systems to the nearest isolation valve, Contractor shall provide a tee in the line adjacent to the valve. The branch outlet on the tee shall be valved and used for cleaning, pressure testing, draining, and drying the line. Unless otherwise indicated, the existing chlorine or sulfur dioxide system shall not be shut down during testing or connecting the tee and valve. Prior to placing the line in service, the valve on the branch outlet shall be plugged or sealed with a blind flange or threaded plug. Contractor shall be responsible for all damage to the existing system as a result of this work.

B. Liquid Systems:
   1. Leakage shall be zero at the specified test pressure throughout the specified duration for exposed piping. Unless otherwise specified, leakage from other buried liquid piping systems shall be less than 0.02 gallon per hour per inch diameter per 100 feet of buried piping.

C. Drains:
   1. Drain systems, other than pumped drain systems, shall be tested in accordance with UPC.

3.04 CLEANING AND FLUSHING

A. General:
   1. Piping systems shall be cleaned following completion of testing and prior to connection to operating, control, regulating or instrumentation equipment. The Contractor may, at his option, clean and test sections of buried or exposed piping systems. Use of this procedure, however, will not waive the requirement for a full pressure test of the completed system. Unless specified otherwise, piping 24 inches in diameter and smaller shall first be cleaned by pulling a tightly fitting cleaning ball or swab through the system. Piping larger than 24 inches in diameter may be cleaned manually or with a cleaning ball or swab.

B. Liquid Systems:
   1. After completion of cleaning, liquid systems, unless otherwise specified, shall be flushed with clean water. With temporary screens in place, the liquid shall be circulated through the piping system using connected equipment for a minimum period of 15 minutes and until no debris is collected on the screens.

C. Potable Water Systems:
   1. Potable water piping systems shall be flushed and disinfected in accordance with AWWA C651.

3.05 PIPING SPECIFICATION SHEETS (PIPESPEC)

A. Piping and valves for groupings of similar plant processes or types of service lines are specified on individual piping specification sheets (PIPESPECs). Piping services are grouped according to the chemical and physical properties of the fluid conveyed and/or by the temperature or pressure requirements. Each grouping of services (PIPESPEC) is identified by a piping system number. Piping services specified in the PIPESPECs and on the drawings are alphabetically arranged by designated service symbols as shown in Table A. Table A also indicates the system number, fluid category, and pipe marker background color of each service.
Table A. Piping Services

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<tr>
<th>Symbol</th>
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<th>System</th>
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<th>Pipe Marker Background Color</th>
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<td>D</td>
<td>Drain</td>
<td>24</td>
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<td>FM</td>
<td>Force Main</td>
<td>9</td>
<td>Water</td>
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<td>Piped Storm Drainage</td>
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<td>Side Sewer - Sanitary</td>
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<td>V</td>
<td>Vent</td>
<td>2</td>
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<td>WS</td>
<td>Potable Water (City water)</td>
<td>7</td>
<td>Water</td>
<td>Blue</td>
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</tbody>
</table>
3.06 PIPING SPECIFICATION SHEETS--PIPESPEC

Piping Symbol/Service: V-Vent System--2

Test Requirements:
None

Gasket Requirements:
Flange: Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder
Push-on/Mech Cpl: N/A

Exposed Pipe and Valves:
(See drawings for pipe size and valve type)

Pipe: Steel; ASTM A53, ERW, Grade B, black, no lining. Ref. spec Section 40 05 24.
Conn: butt weld, flanged for valves.
Ftgs: steel, ASTM A234, ANSI B16.9; ends to match pipe.

Valves: None

Buried and Encased Pipe and Valves:
(See drawings for pipe size and valve type. Omit coatings on encased pipe.)

Pipe: PVC; ASTM D1784, Class 12454-B, ASTM D2665, Sch. 40. Refer to Section 40 05 10, Plastic Pipe.
Conn: plain end, solvent weld.
Ftgs: PVC, socket type, DWV, ASTM D2665.

Valves: None
3.06 PIPING SPECIFICATION SHEETS—PIPESPEC

Piping Symbol/Service: WS – Potable Water

Test Requirements:
- **Medium:** Water; ref. spec paragraph 3.04 Liquid Systems.
- **Pressure:** 150 psig
- **Duration:** 60 minutes

Gasket Requirements:
- **Flange:** Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder
- **Push-on/Mech Cpl:** EPDM

Exposed Pipe and Valves:
(See drawings for pipe size and valve type. See Remarks for insulation requirements.)

- **Pipe:** Copper tube; ASTM B88, Type L, drawn. Ref. spec Section 40 05 11.
  - **Conn:** solder type with threaded or flanged adapters for valves.
  - **Ftgs:** wrought copper or bronze, ANSI B16.22.

- **Valves:**
  - **Ball:** Jamesbury Fig. 351, Nibco T-580, or approved substitute.
  - **Globe:** Crane 7TF or 17TF, Lunkenheimer 123 or 214, or approved substitute.
  - **Swing check:** Crane 137, Lunkenheimer 230, or approved substitute.

Buried and Encased Pipe and Valves:
(See drawings for pipe size and valve type. Omit coating on encased pipe. See Remarks for insulation requirements.)

- **Pipe:** Copper tube; ASTM B88, Type K, annealed or drawn.
  - **Conn:** solder type, with threaded or flanged adapters for valves.
  - **Ftgs:** wrought copper or bronze, ANSI B16.22.

- **Valves:**
  - **Gate:** ref. spec Section 40 05 12, with extension stem and valve box. Coating M-1 per spec Section 09 90 00.

Remarks:

1. Manual air vents shall be provided at the high points and drains provided at the low points of each reach of pipeline as specified in Section 40 05 06.33-3.03.
3.06 PIPING SPECIFICATION SHEETS—PIPESPEC

Piping Symbol/Service: FM – Force Main System–9

Test Requirements:
- Medium: Water; ref. spec paragraph 3.04 Liquid Systems.
- Pressure: 125 psig
- Duration: 60 minutes

Gasket Requirements:
- Flange: Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder
- Push-on/Mech Cpl: Nitrile or Neoprene

Exposed Pipe and Valves:
(See drawings for pipe size and valve type)

(10” and smaller)
Pipe: Ductile iron; AWWA C151 with double cement mortar lining. Ref. spec Section 40 05 19.
Conn: 125# flanged as indicated on drawings.
Ftgs: malleable iron, ductile iron, or steel per spec Section 40 05 24; ends to match pipe.

Valves: Gate: double disk, ref spec 40 05 61.03.
Swing check: spring loaded per spec Section 40 05 65.23.

(12” and larger)
Pipe: Steel; AWWA C200, 3/16 inch thick, with cement mortar lining. Ref. spec Section 40 05 24.
Conn; flanged, plain end butt weld, or grooved end as indicated on Drawings.
Ftgs: fabricated steel, AWWA C208; lining and ends to match pipe.

Valves: None.
Buried and Encased Pipe and Valves:
(See drawings for pipe size and valve type. Omit coating on encased pipe.)

(12" and larger)
Pipe: Ductile iron; AWWA C151 with double cement mortar lining. Ref. spec Section 40 05 19.
Conn: restrained mechanical joints. Flanged adapters for valves.
Ftgs: ductile iron per spec Section 40 05 19; coating, lining and ends to match pipe.

Valves: Swing check: spring loaded per spec Section 40 05 65.23.
Gate: double disk, ref spec 40 05 61.03.
### 3.06 PIPING SPECIFICATION SHEETS—PIESPEC

<table>
<thead>
<tr>
<th>Piping Symbol/Service:</th>
<th>PSD – Piped Storm Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Requirements:</td>
<td>Air; ref. Section 33 40 00, Storm Drainage System.</td>
</tr>
<tr>
<td>Gasket Requirements:</td>
<td>Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder</td>
</tr>
<tr>
<td>Flange:</td>
<td>Nitrile or Neoprene</td>
</tr>
<tr>
<td>Push-on/Mech Cpl:</td>
<td></td>
</tr>
</tbody>
</table>

**Exposed Pipe and Valves:**
(See drawings for pipe size and valve type)

<table>
<thead>
<tr>
<th>Pipe:</th>
<th>Steel; AWWA C200, 3/16 inch thick, with lining. Ref. spec Section 40 05 24.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conn:</td>
<td>sleeve or shouldered mech pipe coupling, flanged, plain end butt weld, or slip joint fillet weld.</td>
</tr>
<tr>
<td>Ftgs:</td>
<td>fabricated steel, AWWA C208; lining and ends to match pipe.</td>
</tr>
<tr>
<td>Valves:</td>
<td>None</td>
</tr>
</tbody>
</table>

**Buried and Encased Pipe and Valves:**
(See drawings for pipe size and valve type. Omit coating on encased pipe.)

(24" and smaller)

<table>
<thead>
<tr>
<th>Pipe:</th>
<th>Ductile iron; AWWA C151 with cement mortar lining. Ref. spec Section 40 05 19.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conn:</td>
<td>flanged or grooved end as indicated on Drawings. Flanged adapters for valves.</td>
</tr>
<tr>
<td>Ftgs:</td>
<td>ductile iron per spec Section 40 05 19; coating, lining and ends to match pipe.</td>
</tr>
<tr>
<td>Valves:</td>
<td>Gate: double disk, ref spec 40 05 61.03, with extension stem and valve box.</td>
</tr>
</tbody>
</table>

(Greater than 24")

<table>
<thead>
<tr>
<th>Pipe:</th>
<th>Reinforced concrete pipe (RCP); Class IV, ASTM C76; refer to Section 33 05 40, Reinforced Concrete Pipe. Provide magnetic tracer tape.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conn:</td>
<td>ASTM C443, o-ring rubber gasket type.</td>
</tr>
<tr>
<td>Ftgs:</td>
<td>concrete manhole as specified on the drawings.</td>
</tr>
<tr>
<td>Coating: None</td>
<td></td>
</tr>
<tr>
<td>Valves:</td>
<td>None</td>
</tr>
</tbody>
</table>
3.06 PIPING SPECIFICATION SHEETS—PIPESPEC

Piping Symbol/Service: D--Drain System--24
SSS – Side Sewer - Sanitary

Test Requirements:
Medium: In accordance with Section 712, Uniform Plumbing Code.
Pressure: In accordance with Section 712, Uniform Plumbing Code.
Duration: In accordance with Section 712, Uniform Plumbing Code.

Gasket Requirements:
Flange: Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder
Push-on/Mech Cpl: Nitrile or neoprene

Exposed Pipe and Valves:
(See drawings for pipe size.)

Pipe: Steel; ASTM A53, galvanized. Ref. spec Section 40 05 24.
Conn: taper threaded, ANSI B1.20.1.
Ftgs: cast iron, threaded drainage fittings, ASTM A126, ANSI B16.12, galvanized.
Valves: None

Buried and Encased Pipe and Valves
(See drawings for pipe size.)

(2" and smaller)
Conn: plain end, solvent weld.
Ftgs: PVC, socket type, DWV, ASTM D2665.
Valves: None

(2 1/2" through 6")
Pipe: PVC; ASTM D3034, SDR 35. Provide magnetic tracer tape.
Conn: Push-on with nitrile gasket.
Ftgs: PVC or IPS cast iron; ends to match pipe.
Valves: None
(8" and larger)

Pipe: Ductile iron; AWWA C151, Class 50 with asphalt lining. Refer to Section 40 05 19, Ductile Iron Pipe. Conn: flanged. Ftg: ductile iron, per spec Section 40 05 19, Ductile Iron Pipe; ends to match pipe.

Valves: None

END OF SECTION 40 05 08
PART 1 - GENERAL

1.01 SUMMARY

A. Scope:
   1. This section specifies polyvinylchloride pipe and fittings.

B. Pipe Designations:
   1. For use in the Piping System Specification Sheets (PIPESPEC) in Section 40 05 08 and in this section, the following plastic pipe designations are defined:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>Polyvinylchloride</td>
</tr>
</tbody>
</table>

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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<tbody>
<tr>
<td>ASTM D1248</td>
<td>Polyethylene Plastics Molding and Extrusion Materials</td>
</tr>
<tr>
<td>ASTM D1784</td>
<td>Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds</td>
</tr>
<tr>
<td>ASTM D1785</td>
<td>Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120</td>
</tr>
<tr>
<td>ASTM D2241</td>
<td>Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)</td>
</tr>
<tr>
<td>ASTM D2464</td>
<td>Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80</td>
</tr>
<tr>
<td>ASTM D2466</td>
<td>Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40</td>
</tr>
<tr>
<td>ASTM D2467</td>
<td>Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80</td>
</tr>
<tr>
<td>ASTM D2564</td>
<td>Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings</td>
</tr>
<tr>
<td>ASTM D2657</td>
<td>Heat-Joining Polyolefin Pipe and Fittings</td>
</tr>
<tr>
<td>Reference</td>
<td>Title</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>ASTM D2665</td>
<td>Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings</td>
</tr>
<tr>
<td>ASTM D3034</td>
<td>Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings</td>
</tr>
<tr>
<td>ASTM D4101</td>
<td>Propylene Plastic Injection and Extrusion Materials</td>
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<tr>
<td>ASTM F402</td>
<td>Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings</td>
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<tr>
<td>ASTM F437</td>
<td>Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80</td>
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<tr>
<td>ASTM F438</td>
<td>Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40</td>
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<tr>
<td>ASTM F439</td>
<td>Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80</td>
</tr>
<tr>
<td>ASTM F441</td>
<td>Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80</td>
</tr>
<tr>
<td>ASTM F477</td>
<td>Elastomeric Seals (Gaskets) for Joining Plastic Pipe</td>
</tr>
<tr>
<td>ASTM F493</td>
<td>Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

(Not Used)

1.04 SUBMITTALS

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Product Data:

1. Manufacturer’s certificates of compliance with the specified standards.
2. Contractor’s layout drawings as specified in Section 40 05 08, Piping Systems.
3. Product literature.
PART 2 - PRODUCTS

2.01 PVC PIPE

A. Nonpressure Pipe:

1. Underdrain Pipe: PVC material for sewer pipe and fittings shall conform to Class 12454-B, as defined in ASTM D1784. Pipe and fittings shall meet the requirements of ASTM D3034 for SDR 35. Pipe shall be coupled per paragraph 2.02 below.

2. Drain, Waste and Vent Pipe: PVC material for drain waste and vent (DWV) pipe and fittings shall conform to Class 12454-B, ASTM D1784. Pipe and fittings shall conform to ASTM D2665. Connections shall be solvent weld. Connections to traps, closet flanges, and nonplastic pipe shall be with approved adapter type fittings designed for intended use. Solvent weld cement for socket connections shall meet requirements of ASTM D2564.

3. Sewer Pipe: PVC material for sewer pipe and fittings shall conform to Class 12454-B, as defined in ASTM D1784. Pipe and fittings shall meet the requirements of ASTM D3034 for SDR 35. Neoprene gaskets with push-on joints shall conform to ASTM F477.

4. Foundation Drain Pipe: PVC material for sewer pipe and fittings shall conform to Class 12454-B, as defined in ASTM D1784. Pipe and fittings shall meet the requirements of ASTM D3034 for SDR 35. Neoprene gaskets with push-on joints shall conform to ASTM F477.

2.02 FITTINGS

A. Couplings:

1. Underdrain pipe coupling shall be shielded type, Fernco 1000 series flexible coupling with stainless steel shear ring or approved substitute.

PART 3 - EXECUTION

3.01 INSTALLATION

A. PVC pipe 3 inches in diameter and smaller shall be joined by means of socket fittings and solvent welding in conformance with ASTM F402. Solvent-cemented joints shall be made in strict compliance with the manufacturer's/supplier's instructions and recommended procedures. Unless otherwise specified, PVC pipe 4 inches in diameter and greater shall be joined by means of gasketed push-on joints and steel or ductile iron push-on or mechanical joint fittings. Fittings shall be lined and coated as specified in Section 40 05 19 or Section 40 05 24. Unless otherwise specified, PVC and CPVC piping exposed to sunlight shall be painted with coating system L-2 as specified in Section 09 90 00.

B. Connections to different types of pipe shall be by means of flanges, specified adapters or transition fittings. Where sleeve type couplings are used, both shall be uniformly torqued in accordance with pipe manufacturer's recommendation. Foreign material shall be removed from the pipe interior prior to assembly.
3.02 TESTING

A. Testing of plastic piping shall be as specified in Section 40 05 08.

END OF SECTION 40 05 10
PART 1 - GENERAL

1.01  SUMMARY
A. This section specifies copper piping, tubing, couplings and fittings.

1.02  REFERENCES
A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
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<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>ANSI B16.22</td>
<td>Wrought Copper and Copper Alloy Solder Joint Pressure Fittings</td>
</tr>
<tr>
<td>ANSI B16.26</td>
<td>Cast Copper Alloy Fittings for Flared Copper Tubes</td>
</tr>
<tr>
<td>ASTM B32</td>
<td>Solder Metal</td>
</tr>
<tr>
<td>ASTM B88</td>
<td>Seamless Copper Water Tube</td>
</tr>
</tbody>
</table>

1.03  DEFINITIONS
(NOT USED)
1.04 SUBMITTALS

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Product Data:
1. Contractor's layout drawings as specified in Section 40 05 08, Piping Systems.
2. Product literature.

PART 2 - PRODUCTS

2.01 COPPER TUBING

A. Copper tubing shall be seamless copper, conforming to ASTM B88. Unless otherwise specified, copper tubing shall be Type L, drawn, where used in exposed service and Type K, annealed or drawn for buried service.

2.02 COUPLINGS AND FITTINGS FOR COPPER TUBING

A. Unless otherwise specified, couplings and fittings for copper tubing 1/2 inch and smaller nominal diameter shall be compression type, brass or bronze, capable of holding the full bursting strength of the tubing; shall meet the requirements of ANSI B16.26; and shall be Swagelok, Gyrolok, or approved substitute.

B. Couplings and fittings for copper tubing larger than 1/2-inch nominal diameter shall be wrought copper or bronze, solder joint pressure fittings and shall conform to ANSI B16.22.

2.03 SOLDER

A. Solder to be used in copper piping shall be ASTM B32, Alloy Grade Sn95 or Silvabrite 100.
PART 3 - EXECUTION

3.01 FABRICATION

A. Solder Joints:
   1. All pipe and fittings to be jointed with solder shall be free from all burrs and wire
      brushed or steel wool cleaned. After cleaning, a paste flux shall be evenly and
      sparingly applied to the surfaces to be joined. Solder shall then be applied and
      flame passed toward the center of the fitting until the solder disappears. All
      excess solder shall be removed while it is still plastic. Absolutely no acid flux or
      acid wipe shall be used in making solder joints.

B. Takedown Couplings:
   1. Takedown couplings shall be screw union type and shall be provided in
      accordance with Section 40 05 12.

C. Dielectric Protection:
   1. Copper tubing or fittings shall not be permitted to come in contact with steel
      piping, reinforcing steel, or other steel at any location. Electrical checks shall be
      made to assure no contact is made between copper tubing and steel elements.
      Wherever electrical contact is demonstrated by such tests, the Contractor shall
      provide dielectric protection as specified in Section 40 05 12.

3.02 INSTALLATION, CLEANING, DISINFECTION, AND TESTING

A. The installation, cleaning, disinfection, and testing of copper piping shall be as specified
   in Section 40 05 08.

END OF SECTION 40 05 11
Part 1 - GENERAL

1.01 SUMMARY
A. This section specifies the following methods of connecting metallic piping: flanges, threading, mechanical couplings, equipment connection fittings, dielectric unions, and welding.

1.02 REFERENCES
A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

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<th>Title</th>
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<tbody>
<tr>
<td>ANSI Bl.1</td>
<td>Unified Inch Screw Threads (UN and UNR Thread Form)</td>
</tr>
<tr>
<td>ANSI Bl.20.1</td>
<td>Pipe Threads, General Purpose (Inch)</td>
</tr>
<tr>
<td>ANSI B16.1</td>
<td>Cast Iron Pipe Flanges and Flanged Fittings</td>
</tr>
<tr>
<td>ANSI B16.5</td>
<td>Pipe Flanges and Flanged Fittings</td>
</tr>
<tr>
<td>ANSI B18.2.1</td>
<td>Square and Hex Bolts and Screws Inch Series</td>
</tr>
<tr>
<td>ANSI B18.2.2</td>
<td>Square and Hex Nuts (Inch Series)</td>
</tr>
<tr>
<td>ANSI B31.1</td>
<td>Power Piping</td>
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<tr>
<td>ANSI B31.3</td>
<td>Chemical Plant and Petroleum Refinery Piping</td>
</tr>
<tr>
<td>ASME Section IX</td>
<td>Boiler and Pressure Vessel Code; Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Qualifications</td>
</tr>
<tr>
<td>ASTM B98</td>
<td>Copper-Silicon Alloy Rod, Bar and Shapes</td>
</tr>
<tr>
<td>ASTM F37</td>
<td>Standard Test Methods for Sealability of Gasket Materials</td>
</tr>
<tr>
<td>ASTM F104</td>
<td>Standard Classification System for Nonmetallic Gasket Materials</td>
</tr>
<tr>
<td>ASTM F152</td>
<td>Standard Test Methods for Tension Testing of Nonmetallic Gasket Materials</td>
</tr>
<tr>
<td>ASTM F593</td>
<td>Stainless Steel Bolts, Hex Cap Screws, and Studs</td>
</tr>
<tr>
<td>AWWA C111</td>
<td>Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings</td>
</tr>
<tr>
<td>AWWA C206</td>
<td>Field Welding of Steel Water Pipe</td>
</tr>
<tr>
<td>AWWA C207</td>
<td>Steel Pipe Flanges for Waterworks Service-Size 4 in. through 144 in.</td>
</tr>
</tbody>
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### Reference Title

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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<tbody>
<tr>
<td>AWWA C219</td>
<td>Bolted, Sleeve-Type Couplings for Plain-End Pipe</td>
</tr>
<tr>
<td>AWWA C550</td>
<td>Protective Epoxy Coatings for Valves and Hydrants</td>
</tr>
<tr>
<td>AWWA C606</td>
<td>Grooved and Shouldered Joints</td>
</tr>
<tr>
<td>AWWA M11</td>
<td>Steel Pipe-A Guide for Design and Installation</td>
</tr>
<tr>
<td>NSF 61</td>
<td>Drinking Water System Components - Health Effects</td>
</tr>
</tbody>
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#### 1.03 Definitions

(NOT USED)

#### 1.04 Submittals

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Product Data:

1. The Contractor shall provide, for each welder, a welder qualification certificate indicating the welder is certified for pipe welding in accordance with ASME Section IX. Each welder’s certificate shall be provided to the Engineer prior to that welder working on the job.

2. Product catalog information for each item provided under this section.
Part 2 - PRODUCTS

2.01 FLANGE ASSEMBLIES

A. Flanges:

1. General: Flanges shall either be flat flanges or convoluted ring flanges as specified in the following paragraphs.

2. Flat Flanges: Cast iron flanges shall be faced in accordance with ANSI B16.1. Where companion flanges are used, the flanges on pipe shall be refaced to be flush with the companion flange face. Class 150 forged steel flanges shall be raised face conforming to ANSI B16.5. Lightweight slip-on flanges shall be plain face conforming to AWWA C207, Class B and ANSI B16.5. Unless otherwise specified, steel flanges shall be ANSI B16.5, Class 150 or AWWA C207, Class D. Class E AWWA flanges shall be provided where test pressure exceeds 175 psi. Plain faced flanges shall not be bolted to raised face flanges.

B. Gaskets:

1. Gasket material shall be as specified in paragraph 2.03.

2. Gaskets for plain faced flanges shall be the full face type. Thickness shall be 1/16 inch for pipe 10 inches and less in diameter and 1/8 inch for pipe 12 inches and larger in diameter. Unless otherwise specified, gaskets for raised face flanges shall match the raised face and shall be 1/16 inch thick for pipe 3-1/2 inches and less in diameter and 1/8 inch thick for pipe 4 inches and larger.

C. Bolts:

1. Flange assembly bolts shall be ANSI B18.2.1 standard square or hexagon head bolts with ANSI B18.2.2 standard hexagon nuts. Threads shall be ANSI Bl.1, standard coarse thread series; bolts shall be Class 2A, nuts shall be Class 2B. Bolt length shall conform to ANSI B16.5.

2. Unless otherwise specified, bolts shall be carbon steel machined bolts with hot pressed hexagon nuts. Bolts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04 or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.
2.02 MECHANICAL COUPLINGS

A. Grooved End Couplings:

1. Grooved end flexible-type couplings shall be Gustin-Bacon 100, Victaulic Style 77, or approved substitute. Grooved end rigid-type couplings shall be Gustin-Bacon 120 Rigi-Grip, Victaulic Style 07 Zero-Flex, or approved substitute. Flexible-type couplings shall be used for all piping greater than 12 inches in diameter; for pipe 12 inches in diameter and less in rack-mounted tunnel piping applications; and for grooved joints adjacent to pump or blower suction and discharge where grooved couplings are used for noise and vibration control. All other applications for piping 12 inches in diameter and less shall utilize rigid-type couplings. Grooved end flanged coupling adapters shall be either Gustin-Bacon 154, Victaulic Style 741, or approved substitute. Snap-joint grooved end couplings shall be Gustin-Bacon 115, Victaulic Style 78, or approved substitute. Cut grooves are not permitted on fabricated or lightwall pipe.

2. Unless otherwise specified, bolts and nuts shall comply with AWWA C606. Bolts for submerged service shall be Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04 or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.

3. Gaskets shall be as specified in paragraph 2.03 and AWWA C 606.

B. Dismantling Joints:

1. Dismantling joints may be used as takedown couplings in accordance with paragraph 3.03. Dismantling joints shall fully restrained double flange fittings consisting of a flange coupling adapter and flanged spool piece that allows for longitudinal adjustment. Thrust restraint shall be provided by means of all threaded rod spanning between flanges and secured to the flanges with a minimum of two flange bolts. Design of equipment connection fittings shall conform to AWWA C219. Sleeves shall be carbon steel or as specified for the specific piping system. Pressure rating of flange adapters shall approved substitute or exceed the pressure rating of mating flanges. All metal portions of equipment connection fittings, with the exception of 316 stainless steel components, shall be coated and lined with fusion bonded epoxy conforming to AWWA C550 and NSF 61. Dismantling joints shall be Romac DJ-400, Smith Blair 975, or Crane-Viking Johnson Dismantling Joint.
C. Flexijoint:
   1. Where specified Flexijoint couplings shall be Flanged Romac Flexijoint couplings. The Flexijoint is a flexible, ductile iron joint that can accommodate expansion, contraction, rotation and bending and is rated at 350 psi working pressure. The joint can accommodate 15 to 20 degree deflection depending on size. Body shall be ductile iron, lock rings Type 410 stainless steel, and ring gasket, casing, ball and cover shall be EPDM molded watertight construction. All metal portions of Flexijoint coupling including the stainless steel lock rings shall be coated and lined with fusion bonded epoxy conforming to AWWA C550 and NSF 61. For buried installations, install with polyethylene baggy cover in accordance with the manufacturer’s instructions.

2.03 GASKETS
A. Gaskets designated in Section 40 05 08 shall be as follows:
   1. EPDM: ethylene-propylene-diene-terpolymer.
   3. Nitrile: nitrile (Buna N).
   4. Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder; ASTM F104 (F712400), 2500 psi (ASTM F152), 0.2 ML/HR LEAKAGE FUEL A (ASTM F37).
   5. Compressed gasketing consisting of organic fibers (Kevlar) and SBR binder; ASTM F104 (F712400), 2500 PSI (ASTM F152), 0.1 ml/hr leakage Fuel A (ASTM F37).

2.04 THREAD
A. Pipe thread dimensions and size limits shall conform to ANSI B1.20.1.

2.05 DIELECTRIC UNIONS
A. Dielectric unions shall be EPCO, Capitol Manufacturing, or approved substitute.

2.06 COATINGS
A. Unless otherwise specified, flange assemblies and mechanical type couplings for buried installation shall be field coated with System M-1 as specified in Section 09 90 00.

Part 3 - EXECUTION
3.01 PIPE CUTTING, THREADING AND JOINTING
A. Pipe cutting, threading and jointing shall conform to the requirements of ANSI B31.1.

3.02 PIPE WELDING
A. Pipe shall be welded by ASME-certified welders using shielded metal arc, gas shielded arc or submerged arc welding methods.
B. Welds shall be made in accordance with AWWA C206.
3.03 TAKEDOWN COUPLINGS
A. Takedown couplings shall be screw unions, flanged or grooved end mechanical coupling type joints and shall be provided as specified. Flanged or grooved end joints shall be employed on pipelines 2-1/2 inches in diameter and larger. Where piping passes through walls, takedown couplings shall be provided within 3 feet of the wall, unless specified otherwise.
B. A union or flanged connection shall be provided within 2 feet of each threaded end valve.

3.04 FLEXIBILITY
A. Unless otherwise specified, piping passing from concrete to earth shall be provided with two pipe couplings or flexible joints (or a single Flexijoint) as specified on the buried pipe within 2 feet of the structure for 2-inch through 6-inch diameter pipe; within 3 feet of the structure for 8-inch through 24-inch diameter pipe; and within one and one-half pipe diameters of the structure for larger pipe. Where required for resistance to pressure, mechanical couplings shall be restrained in accordance with Chapter 13 of AWWA M11, including Tables 13-4, 13-5 and 13-5A, and Figure 13-20.

3.05 DIELECTRIC CONNECTIONS
A. Where a copper pipe is connected to steel or cast iron pipe, an insulating section of rubber or plastic pipe shall be provided. The insulating section shall have a minimum length of 12 pipe diameters. Dielectric unions as specified in paragraph 2.05 may be used instead of the specified insulating sections. Where copper pipe is supported from hangers, it shall be insulated from the hangers, or copper-plated hangers shall be used.

3.06 EQUIPMENT CONNECTION FITTINGS
A. Where shown, equipment connection fittings shall be provided between field piping systems and equipment inlet and outlet connections.

END OF SECTION 40 05 12
PART 1 – GENERAL

1.01 SUMMARY

A. Scope: This section specifies supports and seismic restraints for bracing of all piping systems specified in Section 40 05 08.

B. Contractor Design of Piping Systems: In addition to materials, labor, and plant required to construct piping systems, Contractor shall provide professional engineering services for the design and inspection of piping systems work. The Contractor shall provide the final design, inspection, and certification for the piping supports, anchors, and seismic restraints. The design of these systems shall be the product of a structural engineer ("Design Professional") licensed to practice in the State of Washington retained by the Contractor. The Design Professional shall have not less than five years experience in the type of piping work required for this project. This requirement, however, shall not be construed as relieving the Contractor of overall responsibility for this portion of the work.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI A58.1-82</td>
<td>Minimum Design Loads for Buildings and Other Structures</td>
</tr>
<tr>
<td>FEDSPEC WW-H-171e-78</td>
<td>Hangers and Supports, Pipe</td>
</tr>
<tr>
<td>MFMA-2-91</td>
<td>Metal Framing Standards Publication</td>
</tr>
<tr>
<td>MSS SP-58-93</td>
<td>Pipe Hangers and Supports - Materials, Design and Manufacture</td>
</tr>
<tr>
<td>MSS SP-69-91</td>
<td>Pipe Hangers and Supports - Selection and Application</td>
</tr>
<tr>
<td>SMACNA, PPIC</td>
<td>Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

(NOT USED)
1.04 SUBMITTALS
A. Procedures: Section 01 33 10.
B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
C. Support and seismic restraint locations shall be indicated on the piping layout drawings required by Section 40 05 08, Piping Systems. The Contractor shall provide a legend giving load information and restraint component selection at each support and restraint location.
D. Pipe support and seismic restraint calculations as specified in this Section.
E. Manufacturer’s product information for supports and restraints.

1.05 OPERATING CONDITIONS
A. The pipe supports specified in this section are provided to resist pipe loads occurring primarily in the downward (gravity) direction.
B. The seismic restraints specified in this section are provided to resist pipe movements and loads occurring as a result of an earthquake or other seismic event.
C. All piping shall have bracing to resist seismic loading caused by forces applied at the individual pipe’s center of gravity. Structural and seismic loading design criteria shall be as provided in Section 01 73 24.

1.06 SUPPORT AND RESTRAINT DESIGN
A. The Contractor shall select, locate and provide pipe supports and seismic restraints for piping as specified in this Section.
B. The Contractor shall review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the type of support or restraint to be used at each point.
C. Supports shall withstand all static and specified dynamic conditions of loading to which the piping and associated equipment may be subjected. As a minimum, consideration shall be given to the following conditions:

1. Weights of pipe, valves, fittings, insulating materials, and normal fluid contents.
2. Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid contents are lighter.
3. Wind, snow or ice loadings on outdoor piping.
4. Seismic loading. Refer to Section 01 73 24, Design Requirements for Non-Structural Components and Non-Building Structures.

D. Supports and restraints shall be sized to fit the outside diameter of pipe, tubing, or, where specified, the outside diameter of insulation.

E. Piping systems shall not be braced to dissimilar parts of a building or to dissimilar building systems that may respond in a different mode during an earthquake. Examples: wall and a roof; solid concrete wall and a metal deck with lightweight concrete fill.

F. Branch lines shall not be used to brace main lines.

G. The supporting systems shall provide for and control the free or intended movement of the piping including its movement in relation to that of connected equipment. Seismic bracing shall not limit the expansion and contraction of the piping system.

H. There shall be no contact between a pipe and support or restraint components of dissimilar metals. Prevent contact between dissimilar metals when supporting copper tubing by use of copper-plated, rubber, plastic or vinyl coated, or stainless steel support components.

I. Stock support components shall be used wherever practical.

1.07 APPROVAL

A. The pipe hanger and support design drawings and calculations shall be prepared and signed by the Design Professional and shall bear the Design Professional’s registration seal.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Standard pipe supports and components shall be manufactured by B-Line, Carpenter & Patterson, Kin-Line, Anvil, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or approved substitute. Pipe support components shall conform to the requirements of MSS SP-69 and FEDSPEC WW-H-171e. Pipe support materials shall conform to the requirements of MSS SP-58. Metal framing system components shall conform to the metal framing manufacturers’ Association Standard MFMA-2.

B. Standard pipe restraints and components shall be manufactured by Carpenter & Patterson, B-Line, Kin-Line, ITT Anvil, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or approved substitute. Pipe restraint materials shall conform to the requirements of MSS SP-58 and MFMA.
2.02 MATERIALS

A. General: Unless otherwise specified, pipe supports, restraints, structural attachments, fittings and accessories shall be type 304 stainless steel. Nuts, bolts and washers shall be type 304 stainless steel. Galvanized products will not be accepted.

PART 3 - EXECUTION

3.01 SUPPORT AND RESTRAINT LOCATIONS

A. The Contractor shall locate supports as near as possible to concentrated loads such as valves, flanges, etc. The first seismic restraint on a piping system shall be located not more than 10 feet from the main riser, entrance to a building or piece of equipment.

B. At least one support shall be located within 2 feet from a pipe change in direction.

C. The Contractor shall locate supports to ensure that connections to equipment are substantially free from loads transmitted by the piping.

D. Where piping is connected to equipment, instrumentation, piping assembly, etc. that will require removal for maintenance, the piping shall be supported in such a manner that temporary supports shall not be necessary for this procedure.

E. Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.

3.02 INSTALLATION

A. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of the AISC Manual of Steel Construction. Unless otherwise specified, there shall be no drilling or burning of holes in the building structural steel.

B. Support and restraint components shall not be used for purposes other than for which they were designed. They shall not be used for rigging and erection purposes.

C. Lateral and longitudinal bracing shall be installed between 45 degrees above and 45 degrees below horizontal, inclusive, relative to the horizontal centerline of the pipe.

D. Hanger and support components in contact with plastic pipe shall be free of burrs and sharp edges.

3.03 ADJUSTMENTS

A. The Contractor shall adjust supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used.

END OF SECTION 40 05 15
PART 1 - GENERAL

1.01 SUMMARY
A. Scope:
   1. This section specifies ductile iron pipe, ductile fittings and gaskets.

1.02 REFERENCES
A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>ANSI A21.14</td>
<td>Ductile-Iron Fittings 3 In. Through 24 In., for Gas</td>
</tr>
<tr>
<td>ANSI A21.52</td>
<td>Ductile-Iron Pipe, Centrifugally Cast, in Metal Molds or Sand Lined Molds for Gas</td>
</tr>
<tr>
<td>ANSI B16.1</td>
<td>Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800</td>
</tr>
<tr>
<td>ANSI B16.5</td>
<td>Pipe Flanges and Flanged Fittings</td>
</tr>
<tr>
<td>ASTM C150</td>
<td>Portland Cement</td>
</tr>
<tr>
<td>AWWA C104 (ANSI A21.4)</td>
<td>Cement-Mortar Lining for Ductile- Iron and Gray-Iron Pipe and Fittings for Water</td>
</tr>
<tr>
<td>AWWA C110 (ANSI A21.10)</td>
<td>Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In., for Water and Other Liquids</td>
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<tr>
<td>AWWA C115 (ANSI A21.15)</td>
<td>Flanged Ductile-Iron and Gray-Iron Pipe With Threaded Flanges</td>
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<tr>
<td>AWWA C150 (ANSI A21.50)</td>
<td>Thickness Design of Ductile-Iron Pipe</td>
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<tr>
<td>AWWA C151 (ANSI A21.51)</td>
<td>Ductile-Iron Pipe, Centrifugally Cast, in Metal Molds or Sand-Lined Molds, for Water or Other Liquids</td>
</tr>
<tr>
<td>AWWA C153 (ANSI A21.53)</td>
<td>Ductile-Iron Compact Fittings, 3 In. Through 12 In. for Water and Other Liquids</td>
</tr>
</tbody>
</table>
1.03 DEFINITIONS
A. Where cast iron pipe is specified, the term and symbol shall mean ductile iron pipe.

1.04 SUBMITTALS
A. Procedures: Section 01 33 10:
B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
C. Product Data:
   1. Shop drawings.
   2. Alignment drawings, if necessary. Refer to paragraph 3.01 A.1.
   3. Certifications specified in the following documents:
      a. AWWA C110, paragraph 10-5.3
      b. AWWA C111, paragraph 11-7.1
      c. AWWA C115, paragraph 15-4.2
      d. AWWA C151, paragraph 51-5.2
      e. AWWA C153, paragraph 53-6.3
      f. AWWA C606, paragraph 4.1.1.1
PART 2 - PRODUCTS

2.01 GENERAL

A. Pipe design, materials and manufacture shall comply with the following documents:

<table>
<thead>
<tr>
<th>Item</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness design</td>
<td>AWWA C150</td>
</tr>
<tr>
<td>Manufacturing requirements</td>
<td>AWWA C151</td>
</tr>
<tr>
<td>Gravity service pipe</td>
<td>AWWA C151</td>
</tr>
<tr>
<td>Joints</td>
<td></td>
</tr>
<tr>
<td>Rubber gasket</td>
<td>AWWA C111</td>
</tr>
<tr>
<td>Fittings</td>
<td>AWWA C110/AWWA C153</td>
</tr>
<tr>
<td>Cement mortar lining</td>
<td>AWWA C104</td>
</tr>
</tbody>
</table>

2.02 PIPE

A. Unless otherwise specified, ductile iron pipe shall be Class 50 and have nominal laying lengths of 18 or 20 feet. For grooved-end pipe, wall thickness shall be minimum Class 53 except where the specified pressure requires heavier pipe.

2.03 GASKETS

A. Unless otherwise specified, gasket stock shall be a synthetic rubber compound in which the elastomer is nitrile or neoprene. The compound shall contain not less than 50 percent by volume nitrile or neoprene and shall be free from factice, reclaimed rubber and other deleterious substances. Gaskets shall, in addition, comply with AWWA C111 for push-on and mechanical joints and with AWWA C606 for grooved end joints.

2.04 FITTINGS

A. Unless otherwise specified, fittings shall conform to AWWA C110. Ends shall be flanged, restrained mechanical joint, restrained push-on, or grooved to suit the conditions specified. The AWWA C153 compact ductile iron fittings in sizes 3 through 12 inches are an acceptable substitute for standard fittings unless otherwise specified. Long-radius elbows shall be provided where specified. Grooved end fittings shall comply with Section 40 05 08.
2.05 JOINTS

A. Restrained Joints:

1. General: Unless otherwise specified, restrained joints shall be flanged or grooved end.

2. Flange Assemblies: Unless otherwise specified, flanges shall be ductile iron and shall be threaded-on flanges conforming to ANSI/AWWA A21.15/C115 or cast-on flanges conforming to ANSI/AWWA A21.10/C110. Flanges shall be adequate for 250 psi working pressure. Bolt circle and bolt holes shall match those of ANSI B16.1, Class 125 flanges and ANSI B16.5, Class 150 flanges. Where specified, flanges shall be threaded-on or cast-on flanges conforming to ANSI B16.1, Class 250.

   a. Unless otherwise specified, bolts and nuts for flange assemblies shall conform with Section 40 05 12. Gaskets shall be as specified in Section 40 05 12.

3. Restrained Mechanical Joints: Where specified, restrained mechanical joints shall be fully restrained. Fully restrained mechanical joints for above or below ground service shall meet the requirements of ANSI/AWWA A21.10/C110 and ANSI/AWWA A21.11/C111. Gaskets and bolts and nuts shall be as specified in ANSI/AWWA A21.11/C111. Where washers are required, they shall be of the same material as the associated bolts. Candidate manufacturers and products include:

   a. American Cast Iron Pipe Company, Mechanical Joint Coupled Joint
   b. U.S. Pipe, MJ HARNESS-LOK
   c. Approved Equal

1) Note that for metallic pipe using add-on restraint devices which employ teeth, set screws, or wedges to grip the pipe similar to Megalug, Stargrip, Romagrip, etc., the pipe must be wrapped with wax tape.

B. Bolts and Nuts: Corrosion-resistant bolts and nuts for use with ductile iron joints shall be high-strength, low-alloy steel as specified in ANSI/AWWA C111/A21.11.

2.06 PIPE COATING

A. Unless otherwise specified, pipe and fittings shall be coated with asphaltic material as specified in AWWA C151.

2.07 PIPE LINING

A. Cement Mortar Lining: Where specified, interior surfaces of pipe and fittings shall be cement mortar lined in accordance with AWWA C104. Cement shall be ASTM C150, Type II or V, low alkali, containing less than 0.60 percent alkali.
PART 3 - EXECUTION

3.01 INSTALLATION

A. General:
   1. Piping runs specified on the drawings shall be followed as closely as possible. Proposed deviations shall be submitted in accordance with Section 01 33 10.
   2. Pipe shall be installed in accordance with AWWA C600.
   3. Connections to existing structures and manholes shall be made so that the finished work will conform as nearly as practicable to the requirements specified for the new manholes, including necessary concrete work, cutting and shaping. Concrete mortar shaping within any structure and manhole shall be as specified.

B. Insulating Sections:
   1. Where a metallic nonferrous pipe or appurtenance is connected to ferrous pipe or appurtenance, an insulating section shall be provided as specified in Section 40 05 12.

C. Anchorage:
   1. Anchorage shall be provided as specified. Calculations and drawings for proposed alternative anchorage shall be submitted in accordance with Section 01 33 10.

3.02 ACCEPTANCE TESTING

A. Hydrostatic pressure tests shall be conducted in accordance with Section 4 of AWWA C600 except that test pressures and allowable leakage shall be as listed in Section 40 05 08.

B. The Contractor shall conduct the tests in the presence of the Engineer.

END OF SECTION 40 05 19
PART 1 - GENERAL

1.01 SUMMARY

A. Scope:
   1. This section specifies reduced pressure principle backflow preventers.

B. Equipment List:
   1. Backflow preventers shall be as follows:

<table>
<thead>
<tr>
<th>Equipment No.</th>
<th>Connection Size, Inch</th>
<th>Capacity, GPM</th>
<th>Max Pressure Loss, PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPBA-0165</td>
<td>1</td>
<td>20</td>
<td>10</td>
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<tr>
<td>RPBA-0166</td>
<td>2</td>
<td>48</td>
<td>15</td>
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</tbody>
</table>

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWWA C511</td>
<td>Standard for Reduced-Pressure Principle Backflow Prevention Assembly</td>
</tr>
<tr>
<td>WAC 246-290-940</td>
<td>Washington Administrative Code</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

(NOT USED)

1.04 QUALITY ASSURANCE

A. Testing:
   1. Backflow preventers shall meet the factory, laboratory and field test provisions of AWWA C511.
1.05 SUBMITTALS

A. Procedures: Section 01 33 10.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Product Data:
   1. Affidavit of Compliance with AWWA C511.
   2. Certificate of Approval as specified in AWWA C511.

D. Operation and Maintenance information.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed that named manufacturers’ standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Cla-Val, Febco, Watts, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Backflow preventers shall be installed in accordance with the manufacturer’s instructions.

END OF SECTION 40 05 20
PART 1 - GENERAL

1.01 SUMMARY

A. This section specifies steel pipe and fittings.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI B16.3</td>
<td>Malleable Iron Threaded Fittings, Class 150 and 300</td>
</tr>
<tr>
<td>ANSI B16.9</td>
<td>Factory-Made Wrought Steel Butt welding Fittings</td>
</tr>
<tr>
<td>ANSI B16.11</td>
<td>Forged Steel Fittings, Socket-Welding and Threaded</td>
</tr>
<tr>
<td>ASTM A36/A36M</td>
<td>Structural Steel</td>
</tr>
<tr>
<td>ASTM A47</td>
<td>Ferritic Malleable Iron Castings</td>
</tr>
<tr>
<td>ASTM A53</td>
<td>Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless</td>
</tr>
<tr>
<td>ASTM A105/A105M</td>
<td>Forgings, Carbon Steel, for Piping Components</td>
</tr>
<tr>
<td>ASTM A106 REV A</td>
<td>Seamless Carbon Steel Pipe for High-Temperature Service</td>
</tr>
<tr>
<td>ASTM A197</td>
<td>Cupola Malleable Iron</td>
</tr>
<tr>
<td>ASTM A234/A234M</td>
<td>Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures</td>
</tr>
<tr>
<td>ASTM A283/A283M REV A</td>
<td>Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars</td>
</tr>
<tr>
<td>ASTM A536</td>
<td>Ductile Iron Castings</td>
</tr>
<tr>
<td>ASTM A570/A570M</td>
<td>Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality</td>
</tr>
<tr>
<td>ASTM A572/A572M REV B</td>
<td>High Strength Low Alloy Columbium-Vanadium Steels of Structural Quality</td>
</tr>
<tr>
<td>AWWA C200</td>
<td>Steel Water Pipe 6 Inches and Larger</td>
</tr>
</tbody>
</table>
1.03 DEFINITIONS

(NOT USED)

1.04 QUALITY ASSURANCE

A. Testing:

1. Factory testing shall conform to the requirements of ASTM A53, ASTM A106, or AWWA C200 as applicable.

1.05 SUBMITTALS

A. Procedures: Section 01 33 10:

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Product Data:

1. Shop drawings.

2. Alignment drawings, if necessary. Refer to paragraph 3.01 A.1.
PART 2 - PRODUCTS

2.01 PIPE MATERIALS
A. Steel pipe and fittings shall be provided in accordance with ASTM A53, ASTM A106, or AWWA C200 as specified in Section 40 05 08.
B. Steel for pipe fabricated to meet requirements of AWWA C200 shall conform to the requirements of ASTM A36, ASTM A572, Grade 42, ASTM A570, Grades 33 and 36, or ASTM A283, Grade D. Steel for ASTM A53 and ASTM A106 pipe shall be Grade B.

2.02 PIPE MANUFACTURER
A. Unless otherwise specified, ASTM A53 pipe shall be Type E, electric resistance welded or Type S, seamless pipe as specified in Section 40 05 08. The minimum wall thickness for ASTM A53 or ASTM A106 pipe shall be Schedule 40 for pipe 10 inch diameter and less and 3/8 inch for pipe 12 inch through 24 inch diameter. Increased shell thickness shall be provided where specified.
B. AWWA C200 pipe shall be straight or spiral seam. The minimum wall thickness shall be 7 gage for pipe 6 inch through 24 inch diameter and 1/4 inch for pipe 26 inch diameter and larger. Increased shell thickness shall be provided where specified.

2.03 CONNECTIONS
A. Connections shall be as specified in Section 40 05 08 and shall conform to Section 40 05 12.

2.04 FITTINGS AND APPURTEINANCES
A. Malleable iron threaded fittings and appurtenances shall conform to the requirements of ASTM A47 or ASTM A197, ANSI B16.3.
B. Unless otherwise specified, steel fittings and appurtenances shall conform to the requirements of ASTM A234, ASTM A105, or ANSI B16.11; and fabricated steel fittings and appurtenances shall conform to AWWA C208.
C. Fittings for grooved end piping systems shall be full flow cast fittings, steel fittings, or segmentally welded fittings with grooves or shoulders designed to accept grooved end couplings. Cast fittings shall be cast of ductile iron conforming to ASTM A536 or malleable iron conforming to ASTM A47. Standard steel fittings, including large size elbows, shall be forged steel conforming to ASTM A106. Standard segmentally welded fittings shall be fabricated of Schedule 40 carbon steel pipe.
D. Unless otherwise specified, all fittings shall be rated for pressure and loadings equal to the pipe.

2.05 PIPE LINING
A. Cement Mortar:
   1. Where specified, pipe and fittings shall be lined with cement mortar as specified in AWWA C205. Fittings and specials larger than 24 inches, not fabricated from centrifugally lined straight sections, shall require 2-inch by 4-inch by 13-gage self-furring wire mesh reinforcement for hand-applied lining.
2.06 PIPE COATING

A. Epoxy:

1. Unless otherwise specified, pipe and fittings shall be coated with a liquid epoxy as specified in AWWA C210 with the following exceptions:
   a. No coal tar products shall be incorporated in the liquid epoxy.
   b. The curing agent may be an amidoamine as well as the other curing agents listed in AWWA C210.

2. The coating shall be applied to a minimum thickness of 16 mils in not less than two coats.

2.07 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 10:

1. Affidavits of Compliance with AWWA C200, ASTM A53, or ASTM A106 as applicable.

2. Contractor’s layout drawings as specified in Section 40 05 08-2.04.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General:

1. Pipe shall be installed in accordance with AWWA M11, Chapter 16. Welded joints shall be in accordance with AWWA C206 and Section 40 05 12.

2. Sleeve-type restrained mechanical pipe couplings shall be provided in accordance with AWWA M11 and Section 40 05 12-2.02 Sleeve-Type Couplings.

3. Pipe lining and coatings at field joints shall be applied as specified in paragraphs 2.05 and 2.06.

4. Unless otherwise specified, buried mechanical couplings and valves shall be field coated as specified in Section 40 05 12-2.06.

5. Connections to existing structures and manholes shall be made so that the finished work will conform as nearly as practicable to the requirements specified for the new manholes, including necessary concrete work, cutting and shaping. Concrete mortar shaping within any structure and manhole shall be as specified.

6. Piping runs specified on the drawings shall be followed as closely as possible. Proposed deviations shall be submitted in accordance with Section 01 33 10.

B. Anchorage:

1. Anchorage shall be provided as specified. Calculations and drawings for proposed alternative anchorage shall be submitted in accordance with Section 01 33 10.
3.02 ACCEPTANCE TESTING

A. Hydrostatic pressure tests shall be conducted in accordance with Section 4 of AWWA C600 except that test pressures and allowable leakage shall be as listed in Section 40 05 08.

B. The Contractor shall conduct the tests in the presence of the Engineer.

END OF SECTION 40 05 24
PART 1 - GENERAL

1.01 SUMMARY

A. Scope:

1. This section specifies iron-body, double disc wedge gate valves.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>ANSI B16.1</td>
<td>Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800</td>
</tr>
<tr>
<td>ASTM A126</td>
<td>Gray Iron Castings for Valves, Flanges, and Pipe Fittings</td>
</tr>
<tr>
<td>AWWA C500</td>
<td>Gate Valves for Water and Sewerage Systems</td>
</tr>
</tbody>
</table>

B. Design Criteria:

1. Gate valves 3 inches through 48 inches in size shall comply with AWWA C500, including applicable hydrostatic testing.
1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 10:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Product Data:
   a. Product information, charts, or graphs to verify that the product provided meets the requirements set forth in this specification.
   b. Affidavits of compliance, as required by AWWA C500.

3. Hydrostatic test results.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Clow DDGV

B. Or Approved Equal

2.02 MATERIALS

A. Materials of construction shall be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body:</td>
<td>Cast iron, ASTM A126, Class B</td>
</tr>
<tr>
<td>Wedge:</td>
<td>Cast iron, ASTM A126, Class B</td>
</tr>
<tr>
<td>Mounting</td>
<td>Bronze</td>
</tr>
<tr>
<td>Stem</td>
<td>Bronze, AWWA C500</td>
</tr>
<tr>
<td>Seat rings</td>
<td>Bronze, Grade A, AWWA C500</td>
</tr>
</tbody>
</table>

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.
2.03 MANUFACTURE

A. General:
   1. Unless otherwise specified, bronze gate valves shall be provided with integral seats. Iron body valves shall be provided with screwed-on seat rings. Exposed, buried or submerged gate valves shall be of the nonrising stem type. Iron body nonrising stem valves shall be provided with O-ring stem seals.

B. End Connections:
   1. Gate valve end connections shall be flanged or threaded as specified. Threaded ends shall not be provided on gate valves with end connections larger than 4 inches. End flanges shall be integral with the gate valve body and be faced and drilled in accordance with ANSI B16.1 for 125-pound flanges.

C. Manual Operators
   1. Unless specified otherwise, valves less than 12 inch size shall be provided with handwheels, and valves 12 inches and larger shall be provided with geared operators.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Gate valves shall be installed in the closed position.

B. Gate valves shall be installed in accordance with the manufacturer’s recommendation.
PART 1 - GENERAL

1.01 SUMMARY
A. Scope:

1. This section specifies powered actuators for gates and actuator appurtenances.

1.02 REFERENCES
A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A519</td>
<td>Seamless Carbon and Alloy Steel Mechanical Tubing</td>
</tr>
<tr>
<td>ASTM B584</td>
<td>Copper Alloy Sand Castings for General Applications</td>
</tr>
<tr>
<td>NEMA ICS-2</td>
<td>Industrial Control Devices, Controllers and Assemblies</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS
A. For use in this section, powered actuators are defined as follows:

<table>
<thead>
<tr>
<th>Actuator Type (ACTUSPEC)</th>
<th>Service</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMTI</td>
<td>Isolating (Open-Close)</td>
<td>Electric motor multi-turn</td>
</tr>
</tbody>
</table>
1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 10:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

3. Manufacturer's catalog information and other data confirming conformance to design and material requirements.

4. Application sheets and schedules for each valve and actuator showing required mounting, operating torque for valve, torque capacity of actuator, and power or air pressure requirements. Valve identification (tag) number shall be clear for each application.

5. List of components being provided for each valve, actuator and positioner.

6. Testing procedures and forms specified in paragraph 3.02 A of this section.

7. Training Certification Form 11000-B specified in paragraph 3.03 of this section.

8. Operating and maintenance data in conformance with Section 01 73 00.

9. Manufacturer's instructions for configuring and programming remote network data exchange using Modbus RS-485. This information is required by the Owner for programming the station’s control system in Section 40 90 00, Instrumentation for Process Control: Basic Requirements, to communicate with actuator specified in this Section.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ROTORK

B. No Substitution Allowed
2.02 GENERAL
A. Actuators shall be factory-mounted on the valve or gate and provided as a unit. Each valve body or actuator shall have cast thereon the word "OPEN," an arrow indicating the direction to open, and flow direction arrows.

2.03 POWERED ACTUATORS
A. General:
   1. Actuators shall be sized to produce an operating torque equal to twice the maximum required valve operating torque under the specified flow conditions. Specific requirements for each type powered actuator are specified on the actuator specification sheets in paragraph 3.04.

B. Electric Actuators
   1. General: Unless otherwise specified, electric actuators shall be provided in accordance with the actuator specification sheets and the following requirements specified herein.
   2. Motor: Actuator motors shall be heavy duty, specifically designed for valve or gate actuator service. Motors shall be of totally-enclosed, non-ventilated construction. Motor shall have an internal space heater with nominal rating of 25-watts. Motors shall be rated as specified in Section 40 06 25 and shall be or shall incorporate:
      a. AC motors shall be four-pole 1800 RPM or provide pole-speed as required for the application.
      b. Suitable for use with 460 volt, 3-phase, 60-Hertz power with +/- 10% voltage fluctuation.
      c. NEMA Class F insulation.
      d. Thermistor for thermal protection embedded in the motor windings.
      e. Automatic motor overload relay reset.
      f. Four conduit openings.
   3. Enclosure: Motor and electrical enclosures shall be rated for the application and location specified:
      a. NEMA-4X Weatherproof
   4. Motor Starter:
      a. Actuator controlling AC motors shall be provided with a three phase full voltage reversing starter rated at 30-amperes both mechanically and electrically interlocked with overload protection or elements in each of the three poles.
      b. Control Transformer shall be epoxy encapsulated and impregnated and rated at a minimum of 75VA with 120Vac secondary and other required secondary voltages of 18 Vac and 12 Vac as required, with short-circuit and overload protection.
      c. Provide an isolated “failure” contact for remote indication of any valve malfunction, including loss of power. Contact shall be rated 0.5 amps at 24 V dc.
d. Provide lockable non-fused disconnect switch with one auxiliary contact rated 0.5 amps at 24 V dc. Contact to be closed when disconnect switch is in the closed position; contact to be open when the disconnect switch is in the open position.

5. Gearing:
   a. Gearing shall be double-reduction, with a helical gear and pinion forming the first reduction and a worm and worm gear forming the second. The helical gear and pinion shall be fabricated from heat-treated alloy steel with hobbed and finished shaved teeth. The worm shall be fabricated from heat-treated alloy steel, ground, carburized and hardened. The worm gear shall be fabricated from high tensile strength bronze with hobbed teeth.
   b. The stem nut shall be fabricated from high tensile strength bronze and shall be the two-piece type, when possible. It shall be possible to remove the stem nut from rising stem actuators from the top without removing the actuator from the valve or gate, disconnecting any electrical wiring, or disassembling any of the gearing. All gearing shall be designed to withstand a 100 percent overload.

6. Torque Switch:
   a. Electric actuators shall be provided with a double-torque switch set to disengage motor power at 75 percent of the shaft's design torque. The torque switch shall operate in both the opening and closing directions and shall operate during the complete cycle without the use of auxiliary relays, linkages, latches, or other devices.
   b. Each side of the torque switch shall have a numbered dial for set point adjustment. A calibration tag shall be mounted near each switch for correlating the dial settings with output torque.

7. Manual Actuator: Electric actuators shall be provided with a handwheel for manual operation. The handwheel shall not rotate during motor operation nor shall a locked motor prevent manual operation. Motor or manual selection shall be accomplished by a positive declutching knob or lever which will disengage the motor and motor gearing mechanically but not electrically. Prohibit manual and motor simultaneously operation. Hand operation shall not require more than 100 pounds of rim effort at maximum torque.

8. Hammer Blow Device: Electric actuators shall be provided with a built-in lost-motion device that allows sufficient travel of the worm gear, prior to engaging the stem nut, for the motor to reach full speed. This action shall impart a "hammer blow" to start the valve or gate in motion in either direction. The load shall be shared equally by two lugs cast integrally on the drive sleeve.

9. Conduit Openings: Electric actuators shall be provided with the largest available: power conduit opening; control conduit opening; and instrument conduit opening.

10. Software and Hardware: Diagnostic and configuration software, Microsoft Windows operating platform with wireless connection between a PC, tablet, PDA, or cell phone and the actuator. Or a stand-alone hand held unit with wireless connection used for configuration of the actuator.
11. Interface to Supervisory System: Provide for permanent Modbus RS-485 communication to the station’s control system. Coordinate all register location and valve programming with Owner programming for proper communication and integration to operate as specified in Section 40 90 00 Instrumentation for Process Control: Basic Requirements. Coordinate master/slave setup of all actuators to properly interface with the station’s control system. Provide lightning protection on the communication port.

2.04 ACTUATOR APPURTEANCES

A. Identification Tags:
   1. Each powered actuator shall be provided with a 16-gage stainless steel identification tag that bear the equipment description and tag number of the actuator, as specified. Characters shall be 1/4 inch, die-stamped. Identification tags shall be securely attached to the actuator in a readily visible location using stainless steel screws or wire.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General:
   1. Installation shall be as specified herein. Valve actuators shall be located so that they are readily accessible for operation and maintenance and mounted for unobstructed access.
      a. Valve actuator mounting shall not obstruct walkways.
      b. Valve actuator support systems shall not be attached to handrails, process piping, or mechanical equipment.
      c. Valve actuators mounting shall not be located where shock or vibration will impair their operation.
      d. Valve actuators shall be mounted on top of the wetwell using a top wall mounting bracket.

B. Powered Actuators:
   1. General: Powered actuators shall have their manual operating accessory, where possible, located between 48 inches and 60 inches above the floor or a permanent work platform.
   2. Identification Tags: Tags shall be located in a clearly visible location on the valves. If necessary, reposition and reattachment with stainless steel screws or wire.
3.02 TESTING

A. General Requirements:

1. Testing shall be performed in accordance with Section 01 75 00, and this section. No required test shall be applied without prior notice to the Engineer to witness any test. At least 14 days before the commencement of any testing activity, a detailed step-by-step test procedure, complete with forms for the recording of test results shall be provided. All equipment necessary to perform the required tests shall be provided.

2. Provide a factory-trained manufacturer's representative at the site for the following activities.
   a. Inspect actuator's electrical power, control, signal, communication and grounding wiring for proper termination.
   b. Configure actuator and include:
      1) Actuator Settings: Limit switch, torque position, travel speed, emergency function, and relay functions.
      2) Network Settings: Address, transmission rate, bus loss action, heartbeat interval, consumed path, and production path.
      3) Test actuator control including network in compliance with Section 40 90 00 and Section 40 98 00. Test each electric motor actuator for each modes of operation including but not limited to local - open, close, stop, modulation and network operation as well as the travel rates, limit switches, jam and torque settings.

3.03 TRAINING

A. Operation and maintenance training for the equipment provided under this section shall be provided for the Owner's personnel in accordance with Section 01 75 00. Training shall be certified on Form 43 05 11-B specified in Section 00 60 00.

3.04 ELECTRIC MOTOR ACTUATED VALVES SCHEDULE

<table>
<thead>
<tr>
<th>Valve Number</th>
<th>Service</th>
<th>Number of Valves</th>
<th>Valve size, inches</th>
<th>Actuator Type</th>
<th>Actuator Enclosure</th>
<th>Open/Close Time Seconds; Motor Duty, Minutes</th>
<th>Starter Duty, Starts/ Hour</th>
<th>Positioning Accuracy, Percent</th>
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</thead>
<tbody>
<tr>
<td>ACT-0116</td>
<td>Storm Water</td>
<td>1</td>
<td>60x60</td>
<td>EMTI</td>
<td>NEMA-4X</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

3.05 ACTUATOR SPECIFICATION (ACTUSPEC) SHEETS

A. The following ACTUSPEC sheets are included in this section:

1. EMTI
3.06 VALVE ACTUATOR SPECIFICATION SHEETS (ACTUSPEC)

Actuator Type: EMTI – 460 Vac, 3-Phase, 60-Hertz

Description: Electric Multi-turn Isolation valve actuator

Construction: Actuators shall be Rotork IQ3 series; modified as necessary to provide the specified features and to meet the specified operating requirements.

Controller: The controller shall have local integral controls and a supervisory remote control/monitoring operation which networks to station’s PAC (Section 40 90 00 Instrumentation for Process Control: Basic Requirements) over Modbus RS485. The controller shall allow the station’s PAC to open and close and have position feedback (including full open and full close position status) over the network.

Controls: Control power shall be provided by an integral 120 volts AC, single-phase control transformer unless otherwise shown on the electrical drawings. The transformer shall be sized to operate at not more than 80 percent of rating with the connected load shown. The transformer shall have protective secondary fusing.

Actuators shall be provided with an integral local control station that includes an "OPEN", a "CLOSE", a "STOP", (or OPEN-STOP-CLOSE, OSC, selection instead of individual pushbuttons), a “LOCAL-OFF-REMOTE” (LOR) selection, full open and close indication, and current position and torque readout. Note specified requirements for Modbus communications.

When the LOR selector switch is in the "LOCAL" position, the control station’s "OPEN", “CLOSE” and “STOP” pushbuttons or OSC selector switch shall cause the actuator to drive the valve or gate to full open, full close or stop in travel respectively.

When the LOR selector switch is in the "REMOTE" position, the actuator shall move in response to the external open and close commands via Modbus network and the control station’s “OPEN”, “CLOSE” and “STOP” pushbuttons or OSC selector switch shall have no effect.
Programmable Contacts: Actuators shall be provided with a minimum of 4 contacts. Each contact shall be programmable to represent full open and full close position, as well as other actuator status including fault, local mode, and remote mode indications. Fault contact shall be held closed and shall open on alarm state.

Contacts configurable for normally open or normally closed. Contacts shall be rated at 0.5 amp at 120 volts AC and 1 amp at 24 volts DC.

Position switches and gearing shall be an integral part of the actuator. Position switch gearing shall be of the intermittent type and allow switch set points to be set at any point of travel between fully open and fully closed. Switches shall not be subject to breakage or slippage due to over-travel.

END OF SECTION 40 05 62
PART 1 - GENERAL

1.01 SUMMARY
A. This section specifies spring-loaded swing check valves.

1.02 REFERENCES
A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A126</td>
<td>Gray Iron Castings for Valves, Flanges, and Pipe Fittings</td>
</tr>
<tr>
<td>ASTM A276</td>
<td>Stainless and Heat-Resisting Steel Bars and Shapes</td>
</tr>
<tr>
<td>ASTM A536</td>
<td>Ductile Iron Castings</td>
</tr>
<tr>
<td>ASTM B148</td>
<td>Aluminum-Bronze Sand Castings</td>
</tr>
<tr>
<td>AWWA C508</td>
<td>Swing-Check Valves for Waterworks Service, 2 In. Through 24 In. NPS</td>
</tr>
</tbody>
</table>

1.03 SUBMITTALS
A. The following information shall be provided in accordance with Section 01 33 10:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Product Data:
   a. Product information, charts, or graphs to verify that the product provided meets the requirements set forth in this specification.
   b. Affidavits of compliance, as required by AWWA C508.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

B. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed that named manufacturers’ standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Golden Anderson and APCO, or equal.

2.02 MATERIALS

A. Materials of construction shall be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body, cover</td>
<td>Cast iron, ASTM A126, Class B</td>
</tr>
<tr>
<td>Disc</td>
<td>Ductile iron, ASTM A536</td>
</tr>
<tr>
<td>Seat rings</td>
<td>Aluminum bronze, ASTM B148 or Stainless steel, ASTM A276, Type 316</td>
</tr>
<tr>
<td>Hinge shafts and hinge pins</td>
<td>Stainless steel, ASTM A276, Type 301 or 304</td>
</tr>
<tr>
<td>Shaft bushings</td>
<td>Bronze, AWWA C508</td>
</tr>
</tbody>
</table>

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 MANUFACTURER

A. Disc, disc arm, shaft, keyways, lever and spring shall be capable of closing within .05 seconds of pump stoppage and fluid moving at velocity of 8 feet per second. Spring tension shall be adjustable. The valve design shall permit mounting levers and springs on either side of the valve. The design of the spring attachment shall permit adjustment of closing force by tensioning the spring or replacement with different active length springs.

B. Valves shall be provided with a clear opening equal to or greater than the connecting piping, with no raised seating surface. Seats shall be threaded onto the body or fitted with an O-ring seal and locked in place with stainless steel screws or pins and shall be replaceable. Shafts shall be provided with stuffing box and packing or O-ring seals at each end. Seals shall be externally replaceable. Minimum shaft diameters shall be as follows:
### Valve Inlet Connection Size, Inches

<table>
<thead>
<tr>
<th>Valve Inlet Connection Size, Inches</th>
<th>Shaft Diameter, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td>12</td>
<td>2.5</td>
</tr>
</tbody>
</table>

C. The pivot arm shall be secured to the disc with either twin bolted connections with lockwashers or a pinned nut. In either instance, the connection shall be designed to prevent disc movement relative to the arm. Shaft bearings shall extend the entire length of the shaft other than the section required for the disc arm attachment. Disc and lever arms shall be keyed to the shaft and retained by bushings or pins.

D. Unless otherwise specified, valves shall, as a minimum, conform to the following pressure ratings:

<table>
<thead>
<tr>
<th>Size, Inches</th>
<th>Working Pressure, PSIG</th>
<th>Hydrostatic Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 through 12</td>
<td>175</td>
<td>350</td>
</tr>
</tbody>
</table>

E. Check valves wetted parts shall be coated with fusion bonded epoxy.

#### 2.04 PRODUCT DATA

A. Manufacturer's catalog information including dimensions, cross-sectional views, details of construction and materials list shall be provided in accordance with Section 01 33 10.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

A. Spring loaded swing check valves shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION 40 05 65.23
PART 1 - GENERAL

1.01 SUMMARY

A. This section specifies electric heat tracer tape and control for protection of piping against freezing.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA ICS 1</td>
<td>Industrial Control and Systems</td>
</tr>
</tbody>
</table>

1.03 DEFINITIONS

(NOT USED)

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. General:

1. Tracer tape shall consist of self-limiting, parallel circuit construction with a continuous inner core of conductive material between two copper bus wires. The resistance and heating capacity of the heating material shall vary in response to piping temperature changes. Tape shall withstand continuous exposure to 150 degree F temperature. Tracer tape shall operate using 120 volt AC, 1 phase, 60 Hz power.

2. Tracer tape shall be provided with copper shield and fluoropolymer jacket.

B. Type 1:

1. Type 1 tracer tape shall have a thermal rating of 4 watts per foot at 50 degrees F.
2.02 CONTROLS
A. General:
   1. Each length of tracer tape shall be controlled by a thermostat. Thermostat shall be provided in an aluminum, NEMA 4, watertight enclosure.
   2. Each length of tracer tape shall be provided with a signal light wired to the terminating end. Light shall indicate that tape is energized.

B. Type A:
   1. Type A thermostat shall control by sensing ambient temperature with the following characteristics:
      a. Rating: 22 amperes at 480V AC
      b. Control temperature range: 15 to 140 degrees F
      c. Calibration tolerance: 2 degrees F
      d. Sensor material: stainless steel
      e. Exposure temperature: -65 to 140 degrees F
      f. Temperature setting: 50 degrees F

2.03 PRODUCT DATA
A. The following information shall be provided in accordance with Section 01 33 10:
   1. Manufacturer's product literature.
   2. Certification that tracer tape can withstand temperature specified in Paragraph 2.01.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Tracer tape shall be fastened to pipe and valves as recommended by the manufacturer at intervals not exceeding 1 foot.

3.02 TRACER TAPE SCHEDULE
A. Tracer tape shall be provided in accordance with the following schedule:

<table>
<thead>
<tr>
<th>Piping System Service</th>
<th>Piping Diameter, Inches</th>
<th>Location</th>
<th>Minimum Tracer Tape Length, Ft</th>
<th>Tracer ç</th>
<th>Thermostat Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Supply</td>
<td>1 1/2</td>
<td>Above ground water supply piping after RPBA towards utility station at head box, and water supply piping to utility station in wetwell</td>
<td>30</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>Force Main (storm water)</td>
<td>3, 6</td>
<td>Water feature piping within headbox</td>
<td>50</td>
<td>1</td>
<td>A</td>
</tr>
</tbody>
</table>

END OF SECTION 40 41 03
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Basic requirements for complete instrumentation system for process control.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Division 26 - Electrical.
   4. Section 26 05 19.
   5. Section 40 90 05.
   7. Section 40 94 43.
   8. Section 40 97 00.
   9. Section 40 98 00.
  10. Section 40 99 00.

1.02 REFERENCES

A. Referenced Standards:
   1. Canadian Standards Association (CSA).
   2. FM Global (FM).
   3. The International Society of Automation (ISA):
      a. 5.1, Instrumentation Symbols and Identification.
      b. 5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems.
      c. 5.4, Instrument Loop Diagrams.
      d. 20, Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
   4. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   5. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
7. Underwriters Laboratories, Inc. (UL):
   a. 913, Standard for Safety, Intrinsically Safe Apparatus and Associated
       Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified)
       Locations.
   b. 698A, Standards for Intrinsic Safety.
   c. 508A, Industrial Control Panels.

8. Seattle Public Utilities, SCADA Management:
   a. SPU Design Guidelines & Standards. Section 10 – Instrumentation and
      Control. SCADA.

1.03 DEFINITIONS
A. Hazardous Areas: Class I, II or III areas as defined in NFPA 70.
B. Highly Corrosive and Corrosive Areas: Rooms or areas identified on the Drawings
   where there is a varying degree of spillage or splashing of corrosive materials such as
   water, wastewater or chemical solutions; or chronic exposure to corrosive, caustic or
   acidic agents, chemicals, chemical fumes or chemical mixtures.
C. Outdoor Area: Exterior locations where the equipment is normally exposed to the
   weather and including below grade structures, such as vaults, manholes, handholes and
   in-ground pump stations.
D. Intrinsically Safe Circuit: A circuit in which any spark or thermal effect is incapable of
   causing ignition of a mixture of flammable or combustible material in air under test
   conditions as prescribed in UL 698A.
E. Calibrate: To standardize a device so that it provides a specified response to known
   inputs.

1.04 QUALITY ASSURANCE
A. Qualifications:
   1. Instrumentation subcontractor:
      a. Experience:
         1) Have satisfactorily provided a control system for a minimum of five
            (5) projects of similar magnitude and function.
      b. Location:
         1) Instrumentation subcontractor’s facility to be located within 50
            miles of the City of Seattle.

B. Miscellaneous:
   1. Comply with electrical classifications and NEMA enclosure types shown on
      Drawings and defined in the Specification Sections.
   2. Equipment and installation in hazardous areas shall be suitable for installation
      and use in hazardous areas.
1.05 SYSTEM DESCRIPTION

A. Control System Requirements:

1. The instrument and control system consist of all primary elements, transmitters, switches, controllers, indicators, panels, signal converters, power supplies, special or shielded cable, special grounding or isolation, auxiliaries, software, wiring, and other devices required to provide complete control of the facility as specified in the Contract Documents.

2. Application software for programmable automation controllers, Human Machine Interface and Operator Interface Unit will be provided, configured and programmed by the Owner.

3. Hard wired interlocks that are described in this and other sections and referenced on the P&IDs are to be provided by the contractor.

4. Programmable automation controller (PAC) hard wired inputs and outputs are summarized in the Section 40 90 05A – IO Schedule. Control loop descriptions are provided in Section 40 90 05.

5. Digital communication bus networks interconnecting between mechanical and electrical equipment with PAC are to be provided by the contractor.

B. All signals shall be directly linearly proportional to measured variable unless specifically noted otherwise.

C. Single Instrumentation Subcontractor:

1. Furnish and coordinate instrumentation system through a single instrumentation subcontractor:

   a. The instrumentation subcontractor shall be responsible for functional operations of all systems, performance of control system engineering, supervision of installation, final connections, calibrations, preparation of Drawings, testing procedures and Operation and Maintenance Manuals, start-up, training, demonstration of substantial completion and all other aspects of the control system.

2. Coordinate instrumentation with other work to ensure that necessary wiring, conduits, contacts, relays, converters, and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, and the Owner’s existing SCADA system.

3. Provide testing, commissioning and troubleshooting support for Owner’s programmer for each testing phase following the Contractor’s Testing Schedule Submittal. See Specification Section 01 75 00 – Commissioning for requirements of each testing phase. Support hours to match test phase schedule’s duration and is to be no less than 24 hours per testing phase. Additional hours may be requested by the Owner and will be funded on a time and materials basis.
1.06 SUBMITTALS

A. Shop Drawings:

1. See Section 01 33 10 for requirements for the submittal process.

2. Submittals shall be original printed material or clear unblemished photocopies of original printed material:
   a. Facsimile information is not acceptable.
   b. In addition to printed copies, provide an electronic copy of submittals in pdf format with a table of content and bookmarks to each item in the table of content.

3. Limit the scope of each submittal to one (1) Specification Section:
   a. Each submittal must be submitted under the Specification Section containing requirements of submittal contents.

4. Documentation of instrumentation subcontractor qualifications and experience as defined above.

5. Product technical data including:
   a. Equipment catalog cut sheets.
   b. Instrument data sheets:
      1) ISA 20 or approved equal.
      2) Separate data sheet for each instrument.
   c. Materials of construction.
   d. Minimum and maximum ranges, calibration information (in engineering units or as otherwise noted).
   e. Physical limits of components including temperature and pressure limits.
   f. Size and weight.
   g. Electrical power requirements and wiring diagrams.
   h. NEMA rating of housings.
   i. Submittals shall be marked with arrows to show exact features to be provided. Features and options not being provided shall be crossed out.

6. Loop diagrams per ISA 5.4 as specified in Specification Section 40 98 00 - Control Panels and Enclosures.

7. Comprehensive set of wiring diagrams as specified in Specification Section 40 98 00 - Control Panels and Enclosures.

8. Panel fabrication drawings as specified in Specification Section 40 98 00 - Control Panels and Enclosures.

9. Programmable automation controller (PAC) equipment drawings.

10. Nameplate layout drawings for identification devices for instrumentation system components.
11. Engraving and escutcheon lettering legends.

12. Drawings, systems, and other elements are represented schematically in accordance with ISA 5.1 and ISA 5.3:
   a. The nomenclature, tag numbers, equipment numbers, panel numbers, and related series identification contained in the Contract Documents shall be employed exclusively throughout submittals.

13. All Shop Drawings shall be modified with as-built information/corrections.

14. All panel and wiring drawings shall be provided in both hardcopy and softcopy:
   a. Furnish electronic files on CD-ROM or DVD-ROM media.
   b. Drawings in AUTO CAD and PDF format.

15. Provide a parameter setting summary sheet for each field configurable device.

16. Modbus addresses: Submit a complete list of Modbus slave addresses for all field equipment. List shall include the cable number that has been assigned for serial communications and the port the cable is assigned to in the PAC.

17. Certifications:
   a. Documentation verifying that calibration equipment is certified with NIST traceability:
      1) Test equipment shall be certified within one (1) year of the date of use.
      2) Use of equipment with expired certifications shall not be permitted.
      3) Calibration equipment shall be at least three (3) times more accurate as the device being calibrated.
   b. Approvals from independent testing laboratories or approval agencies, such as UL, FM or CSA:
      1) Certification documentation is required for all equipment for which the specifications require independent agency approval.

18. Testing reports: Source quality control reports.

19. Completed forms located immediately following the end of this Specification Section:
   a. Loop Check-out Sheet.
   b. Instrument Certification Sheet.
   c. Final Control Element Certification Sheet.

B. Operation and Maintenance Manuals:

1. See Section 01 33 10 for requirements for the submittal process:
   a. The mechanics and administration of the submittal process.

2. See Section 00 72 00 for the content of the Project Operation and Maintenance Manual.

3. See Section 01 77 19 for close out detail.
1.07 SITE CONDITIONS
A. See Project/Site Conditions in Section 26 00 00.

PART 2 - PRODUCTS
2.01 NEMA TYPE REQUIREMENTS
A. See Project/Site Conditions in Section 26 00 00.
B. Provide enclosures/housing for control system components in accordance with Project/Site Conditions in Section 26 00 00 and panel requirements of Section 40 98 00.

1. Areas designated as Class I, Division 2 hazardous (classified) as defined in NFPA 70:
   a. NEMA Type 4X with certification approvals for Class I, Division 1 or 2.
   b. NEMA Type 7 with certification approvals for Class I, Division 1.
   c. NEMA Type 4X with intrinsically safe certification approval for Class I, Division 1 or 2 for all electrical components within enclosure and utilization of intrinsically safe circuitry.
   d. Utilize NEMA Type 4X with certification approvals for Class I, Division 1 or 2 to the maximum extent practical and intrinsically safe certification approval for Class I, Division 1 or 2 as depicted in the Contract Documents.

2. Indoor areas with HVAC: NEMA Type 12.
3. Areas designated to be subject to temporary submersion: NEMA Type 6P or 7.
4. Areas designated as corrosive: NEMA Type 4X.

2.02 PERFORMANCE AND DESIGN REQUIREMENTS
A. Instrumentation Performance Criteria:

1. Performance: All instruments and control devices shall perform in accordance with manufacturer’s specifications.
2.03 ACCESSORIES

A. Provide identification devices for instrumentation system components in accordance with the following:

1. Instrumentation Equipment (e.g., flow control valves, primary elements, etc.):
   a. Tag type:
      1) Outdoor and/or corrosive locations: Type B1 - Square Non-Metallic Tags:
         a) Stainless steel Type A1 - Round Metal Tags:
            (1) Size:
               (a) Diameter: 1-1/2-IN minimum.
               (b) Thickness: 0.035-IN (20 gage) minimum.
            (2) Fabrication:
               (a) 3/16-IN minimum mounting hole.
               (b) Legend stamped and filled with black coloring.
            (3) Color:
               (a) Natural
               b) Type B1 - Square Non-Metallic Tags.
      b. Fastener:
         1) Type A1: Chain of the same material.
         2) Type B1: Stainless steel chain.
   c. Legend:
      1) Letter height: 1/4-IN minimum.
      2) Equipment ISA designation as indicated on the Drawings (e.g., “FIT-xxxx”).

2. Enclosure for instrumentation and control equipment, (e.g., MCP & LCP control panels, etc.):
   a. Tag type: Type C - Phenolic Name Plates:
      1) Materials: Phenolic.
      2) Size:
         a) Surface: As required by text.
         b) Thickness: 1/16-IN.
3) Fabrication:
   a) Two layers laminated.
   b) Legend engraved through top lamination into bottom lamination.
   c) Two drilled side holes, for screw mounting.

4) Color: Black top surface, white core, unless otherwise indicated.

b. Fastener: Screws, sealed as required to maintain enclosure UL and NEMA rating.

c. Legend:
   1) Letter height: 1/2-IN minimum.
   2) Equipment name (e.g., "MAIN CONTROL PANEL MCP-xxxx").

3. Components inside equipment enclosure, (e.g., PLC’s, control relays, contactors, and timers):
   a. Tag type: Type D - Self-Adhesive Tape Tags:
      1) Materials: Vinyl tape or vinyl cloth.
      2) Size:
         a) Surface: as required by text.
         b) Thickness: 5 mils minimum.
      3) Fabrication:
         a) Indoor/Outdoor grade.
         b) Weather and UV resistant links.
         c) Permanent adhesive.
         d) Preprinted legend.
         e) Wire marker to be self-laminating.
      4) Color: White with black lettering or as specified.

b. Fastener: Self.

c. Legend:
   1) Letter height: 3/16-IN minimum.
   2) Description or function of component (e.g., "PLC-xxxx" or "CR-xxxx").
4. Through enclosure door mounted components (e.g., selector switches, controller digital displays, etc.):
   a. Tag type: Type C - Phenolic Name Plates (as defined at Paragraph 2.03.A.2.a, above).
   b. Fastener: Screws, sealed as required to maintain enclosure UL and NEMA rating.
   c. Legend:
      1) Letter height: 1/4-IN minimum.
      2) Component ISA tag number as indicated on the Drawings (e.g., “HS-xxx”).

B. Provide corrosion resistant spacers to maintain 1/4-IN separation between equipment and mounting surface in wet areas, on below grade walls and on walls of liquid containment.

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. Do not remove shipping blocks, plugs, caps, and desiccant dryers installed to protect the instrumentation during shipment until the instruments are installed and permanent connections are made.

3.02 INSTALLATION

A. Wherever feasible, use bottom entry for all conduit entry to instruments and junction boxes. Provide weep holes in conduits where necessary to prevent liquid buildup.

B. Install electrical components per Division 26.

C. Panel-Mounted Instruments:
   1. Mount and wire so removal or replacement may be accomplished without interruption of service to adjacent devices.
   2. Locate all devices mounted inside enclosures so terminals and adjustment devices are readily accessible without use of special tools and with terminal markings clearly visible.

D. See Section 26 05 19 for electrical conductors and cabling.
3.03 **FIELD QUALITY CONTROL**

A. Maintain accurate daily log of all startup activities, calibration functions, and final set point adjustments.

   1. Documentation requirements include the utilization of the forms located at the end of this Specification Section:
      a. Loop Check-out Sheet.
      b. Instrument Certification Sheet.
      c. Final Control Element Certification Sheet.

B. **Instrumentation Calibration:**

   1. Verify that all instruments and control devices are calibrated to provide the performance required by the Contract Documents.
   2. Calibrate all field-mounted instruments after the device is mounted in place to assure proper installed operation.
   3. Calibrate in accordance with the manufacturer's specifications.
   4. Check the calibration of each transmitter and gage across its specified range at 0, 25, 50, 75, and 100 percent:
      a. Check for both increasing and decreasing input signals to detect and document any hysteresis.
   5. Replace any instrument which cannot be properly adjusted or calibrated.
   6. Stroke control valves to verify control action, feedback, and positioner settings.
   7. Calibration equipment shall be certified by an independent agency with traceability to NIST:
      a. Certification shall be certified within one (1) year of the date of use.
      b. Use of equipment with expired certifications shall not be permitted.
   8. Calibration equipment shall be at least three (3) times more accurate as the device being calibrated.

C. Loop check-out requirements are as follows:

   1. Check control signal generation, transmission, reception and response for all control loops under simulated operating conditions by imposing a signal on the loop at the instrument connections:
      a. Use actual signals where available.
      b. Closely observe controllers, indicators, transmitters, displays, alarm and trip units, and other control components:
         1) Verify that readings at all loop components are in agreement.
         2) Make corrections as required:
            a) Following any corrections, retest the loop as before.
2. Stroke all control valves, from the local control station and from the local operator interface.

3. Check all interlocks to the maximum extent possible.

4. In addition to any other as-recorded documents, record all calibration changes on all affected Contract Documents and turn over to the Owner.

D. Provide verification of system assembly, power, ground, and I/O tests.

E. Verify existence and measure adequacy of all grounds required for instrumentation and controls.

F. Perform Start-up and Training as defined in this Section and other Sections:

1. See Section 40 98 00 for description of control cabinet testing requirements, which includes Manual & full Auto test for the complete system.

END OF SECTION 40 90 00
LEAK AND TERMINATION/CONTINUITY CHECKS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FIELD</th>
<th>CONTROL CAB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LEAK CHECK₁</td>
<td>TERM/CONT CHECK₂</td>
</tr>
</tbody>
</table>

1. Leak check for pneumatic signal tubing to be per ISA-PR7.1.
2. Termination/continuity check includes check at terminated equipment for: (a) correct polarity, (b) appropriate signal generation, transmission and reception, and (c) correct shield & ground terminations.

OPERATOR INTERFACE CHECK-OUT

MONITORING POINTS OBSERVED

<table>
<thead>
<tr>
<th>PARAMETER TYPE</th>
<th>TAG NO.</th>
<th>TAG NO.</th>
<th>TAG NO.</th>
<th>TAG NO.</th>
<th>TAG NO.</th>
<th>TAG NO.</th>
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</thead>
<tbody>
<tr>
<td>PROCESS VAR</td>
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<tr>
<td>EQUIP STATUS</td>
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</tr>
<tr>
<td>ALARM POINT</td>
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OPERATOR CONTROL FUNCTIONS CHECKED

<table>
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<th>FUNCTION TYPE</th>
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<th>LOCATION</th>
<th>TAG NO.</th>
<th>LOCATION</th>
<th>TAG NO.</th>
<th>LOCATION</th>
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</thead>
</table>

AS LEFT SETTINGS

<table>
<thead>
<tr>
<th>TAG NO.</th>
<th>SWITCH &amp; ALARM SP</th>
<th>CONTROLLERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gain</td>
<td>Reset, rpm</td>
</tr>
</tbody>
</table>

Describe all interlocks checked, equipment started/stopped, valves/operators stroked. Describe modes of operation checked, and location of operator interface (local/remote).

I certify that the control loop referenced on this page has been completely checked and functions in accordance with applicable drawings and specifications.

Certified by: __________________________ Date: ____________
(Work Performed By) __________________________
Witnessed by: __________________________ Date: ____________
## Instrument Certification Sheet

**City of Seattle**  
**Seattle Public Utilities**

### Project Information
- **Project Name:**  
- **Project No.:**  
- **Project Owner:**  
- **Regulatory Agency Project No. (if applicable):**  
- **Project No.:**  
- **Date:**  
- **Control Loop No.:**
- **Instrument Tag No.:**
- **Transmitter/gauge span:**  
- **Manufacturer:**
- **Model No.:**
- **Switch set-point:**  
- **Serial No.:**
- **Switch dead band:**
- **Switch range:**

### Transmitters and Indicators

<table>
<thead>
<tr>
<th>% OF SPAN</th>
<th>INCREASING INPUT</th>
<th>DECREASING INPUT</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>INPUT</td>
<td>OUTPUT</td>
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<tr>
<td>0%</td>
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<tr>
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<td>100%</td>
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<tr>
<td><strong>Other (if applicable)</strong></td>
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### Switches

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<tr>
<th>ACTUATION POINT</th>
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<tbody>
<tr>
<td></td>
<td>INPUT</td>
<td>OUTPUT</td>
</tr>
<tr>
<td>High (Increasing input)</td>
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<tr>
<td>Low (Decreasing input)</td>
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Maximum allowable error (per Contract Documents):

Remarks:

### Calibration Equipment Utilized

<table>
<thead>
<tr>
<th>DEVICE TYPE</th>
<th>MFR/MODEL NO.</th>
<th>ACCURACY</th>
<th>NIST TRACEABILITY?</th>
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Certified by: ____________________________  
Date Certified: _________________________

Witnessed by: ____________________________  
Date: ________________________________

40 90 00B
Final Control Element Certification Sheet

City of Seattle
Seattle Public Utilities

<table>
<thead>
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<table>
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<table>
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<tr>
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</table>

<table>
<thead>
<tr>
<th>Actuator:</th>
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<table>
<thead>
<tr>
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<th>Direct:</th>
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<tr>
<th>Description:</th>
<th>Positioner:</th>
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<table>
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<tr>
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<th>I/P Converter:</th>
<th>Input:</th>
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<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Model No.</th>
<th>Valve to:</th>
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<table>
<thead>
<tr>
<th>Serial No.</th>
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<td>on power failure</td>
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### I/P CONVERTER

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<th>OUTPUT</th>
<th>ERROR (% of span)</th>
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Specified I/P converter accuracy: ________ % of span.

### FINAL CONTROL ELEMENT

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<th>TRAVEL</th>
<th>ERROR (% of full travel)</th>
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<th>TRAVEL</th>
<th>ERROR (% of full travel)</th>
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<tbody>
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Remarks:

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### CALIBRATION EQUIPMENT UTILIZED

<table>
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<tr>
<th>DEVICE TYPE</th>
<th>MFR/MODEL NO.</th>
<th>ACCURACY</th>
<th>NIST TRACEABILITY?</th>
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Certified by: ___________________________ Date Certified: ____________

Witnessed by: ___________________________ Date: ____________
PART 1 - GENERAL
1.01 SUMMARY
A. Section Includes:
   1. Instrumentation control loops.
   2. Hard wired interlocks that are described in this and other sections are referenced on the P&ID’s and are to be provided by the Contractor.
   3. The intent of including this specification section is to describe how the site will operate; the Owner will use this to accomplish the programming (application software development).
   4. This section is provided as part of the bid documents for reference only.
B. Related Sections include but are not necessarily limited to:
   1. Division 00.
   2. Division 01.
   4. Section 40 90 00.

1.02 REFERENCES
(Not used)

1.03 DEFINITIONS
(Not used)

1.04 QUALITY ASSURANCE
A. See Section 40 90 00.

1.05 SYSTEM DESCRIPTION
A. Instrumentation drawings in conjunction with the control strategies described below work together to clarify the South Park Pump Station control system operational requirements.

B. The Owner will provide all application software development (this includes programming of the Opto 22 PAC, Red Lion OIU and SCADA at OCC) required implementing the functional requirements of the control loops.

C. The control loop descriptions provide the functional requirements represented in the Contract Documents.

D. The control loop descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions, but are rather intended to supplement and complement the Drawings and other Specification Sections:
   1. The control loop descriptions shall not be considered equal to a bill of materials.
   2. The control loop descriptions include hard wired interlocks which are to be provided by the contractor.
   3. The control loop descriptions programming will be implemented by the Owner.
E. SPU software standards will be followed for communications with this site, including the following:
   1. Programmable Automation Controller (PAC) address assignment.
   2. Communications configuration.

F. Process control logic will reside and be executed in the PAC as much as possible.

G. Supervisory process control functionality will follow SPU software standards. In general, SPU staff (with appropriate security access rights) can change applicable process control, process alarm, control modes, etc. from the operator interface unit (OIU) system, the changes are communicated to the PAC, the PAC confirms back to the OIU system when the change has been implemented, and the change appears on the OIU system.

H. Alarm management functionality will follow SPU software standards.

I. Data collection, archiving, reporting, displaying and functionality will follow SPU software standards.

J. OIU display layout, color conventions, navigation, security access rights, and control functionality will follow SPU software standards.

K. Human machine interface (HMI) displays, functionality, and control will be identical to those of the OIU (at MCP-0100).

1.06 SUBMITTALS

A. See Section 01 33 10 for requirements for the submittal process.

B. Programming schedule workshop agenda. The Contractor shall hold a minimum of two (2) workshops prior to testing as defined in Section 01 75 00 with SPU’s SCADA staff to coordinate contractor’s work with Owner’s programming work including coordination requirements and schedule for downloading of Owner’s application programs. The Contractor shall submit a workshop agenda two (2) weeks prior each scheduled workshop.

C. For submittals associated with Start-up and Testing see Section 01 75 00.

PART 2 - PRODUCTS

(PART 3 - EXECUTION)

3.01 SOUTH PARK PUMP STATION CONTROL LOOPS

A. The following COMMON functions will follow SPU software standards:
   1. Common analog I/O functions:
      a. Conditioning.
      b. Alarming.
      c. Scaling.
      d. Process Data Logging.
e. Flow totalization. When associated instrument is in MAINTENANCE mode, use last good value for totalization and mark historical data accordingly.

f. Alarm set point dead bands.

g. Calculated analog values.

h. Instrument or equipment calibration mode (operate mode, maintenance mode, alarm inhibit, timed monitoring in maintenance mode, data collection management when in maintenance mode, etc.).

2. Common discrete I/O functions:
   a. Alarming (alarms specified below).
   b. Nuisance tripping.

3. Common gate control functions:
   a. Local/remote mode monitoring, and OIU auto/manual mode monitoring and control.
   b. Position monitoring (open, in transition, closed, position).
   c. Equipment failure monitoring and alarming:
      1) FAULT.
      2) Fail to OPEN (within preset time delay).
      3) Fail to CLOSE (within preset time delay).
      4) High torque alarms.
      5) Gate position from set point deviation alarm.
      6) Remote not selected.

4. Common monitoring functions:
   a. Accessing information on the OIU (number of screen touches for navigation, diagnostics information, etc.).
   b. Communications:
      1) Status.
      2) Failure.
      3) Power failure and restore.

5. Common instrument functions:
   a. Redundant instruments provide level measurements.
      1) Both instruments identically calibrated in engineering units (see Specification Section 40 91 10 - Primary Elements and Transmitters).
      2) Both instruments configured to fail high (where possible).
      3) Individual instrument high and low out-of-range alarming.
4) Deviation set point: PAC logic generates an alarm when the difference between the two values (deviation set point) exceeds an operator adjustable value (initially set at 0.25 feet) for an operator adjustable time delay (initially set at 5 minutes). Display alarm message: “Level signals not matching”.

5) A selector switch (manual / automatic) shall be available for each level system being monitored.

6) Manual mode:
   a) In manual mode, the operator manually selects the level transmitter used for level input to the control system.
   b) “Maintenance mode”: manually select the instrument to be used for control.

7) In Automatic mode, the system functions as follows:

8) When the deviation set point has not been exceeded, the level instrument “A” is the primary instrument.

9) If the deviation set point is exceeded, the level transmitter with the highest reading is used for level control function (where applicable).

B. Loop 011A – Pump Station: Measurement and Level Control

1. P&ID Reference: I-03, I-04, I-05 and I-06

2. Key Elements:
   a. Pump Station Continuous Level Measurement (staff gauge, digital indicators, and level transducers), GA-0110, LI/LT-0110A & B.
   d. Flood Control Pump 2 Discharge Flow Measurement (magmeter), FE/FIT-0112.
   e. Flood Control Pump 3 Discharge Flow Measurement (magmeter), FE/FIT-0113.
   g. Flood Control Pump 1, P-0111.
   h. Flood Control Pump 2, P-0112.
   i. Flood Control Pump 3, P-0113.
   j. Flood Control Pump 4, P-0114.
3. System Description:
   a. Four submersible flood control pumps, P0111, P0112, P0113 and P-0114 are located in the pump station.
   b. All four flood control pumps are 60 hp and have the same capacity.
   c. All four flood control pumps are variable speed driven (VFD) with discrete output contacts for FAULT, in HAND, in AUTO, RESET; discrete input for PAC call to run, analog input for PAC speed control, additional data read through a digital communication bus network to PAC (for field alarms and status; VFD diagnostic alarms and status parameters). The flood control pumps run at a set speed.
   d. Each flood control pump has a discharge flow meter. The discharge flow meter shall measure flow when associated flood control pump is running. When the associated flood control pump is not running the flow meter shall see empty pipeline.
   e. Incoming flow passes through a diversion structure where flow is diverted to the pump station when the storm water surface elevation exceeds the water surface elevation in the Duwamish River. Otherwise, the flow is discharged to the tide gate vault and to the Duwamish River.
   f. The flood control pumps discharge into a headbox where flow is gravity discharge to the outfall structure.
   g. The pump station has redundant level measurement devices LT-0110A and LT-0110B.
   h. The station generator can only run two of the four flood control pumps when there is a utility power outage.

4. Alarms:
   a. Each flood control pump has both pump and motor leak detection; a motor over temperature; and VFD FAULT.

5. Process Data Logging:
   a. Trend the run status of each flood control pump.
   b. Trend each flood control pump discharge flow.

6. Operation:
   a. General description:
      1) The flood control pumps empty the pump station wet well by pumping to a headbox which flows by gravity to the outfall structure.
      2) The control intent is to empty the pump station wet well as quickly as possible without overwhelming Diversion Structure and Outfall Structure.
      3) The generator is only able to run two of the four flood control pumps. Hardwired interlocks are present for local and remote operation to be limited to two pump operation while operating on generator power.
4) The following I/O will be used to control the pumps:
   a) Redundant level of water in the pump station wet well (LT-0110A/B).

b. Manual control functions:
   1) OIU: The pumps may be operated in manual for pumping out the wet well.
      a) Flood Control Pump Start
      b) Flood Control Pump Stop
      c) Flood Control Pump Speed

   2) PAC: None.

c. Automatic control functions:
   1) There are two automatic control functions- PAC and floats.
   2) The normal automatic control function is PAC control of the pumps. The following describes PAC pump operation:
      a) When the level in the pump station wet well measured by LT-0110A or B is above the lead pump on level, the lead pump shall start. If after an adjustable time period (initially set at 0 seconds) level in the wet well is above the Lag 1 Flood Control Pump Start Permissive Level, start Lag 1 Flood Control Pump. If after an adjustable time period (initially set at 0 seconds) level in the pump station is above the Lag 2 Flood Control Pump Start Permissive Level, start Lag 2 Flood Control Pump. If after an adjustable time period (initially set at 0 seconds) level in the pump station is above the Lag 3 Flood Control Pump Start Permissive Level, start Lag 3 Flood Control Pump. All pumps run at a fixed speed (initially set at 100%).

      b) When the level in the pump station wet well measured by LT-0110A or B is below the lag 3 pump off level, stop Lag 3 Flood Control Pump. If after an adjustable time period (initially set at 0 seconds) level in the wet well is below the Lag 2 Flood Control Pump Stop Permissive Level, stop Lag 2 Flood Control Pump. If after an adjustable time period (initially set at 0 seconds) level in the pump station is below the Lag 1 Flood Control Pump Stop Permissive Level, stop Lag 1 Flood Control Pump. If after an adjustable time period (initially set at 0 seconds) level in the pump station is below the lead flood control pump off level, stop Lead Flood Control Pump.
c) If the level transducer failed or the PAC failed, then there is a hardwired float system which is identified as AUTO LEVEL OVERRIDE. The operation of the pumps is controlled by the water level in the wet well (as measured by the floats). As the high level, all four pumps are started in a fixed staggered sequence of pumps 1, 2, 3, 4. As the level falls, the four pumps are stopped in a fixed sequence of pumps 4, 3, 2, 1. All pumps run at a fixed speed. The high high level float is outside of the normal level operation range of the pumps.

3) The call for pumps to start and stop as shown in the following table:

<table>
<thead>
<tr>
<th>Action</th>
<th>Comments</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSHH-0110 Alarm</td>
<td>If level is above this depth, all pumps start in Auto Level Override which is independent from PAC.</td>
<td>4.0 FT</td>
</tr>
<tr>
<td>LS3-0110 Alarm</td>
<td>If level is below this depth, flood control pump 4 stops in Auto Level Override which is independent from PAC.</td>
<td>1.5 FT</td>
</tr>
<tr>
<td>LS2-0110 Alarm</td>
<td>If level is below this depth, flood control pump 3 stops in Auto Level Override which is independent from PAC.</td>
<td>0.5 FT</td>
</tr>
<tr>
<td>LS1-0100 Alarm</td>
<td>If level is below this depth, flood control pump 2 stops in Auto Level Override which is independent from PAC.</td>
<td>-0.5 FT</td>
</tr>
<tr>
<td>High Level Alarm</td>
<td>PAC generates this alarm from the pressure transducer instruments, LT-0110A/B</td>
<td>3.0 FT</td>
</tr>
<tr>
<td></td>
<td>Reference: Maximum Water Surface (Nominal)</td>
<td>2.6 FT</td>
</tr>
<tr>
<td></td>
<td>Reference: Pump Station Inlet Pipeline Invert</td>
<td>-2.5 FT</td>
</tr>
<tr>
<td>Lead Flood Control Pump</td>
<td>If level is above this depth (Set Point for 0 seconds), start a Lead Flood Control Pump.</td>
<td>2.0 FT</td>
</tr>
<tr>
<td>Lead Flood Control Pump</td>
<td>If level is below this depth (Set Point for 0 seconds), stop a Lead Flood Control Pump.</td>
<td></td>
</tr>
<tr>
<td>Lag1 Flood Control Pump</td>
<td>If level is above this depth (Set Point for 0 seconds), start a Lag1 Flood Control Pump.</td>
<td>2.2 FT</td>
</tr>
<tr>
<td>Lag2 Flood Control Pump</td>
<td>If level is above this depth (Set Point for 0 seconds), start a Lag2 Flood Control Pump.</td>
<td>2.4 FT</td>
</tr>
<tr>
<td>Lag3 Flood Control Pump</td>
<td>If level is above this depth (Set Point for 0 seconds), start a Lag3 Flood Control Pump.</td>
<td>2.6 FT</td>
</tr>
<tr>
<td>Lag3 Flood Control Pump</td>
<td>If level is below this depth (Set Point for 0 seconds), stop a Lag3 Flood Control Pump.</td>
<td>1.5 FT</td>
</tr>
<tr>
<td>Lag2 Flood Control Pump</td>
<td>If level is below this depth (Set Point for 0 seconds), stop a Lag2 Flood Control Pump.</td>
<td>0.5 FT</td>
</tr>
<tr>
<td>Lag1 Flood Control Pump</td>
<td>If level is below this depth (Set Point for 0 seconds), stop a Lag1 Flood Control Pump.</td>
<td>-0.5 FT</td>
</tr>
<tr>
<td>Action</td>
<td>Comments</td>
<td>Elevation</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Pump Stop Permissive</td>
<td>a Lag1 Flood Control Pump.</td>
<td></td>
</tr>
<tr>
<td>Lead Flood Control Pump Stop Permissive</td>
<td>If level is below this depth (Set Point for 0 seconds), stop a Lead Flood Control Pump.</td>
<td>-1.5 FT</td>
</tr>
<tr>
<td></td>
<td>Reference: Top of Pump Station Wet Well</td>
<td>16.2 FT</td>
</tr>
<tr>
<td>Low Level Alarm</td>
<td>PAC generates this alarm from the pressure transducer instruments, LT-0110A/B</td>
<td>-2.0 FT</td>
</tr>
<tr>
<td></td>
<td>Reference: Bottom Pump Station Wet Well</td>
<td>-9.0 FT</td>
</tr>
<tr>
<td>LSSL-0110 Alarm</td>
<td>If level is below this depth, all pumps stop in both Hand and Auto mode which is independent from PAC.</td>
<td>-2.0 FT</td>
</tr>
<tr>
<td></td>
<td>Reference: Minimum water depth at which a pump may operate.</td>
<td>-5.0 FT</td>
</tr>
<tr>
<td></td>
<td>Reference: Bottom of Level Element stilling well.</td>
<td>-9.0 FT</td>
</tr>
</tbody>
</table>

b) All PAC action levels in the above table shall be operator adjustable.

c) If a pump fails, an alarm shall be activated, and the remaining pumps shall follow the sequence above as possible.

d) Process Control Interlocks:

1) The level in the pump station wet well must be greater than the lead pump on permissive level for the pumps to operate.

2) All flood control pumps will be turned off if the level of pump station wet well is the activation of LSSL-0110 set point.

3) Because the discharge flow meter only measure flows with a full pipeline occurring when the pump is running, and experiences empty pipe line when the pump is not running; the following interlocks at PAC shall be required:

a) Turn power ON to flow meter when associated pump is running.

b) Hold off recording flow measurements until the flow meter analog input has stabilized. Stabilization should occur once the pump is started, the pipeline has been filled and the flow transmitter has gone through its power up recycle procedure. Hold off time shall be adjustable from 10 to 120 seconds. Field tuning shall be required to determine the best hold off time value.

c) Hold off recording flow measurements when the associated pump is not running. The flow shall be reversed when the pump is stopped, and the discharge pipeline shall empty back into the pump station.
d) Turn power OFF to flow meter when associated pump is not running and the pump station level is below LSLL-0110 set point for an adjustable time period. This time period shall be set to avoid cycling the flow meter power ON/OFF while pump station is still receiving flow from the diversion structure. Field tuning shall be required to determine the best time value.

4) See Loop 018 for generator control interlock to prevent more than two pumps to run.

7. OIU Indication, Alarming and Operator Set Points:

a. OIU Display, typical of all four pumps:
   1) Flood Control Pump in AUTO.
   2) Flood Control Pump in HAND.
   3) OIU Auto/Manual/Out of Service (OOS).
   4) Running.
   5) Storage Tank Level, (LT-0110A/B)/ Maintenance Mode.
   6) Runtime current.
   7) Runtime rolling weekly total.
   8) Flood Control Pump flow current.
   9) Flood Control Pump flow rolling weekly total.
  10) Flood Control Pump speed current.
  11) Flood Control Pump Reset.
  12) Additional status as provided by digital data communications through Modbus with the VFD in the motor control center (MCC). Coordinate with MCC Vendor in Section 26 24 19, Motor Control Centers.

b. Alarms, typical of all four pumps:
   1) Flood Control Pump High Temp/Seal Leaks.
   2) Flood Control Pump VFD FAULT.
   3) Flood Control Pump Common FAULT. This alarm is described on Drawings I-03 through I-06 as Interlock Note I5.
   4) Flood Control Pump VFD outside of allowable (expected) range of speeds. Initially set at above 60 hz.
   5) Additional alarms as provided by digital data communications through Modbus with the VFD in the motor control center (MCC). Coordinate with MCC Vendor in Section 26 24 19.

c. Operator set points:
   1) Time delay permissive to initiate start pump operation.
   2) Time delay permissive to initiate stop pump operation.
3) Start level for each flood control pump.
4) Stop level for each flood control pump.
5) Operator must reset common FAULT at MCP-0100. LSHH-0110 shall automatically reset if LSLL-0110 tripped the common FAULT.

C. Loop 011B – Pump Station Isolation Gate
2. Key Elements:
   a. Pump Station Isolation Gate, SLG-0116
3. System Description:
   a. Pump station has a motorized non-modulating isolation slide gate with local operation. Network communication interconnect with PAC for monitoring.
   b. The isolation gate is used to take the pump station out of service by preventing flow from the diversion structure when the gate is in the closed position.
4. Alarms:
   a. Actuator FAULT.
   b. Digital data communication between the actuator and PAC provides alarm diagnostics associated with actuator FAULT.
5. Process Data Logging:
   a. The following points are logged to the process data historian through digital data communication:
      1) Pump station isolation gate open position.
      2) Pump station isolation gate close position.
6. Operations
   a. General Description: The gate is open and closed locally.
   b. Manual Control Functions:
      1) OIU:
         a) None.
      2) PAC:
         a) None.
      3) Local at Gate:
         a) Gate open control.
         b) Gate closed control.
c. Automatic Control Functions:
   1) OIU: None.
   2) PAC: None.

d. Process Control Interlocks:
   1) Actuator configured to fail in last position:
      a) On self-diagnostic FAULT condition.
      b) Power failure.

7. OIU Indication, Alarming and Operator Set Points:
   a. OIU Display:
      1) The following status as provided by digital data communications
         through Modbus:
         a) LOCAL/STOP.
         b) Gate position (0-100%).
         c) Gate in Transition.
         d) Gate torque.
         e) Gate full open status.
         f) Gate full close status.
      2) The actuator power disconnect switch open/close status. The
         disconnect switch discrete contact is closed when the disconnect
         switch in the field is closed.

   b. Alarms:
      1) Actuator FAULT.
      2) The following alarms as provided by digital data communications
         through Modbus:
         a) Gate Overtorque.
         b) Gate motor over temperature trip.
         c) Cause of Actuator FAULT

   c. Operator Set Points:
      1) None.

D. Loop 011C – Headbox Measurement
   1. P&ID Reference: I-06
   2. Key Elements:
      a. Headbox Level Measurement (digital indicator and level transducer),
         LI/LT-0110C.
3. **System Description:**
   a. The headbox has a level transducer as an analog input to PAC with local digital readout.

4. **Alarms:**
   a. High level WARNING provided through PAC output based upon the headbox level transducer LT-0110C. Default high level WARNING activate above EL 10.00.
   b. High level ALARM provided through PAC output based upon the headbox level transducer LT-0110C. Default high level ALARM to activate above EL 11.3.

5. **Process Data Logging:**
   a. The following points are logged to the process data historian:
      1) Headbox level transducer LT-0110C level signal.

6. **Operation:**
   a. **General Description:** There is no control associated with the headbox.
   b. **Manual Control Functions:**
      1) OIU: None.
      2) PAC: None.
   c. **Automatic Control Functions:**
      1) OIU: None.
      2) PAC: None.
   d. **Process Control Interlocks:**
      1) None.

7. **OIU Indication, Alarming and Operator Set Points:**
   a. **OIU Display:**
      1) Headbox level.
   b. **Alarms:**
      1) Headbox level WARNING.
      2) Headbox level ALARM.
   c. **Operator Set Points:**
      1) Headbox level WARNING.
      2) Headbox level ALARM.

E. **Loop 011D – Pump Station and Electrical Building: Heating, Ventilation and Air Conditioning**

1. **PID Reference:** I-05 and I-07.
2. Key Elements:
   a. Electrical room AC unit.
   b. Pump station supply and exhaust fans.
   c. Electrical Room Smoke Detector, SD-0166.
   d. Main Control Panel (MCP-0100) Temperature Transmitter, TIT-0100.

3. System description:
   a. The internal temperature of MCP-0100 is monitored.
   b. The AC unit operates continuous for temperature control in the electrical room.
   c. Ventilation is provided for the pump station. The supply and exhaust fans operate continually to provide fresh air exchange in the pump station.

4. Alarms:
   a. Pump station supply and/or exhaust fan not running is alarmed at the OIU as ventilation failure.
   b. High panel internal temperature is alarmed at the OIU.

5. Process data logging:
   a. Internal panel temperature.

6. Operation:
   a. General description:
      1) The pump station supply, and exhaust fans operate continually. Current switches in the MCC starter bucket provide feedback for running status.
      2) The electrical room HVAC operates automatically for temperature control.
   b. Manual control functions:
      1) PAC: None.
      2) When the ON/OFF control switches for supply air fan FAN-0160 and exhaust fan FAN-0161 for the pump station are in the ON position, the fans shall operate continually.
      3) The HVAC unit for the electrical room will come with integral temperature control.
   c. Automatic control functions:
      1) None.
   d. Process control interlocks:
      1) None.
7. OIU indication, alarming and operator set points:
   a. OIU Display:
      1) Pump room station supply air fan running.
      2) Pump room station exhaust air fan running.
      3) The fan power disconnect switch open/close status. The disconnect switch discrete contact is closed when the disconnect switch in the field is closed.
      4) Internal main control panel temperature.
   b. Alarms:
      1) An alarm shall be displayed on the OIU if fans not running in the pump station.
      2) An alarm shall be displayed on the OIU if the internal panel temperature exceeds 95 degree Fahrenheit.
   c. Operator Set Points:
      1) None.

F. Loop 012 – Diversion Structure Measurement
   1. P&ID Reference: I-02
   2. Key Elements:
      a. Diversion Structure Level Measurement (digital indicator, level transducer, and staff gauge), LI/LT-0120; GA-0120.
   3. System Description:
      a. The diversion structure has a level transducer as an analog input to PAC with local digital readout. There is also a staff gauge mounted along the inside wall of the diversion structure to assist in calibrating the level transducer.
   4. Alarms:
      a. High level WARNING provided through PAC output based upon the diversion structure level transducer LT-0120. Default high level WARNING to activate above EL 4.00.
      b. High level ALARM provided through PAC output based upon the diversion structure level transducer LT-0120. Default high level WARNING to activate above EL 5.00.
   5. Process Data Logging:
      a. The following points are logged to the process data historian:
         1) Diversion structure level transducer LT-0120 level signal.
   6. Operation:
      a. General Description: There is no control associated with the diversion structure.
b.  Manual Control Functions:
   1)  OIU: None.
   2)  PAC: None.

c.  Automatic Control Functions:
   1)  OIU: None.
   2)  PAC: None.

d.  Process Control Interlocks:
   1)  None.

7.  OIU Indication, Alarming and Operator Set Points:

a.  OIU Display:
   1)  Diversion structure level.

b.  Alarms:
   1)  Diversion structure level WARNING.
   2)  Diversion structure level ALARM.

c.  Operator Set Points:
   1)  Diversion structure level WARNING.
   2)  Diversion structure level ALARM.

G.  Loop 013 - Bar Screen
   1.  System Description: A bar screen is located in the incoming pipeline to the pump station to prevent large debris from entering into the pump station. The bar screen is a mechanical device with no electrical controls. Bar screen is manually cleaned. No control description provided.

H.  Loop 014 - Tide Gate Vault: Measurement
   2.  Key Elements:
      a.  Tide Gate Vault Check Valve, VLV-0141.
      b.  Tide Gate Vault Level Measurement (digital indicator, level transducer and staff gauge), LI/LT-0142; GA-0142.

   3.  System Description:
      a.  The tide gate vault has a tide gate check valve which prevents the Duwamish River from back flowing into the pump station.
      b.  The tide gate vault has a level transducer as an analog input to PAC with local digital readout. There is also a staff gauge mounted along the inside wall of the vault to assist in calibrating the level transducer.
4. Alarms:
   a. High level WARNING provided through PAC output based upon the tide gate vault level transducer LT-0142. Default high level WARNING to activate above EL 0.00.
   b. High level ALARM provided through PAC output based upon the tide gate vault level transducer LT-0142. Default high level ALARM to activate above EL -0.50.

5. Process Data Logging:
   a. The following points are logged to the process data historian:
      1) Tide gate vault level transducer LT-0142 level signal.

6. Operation:
   a. General Description: There is no control associated with the tide gate vault.
   b. Manual Control Functions:
      1) OIU: None.
      2) PAC: None.
   c. Automatic Control Functions:
      1) OIU: None.
      2) PAC: None.
   d. Process Control Interlocks:
      1) None.

7. OIU Indication, Alarming and Operator Set Points:
   a. OIU Display:
      1) Tide gate vault level.
   b. Alarms:
      1) Tide gate vault level WARNING.
      2) Tide gate vault level ALARM.
   c. Operator Set Points:
      1) Tide gate vault level WARNING.
      2) Tide gate vault level ALARM.

I. Loop 019: Facility Intrusion:
   1. P&ID Reference: I-07
   2. Key Elements:
      a. Pump station hatch door, electrical building entry doors and main control panel doors limit switches.
      b. Switches wired NO and contacts close when hatch or door is closed.
c. If there is more than one switch in any one location, then wire in series for a single alarm input for that location.

3. System description:
   a. Monitor for intrusion.

4. Alarms:
   a. Alarm intrusion at SCADA.

5. Process data logging:
   a. None.

6. Operation:
   a. General Description:
      1) Monitor and alarm intrusion.
   b. Manual Control Functions:
      1) OIU: None.
      2) PAC: None.
   c. Automatic Control Functions:
      1) Alarm will be sent to SCADA.
      2) Alarm will be sent to Security Panel SP-0102.
   d. Process Control Interlocks:
      1) None.

7. OIU Indication, Alarming and Operator Set Points:
   a. OIU Display:
      1) None.
   b. Alarms:
      1) Intrusion Main Control Panel, ZS-0100.
      2) Intrusion Electrical Room, ZS-0118A, ZS-0118B.
      3) Intrusion Pump Station Hatch, ZS-0118.
   c. Operator Set Points:
      1) None.

J. Loop 010 – Main Control Cabinet Power:
   1. P&ID Reference: I-07
   2. Key Elements:
      a. 24 VDC Uninterruptible Power Supply, UPS-0100.
   3. System Description:
      a. Monitor DC UPS power supply inside main control panel (MCP-0100).
      b. Monitor battery system operation.
4. Process data logging:
   a. DC battery voltage from DC UPS-0100.

5. Operation:
   a. General Description:
      1) Monitor DC power systems.
   b. Manual Control Functions:
      1) OIU: None.
      2) PAC: None.
   c. Automatic Control Functions:
      1) None.
   d. Process Control Interlocks:
      1) None.

6. OIU Indication, Alarming and Operator Set Points:
   a. OIU Display:
      1) DCUPS, Battery Voltage.
      2) DCUPS, Replace Battery.
      3) DCUPS, Buffering.
      4) DCUPS, Ready.
   b. Alarms:
      1) DCUPS:
         a) Replace Battery.
   c. Operator Set Points: None.

K. Loop 018 – Generator, ATS, and MCC Power:

1. P&ID Reference: I-07

2. Key Elements:
   a. Generator, GEN-0184.
   b. Auto Transfer Switch, ATS-0185.
   c. Motor Control Center, MCC-0186 Power Monitor.

3. System Description:
   a. Monitor generator operation through a digital communication bus network with discrete outputs for generator in AUTO and low fuel.
   b. Monitor ATS through a digital communication bus network with discrete output contacts for load connection indication for both utility/normal and generator and loss of utility power; and discrete input contact for generator exercise.
c. Monitor MCC power monitor through a digital communication bus network with analog output for power and a discrete output for power loss.

4. Process data logging:
   a. SPU standard power usage data logging.

5. Operation:
   a. General Description:
      1) Monitor generator.
      2) Monitor station power meter.
      3) Monitor ATS.
   b. Manual Control Functions:
      1) OIU/PAC: Exercise Generator per SPU standard procedure.
   c. Automatic Control Functions:
      1) OIU/PAC: Exercise Generator per SPU standard procedure.
   d. Process Control Interlocks:
      1) When station connection load on generator, two of the four pumps in Loop 011A operate. Select at MCP-0100 the two pumps for operation on generator as Pump A and Pump B. Only the two pumps selected can start and stop whether run locally or remotely. When the Pump A and Pump B selectors are in the same position (selecting the same pump to operate on the generator), alarm Generator Pump Duplicate Selection.

6. OIU Indication, Alarming and Operator Set Points:
   a. OIU Display:
      1) Generator:
         a) Runtime current.
         b) Runtime rolling weekly total.
         c) In AUTO.
      2) ATS on Utility/Normal.
      3) ATS on Generator.
      4) Generator Pump A Selection as 1, 2, 3 or 4.
      5) Generator Pump B Selection as 1, 2, 3 or 4.
      6) Station power.
   b. Alarms:
      1) ATS loss of utility power.
      2) Generator low fuel.
      3) MCC loss of power.
      4) Digital communication loss with ATS.
5) Digital communication loss with Generator.
6) Digital communication loss with Power Monitor.
7) Generator duplicate pump selection.

7. Operator Set Points: None.

3.02 FIELD QUALITY CONTROL

A. Terminate input/output (IO) points in accordance with MCP-0100 I/O SCHEDULE located at the end of this Specification Section. I/O Schedule may not be complete, use spare I/O points as required.

END OF SECTION 40 90 05
## MCP-0100 PAC I/O Schedule

<table>
<thead>
<tr>
<th>EQUIP NO.</th>
<th>DESCRIPTION 1</th>
<th>DESCRIPTION 2</th>
<th>I/O TYPE</th>
<th>SLOT</th>
<th>CHANNEL</th>
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PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Level Components and Accessories.
   2. Flow Components.
   3. Intrusion Switches.
   4. Accessories.
B. Related Sections include but are not necessarily limited to:
   1. Division 00.
   2. Division 01.
   3. Section 40 90 00.
   4. Section 40 90 05.
   5. Section 40 98 00.

1.02 REFERENCES
A. Referenced Standards:
   1. American Iron and Steel Institute (AISI).
   3. American Society of Mechanical Engineers (ASME):
      b. B31.1, Power Piping.
      c. PTC 19.3, Instruments and Apparatus, Part 3 Temperature Measurement.
      e. Section II, Part A SA-182,Forged or Rolled Alloy Steel Pipe Flanges,
         Forged Fittings, and Valves and Parts for High-Temperature Service.
      f. Section II, Part A. SA-479, Stainless Steel Bars and Shapes for Use in
         Boilers and Other Pressure Vessels.
   4. ASTM International (ASTM):
      a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges,
         and Pipe Fittings.
      b. A182, Standard Specification for Forged or Rolled Alloy and Stainless
         Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-
         Temperature Service.
   5. Federal Communications Commission (FCC):
6. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

7. US Department of Interior Bureau of Reclamation (USDIBR):

1.03 DEFINITIONS

1.04 SYSTEM DESCRIPTION

A. The instruments specified in this Specification Section are the primary element components and accessories shown on the Drawings and as required for a complete installation:
   1. These instruments are integrated with other control system components specified under Section 40 90 00: Basic Requirements series to produce the functional control defined in the Contract Documents.

1.05 SUBMITTALS

A. Shop Drawings:
   1. See Section 01 33 10 for requirements for the submittal process.
   2. See Section 40 90 00 for I&C requirements for the submittal process.

B. Operation and Maintenance Manuals:
   1. See Section 01 33 10 for requirements for the submittal process:
      a. The mechanics and administration of the submittal process.
   2. See Section 00 72 00 for the content of the Project Operation and Maintenance Manual.
   3. See Section 01 77 19 for closeout requirements.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the
B. Articles describing the elements are acceptable.
C. Submit request for substitution in accordance with Section 01 33 10.

2.02 LEVEL COMPONENTS AND ACCESSORIES

A. Submersible Pressure Sensor and Transmitter:
   1. Acceptable Manufacturers:
      b. No equal, to match Owner’s standard.
2. Materials:
   b. Sensing diaphragm: Elastomeric, Teflon coated.
   c. Cable: Polyurethane strengthened with Kevlar.

3. Design and fabrication:
   a. Submersible pressure transmitter with a piezoresistive-micromachined silicon strain gauge type sensor.
   b. Flush polytetrafluoroethylene-coated elastomeric diaphragm.
   c. Pressure port with flush, polytetrafluoroethylene-coated elastomeric diaphragm and fluid fill to reduce grease or biosolids buildup.
   d. In addition to electrical conductors, the sensor support cable contains a tube which is vented to atmosphere to offset changes in barometric pressure.
   e. Provide sensor termination enclosure with micro filter assembly to permit barometric reference, and a replaceable desiccant module to keep vent tube free from moisture.
   f. Operating range: sufficient to handle scale shown in schedule below.
   g. Four times overpressure protection.
   h. Loop-powered (2-wire) device with 4-20 mA DC output and 9-32 VDC excitation.
   i. Continuous cable to control cabinet (no splices) including spare length coiled in the field, no exceptions.
   j. Accuracy: +/- .25 percent of full scale.
   k. Temperature effects: +/- 1.5 percent of full scale.
   l. Relative humidity: 0 to 100 percent.
   m. Operating temperature range: -5 to 140 Deg F.
   o. UL listed: Intrinsically safe for Class I, Division 1 installation.
   p. Coordinate final scale range with Engineer and SPU following sensor installation.
   q. Lightning/Surge Protection: Provide internal unit, factory installed for outdoor installations and the external unit as required by product manufacturer certification drawings.

4. Mounting:
   a. KPSI 750: See detail in contract drawings.
   b. Minimum of 10-feet of spare cable shall be coiled and secured inside each maintenance hole (or Storage Tank Hatch) to facilitate easy removal of instrument for maintenance. Continuous cable to control cabinet (no splices, no exception).
5. Schedule:

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Service</th>
<th>Range (PSI)</th>
<th>Type</th>
<th>Mount</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT-0110A</td>
<td>Pump Station Level A</td>
<td>0 – 10</td>
<td>KPSI 750</td>
<td>See above, 0 ft @ EL -9.0 ft</td>
</tr>
<tr>
<td>LT-0110B</td>
<td>Pump Station Level B</td>
<td>0 – 10</td>
<td>KPSI 750</td>
<td>See above, 0 ft @ EL -9.0 ft</td>
</tr>
<tr>
<td>LT-0110C</td>
<td>Headbox Level</td>
<td>0-10</td>
<td>KPSI 750</td>
<td>See above, 0 ft @ EL 4.35 ft</td>
</tr>
<tr>
<td>LT-0120</td>
<td>Diversion Structure Level</td>
<td>0 – 10</td>
<td>KPSI 750</td>
<td>See above, 0 ft @ EL -5.0 ft</td>
</tr>
<tr>
<td>LT-0142</td>
<td>Tide Gate Vault Level</td>
<td>0 – 10</td>
<td>KPSI 750</td>
<td>See above, 0 ft @ EL -5.0 ft</td>
</tr>
</tbody>
</table>

B. Float-Tilt Type Level Switches:

1. Acceptable manufacturers:
   a. Siemens Water Technologies/Consolidated Electric.
   b. MJK North America, Model 7030.
   c. Anchor Scientific Inc.
   d. Or approved substitute.

2. Materials:
   a. Float material: Polypropylene or Teflon coated type 316 stainless steel.
   b. Cable jacket: PVC or neoprene.
   c. Cable clamp: Polypropylene or 316 stainless steel.
   d. Blind flange: PVC, tapped for cable grommet to secure at set point elevation; fasteners shall be 316 SST (nuts, washers and lock washers) for a complete installation.

3. Design and fabrication:
   a. Sealed mercury-free switch in float.
   b. Break resistant cable.
   c. Provide switch complete with flexible electrical cables.
   d. SPDT contact rated at 0.5 amps at 24 Vdc.
   e. Direct acting float switch:
      1) Switch actuates, contact opens on rising level.
      2) Switch deactivates when liquid falls 1-inch below actuation level.
   f. Terminate cables in junction box.
   g. Install floats per Drawing details and as noted in this Specification Section.
h. Provide SST or non-corrosive mounting hardware as required for installation.

i. Suitable for Installation in Class I, Division 2 (Hermetically sealed).

4. Mounting:
   a. Minimum of 10-feet of spare cable shall be coiled and secured inside each maintenance hole (or Storage Tank Hatch) to facilitate easy removal of instrument for maintenance. Continuous cable to control cabinet (no splices, no exception).
   b. Field verify all elevation settings.

5. Schedule:

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Service</th>
<th>Contact</th>
<th>Set Point 0 ft @ EL -9.0 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSHH-0110</td>
<td>Pump Station - Auto Level Override (Start All Pumps)</td>
<td>SPDT</td>
<td>13 ft (rising)</td>
</tr>
<tr>
<td>LS1-0110</td>
<td>Pump Station - Auto Level Override (Stop Pump 2)</td>
<td>SPDT</td>
<td>8.5 ft (falling)</td>
</tr>
<tr>
<td>LS2-0110</td>
<td>Pump Station - Auto Level Override (Stop Pump 3)</td>
<td>SPDT</td>
<td>9.5 ft (falling)</td>
</tr>
<tr>
<td>LS3-0110</td>
<td>Pump Station - Auto Level Override (Stop Pump 4)</td>
<td>SPDT</td>
<td>10.5 ft (falling)</td>
</tr>
<tr>
<td>LSLL-0110</td>
<td>Pump Station - Auto Level Override (Stop All Pumps)</td>
<td>SPDT</td>
<td>7.0 ft (falling)</td>
</tr>
</tbody>
</table>

C. Staff Gauges:

1. Acceptable manufacturers:
   a. Stevens Water Monitoring Systems, Inc.
   b. Or approved substitute.

2. Requirements:
   a. Style: C (graduations every 100th of a foot with numerical marks every ft. and every tenth of a ft) with white background and black markings.
   b. Gauge Material: 16 gage enameled iron or steel, completely covered with a baked-on porcelain enamel finish to resist rust or discoloration.
   c. Fastening Material: Stainless steel.

3. Schedule:

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Service</th>
<th>Range (FT)</th>
<th>Mount</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA-0110</td>
<td>Pump Station Level</td>
<td>25</td>
<td>Wall</td>
</tr>
<tr>
<td>GA-0120</td>
<td>Diversion Structure Level</td>
<td>15</td>
<td>Wall</td>
</tr>
<tr>
<td>GA-0142</td>
<td>Tide Gate Vault Level</td>
<td>10</td>
<td>Wall</td>
</tr>
</tbody>
</table>
2.03 FLOW COMPONENTS

A. Magnetic Flow Meter:
   1. Acceptable manufacturers:
      a. Toshiba, Mount Anywhere
      b. Or approved substitute.
   2. General:
      a. Flow Meter to consist of a flow tube with separate or integral converter /
         indicating transmitter, as scheduled. System shall have no moving parts.
      b. UL/FM listed: Class I, Division 2.
      c. Meter must require minimal strait run for accuracy specified; one diameter
         upstream and zero diameter downstream.
   3. Sensing Element:
      a. Flow tubes manufacturer shall provide grounding rings fabricated from the
         same metal as for the electrodes below.
      b. Electrodes shall be 316L stainless steel.
      c. Liner shall be hard rubber or polyurethane.
      d. Flow tube shall be IP68 and NEMA 6P submersible type.
      e. Flange mounted connection using standard ASME B16.5 class 150 flange
         (18" meter) or AWWA class D flange (42" meter).
      f. Fluid conductivity: 5 µS/cm minimum.
      g. Fluid temperature: 14 to 140 deg F.
      h. Ambient temperature: 14 to 140 deg F.
   4. Sensor Connecting Cable:
      a. Provide signal cable between the flow tube and transmitter provided by
         the system manufacturer with sufficient length of cable for continuous
         installation between the flow tube and the transmitter.
   5. Transmitter:
      a. Flow measurement accuracy shall be <0.5% of flow rate.
      b. Transmitter shall be 24 VDC powered with surge protection in the power
         supply and the analog output signal.
      c. The transmitter shall have means to calibrate the metering system without
         use of external calibration units, self-diagnostics and certificate of actual
         flow lab certification provided with each flow tube.
      d. Integral 4-digit LCD flow indication calibrated in process units. Data
         retained in non-volatile memory.
      e. Analog signal: 4-20mA current output proportional to process flow rate.
      f. Communications output: standard HART protocol.
6. Schedule:

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Service</th>
<th>Range (GPM)</th>
<th>Meter Size (IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FE/FIT-0111</td>
<td>Pump Station- Pump 1</td>
<td>0-8500</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Discharge Flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FE/FIT-0112</td>
<td>Pump Station- Pump 2</td>
<td>0-8500</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Discharge Flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FE/FIT-0113</td>
<td>Pump Station- Pump 3</td>
<td>0-8500</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Discharge Flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FE/FIT-0114</td>
<td>Pump Station- Pump 4</td>
<td>0-8500</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Discharge Flow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.04 INTRUSION SWITCHES

A. Magnetic Reed Switch:

1. Acceptable manufacturers and models:
   b. Or approved substitute.

2. Hermetically sealed reed switch for installation on metal doors and access hatches for intrusion alarm detection.

3. Switch shall consist of industrial wide gap magnetic contacts surface mounted on doors or hatches.

4. Prevent stick or freezing between the two switch plates that form the magnetic field.

5. Contact: Aluminum housing armored cable contact, Form C, DPDT, 30Vdc, 0.25A, 3.0W maximum. Designate one contact for SCADA and the other contact for Security.

6. UL listed.

7. Weather resistant housing.

8. Schedule:

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZS-0118</td>
<td>Pump Station Hatch Door</td>
</tr>
<tr>
<td>ZS-0118A</td>
<td>Electrical Building Entry Door</td>
</tr>
<tr>
<td>ZS-0118B</td>
<td>Electrical Building Entry Door</td>
</tr>
</tbody>
</table>

2.05 ACCESSORIES

A. Furnish all mounting brackets, expansion rings, hardware and appurtenances required for mounting primary elements and transmitters:

1. Materials, unless otherwise specified, shall be as follows:
b. Mounting brackets and expansion rings:
   1) Standard: 316 stainless steel.
   2) Highly corrosive areas: Aluminum.

c. Mounting plates, angles:
   1) Standard: Stainless steel.
   2) Corrosive areas: 316 stainless steel.

B. Provide handheld HART communicator compatible with all transmitters furnished:
   1. Acceptable manufacturers:
      a. Fluke Model 154 HART Communicator.
      b. Or approved substitute.
   2. Hand held communicator shall provide capability to check calibration, change transmitter range, and provide diagnostics.
   3. If these features are not provided with the transmitter, the hand held communicator is not required.

C. Cable lengths between sensors and transmitters shall be continuous (without splices) and as required to accommodate locations as shown on Drawings and by the installation, no exceptions.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install instrument mounting level and plumb.

C. Locate instrument so as to be free of vibration and interference with other piping, conduit, or equipment.

D. Keep foreign matter out of the system.

E. Plug all open ends and connections to keep out contaminants.

F. Threaded Connection Seals:
   1. Use Tite-Seal or acceptable alternate.
   2. Use of lead base pipe dope or Teflon tape is not acceptable.
   3. Do not apply Tite-Seal to tubing threads of compression fittings.

G. Instrument Mounting:
   1. Mount all instruments where they will be accessible from fixed ladders, platforms, or grade wherever possible.
   2. Mount all meter transmitters so the display is readable and accessible without the use of ladders or special equipment.
   3. Mount all local indicating instruments with face forward toward the normal operating or access area, within reading distance, and in the line of sight.
4. Mount instruments level, plumb, and support rigidly.
5. Mount to provide:
   a. Protection from heat, shock, and vibrations.
   b. Accessibility for maintenance.
   c. Freedom from interference with piping, conduit and equipment.

H. Cable:
   1. Provide ten (10) feet minimum spare length of neatly coiled cable near instrument for each sensor or transmitter.
   2. Do not cut or trim factory cable ends if the cables are too long. Cable ends are sealed to prevent moisture.

I. Grounding: Provide instrument grounding per manufacturer’s instructions.

3.02 TRAINING

A. Provide on-site training in accordance with Section 01 75 00.

B. In addition to the training requirements in Section 01 75 00, training for primary elements shall, at the minimum, include the following:
   1. Transmitter programming and configuration.
   2. Calibration.
   3. Desiccant maintenance (Submersible Pressure Sensor and Transmitter).
   4. Importance of non kinking sensor cable (Submersible Pressure Sensor and Transmitter).

END OF SECTION 40 91 10
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Programmable automation controller (PAC) control system(s), excluding software, programming, and training.
B. Related Sections include but are not necessarily limited to:
   1. Division 00.
   2. Division 01.
   3. **Section 26 05 19**.
   4. **Section 40 90 00**.
   5. **Section 40 90 05**.
   6. **Section 40 97 00**.
   7. **Section 40 98 00**.

1.02 REFERENCES
A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      b. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   2. National Electrical Manufacturers Association (NEMA):
      a. ICS 1, General Standards for Industrial Control and Systems.

1.03 DEFINITIONS
(NOT USED)

1.04 QUALITY ASSURANCE
A. Qualifications:
   1. Installation supervisor shall have had experience in overseeing installation and startup of at least three (3) similar installations.

1.05 SUBMITTALS
A. Shop Drawings:
   1. See **Section 01 33 10** for requirements for the submittal process.
   2. See **Section 40 90 00** for I&C basic requirements.
   3. Product technical data including:
      a. Results of factory testing procedures.
b. Drawings containing the following information to be submitted as part of Section 40 98 00 submittals:
   1) Arrangement drawings for PAC system components.
   2) Panel and enclosure plans, sections and details.
   3) Access opening locations and required clearances for each panel and enclosure.
   4) Enclosure internal wiring and terminal blocks.

c. Catalog cut sheets containing information on PAC components to be submitted as part of this Specification Section submittal(s).

4. Certifications:
   a. Qualifications of installation supervisor.

B. Operation and Maintenance Manuals:
   1. See Section 01 33 10 for requirements for the submittal process.
   2. See Section 00 72 00 for the content of the Project Operation and Maintenance Manual.
   3. Submit maintenance procedures available SPU.
      a. Include the location and phone numbers of service centers (including 24 HR "hot lines").
      b. Provide specific information including operation and maintenance requirements, troubleshooting guide, parts ordering, field service personnel requests, and service contracts.
   4. See Section 01 77 19 for closeout detail.

1.06 SYSTEM DESCRIPTION
A. The contractor is responsible for providing PAC control system hardware (devices, components, accessories, all physical entities, etc.). SPU will provide software, programming, and training for the PAC control system.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Opto 22 Programmable Automation Controller (PAC), SNAP-PAC-S1 with SNAP-PSDIN din rail mount, and rack-mounted Ethernet communications I/O processor, SNAP-PAC-EB1 Ethernet Brain.
   2. No like, equivalent, or substitute item is acceptable.

2.02 PERFORMANCE AND DESIGN REQUIREMENTS
A. See Section 40 90 00.
B. The PAC system shall accomplish the control requirements of the loop descriptions, Drawings, and Specifications.
C. The PAC system shall operate in ambient conditions of -20 to 60 Deg C temperature and
D. 5 to 95 percent relative humidity without the need for purging or air conditioning.

E. All PAC control system components shall be capable of meeting or exceeding electromagnetic interference tests per IEEE C37.90.2.

F. The PAC system shall be capable of the following minimum safety measures:
   1. Watchdog function to monitor:
      a. Internal processor clock failure.
      b. Processor memory failure.
      c. Loss of communication between processor and I/O modules.
      d. Processor ceases to execute logic program.
   2. Safety function wiring: Emergency shutdown switches shall not be wired into the controller.
   3. Safe wiring:
      a. Unless otherwise specified, activation of alarms and stopping of equipment shall result from the de-energization of control circuits, rather than the energization of control circuits.
      b. Low voltage control signal wires:
         1) Place in conduit segregated for that purpose only.
         2) Twisted shielded wire pair.
         3) Not located in the same conduit or bundle with power wiring.
   4. Initial safety conditions:
      a. Utilize program module to dictate output states in a known and safe manner prior to running of control program.
      b. Utilize program each time PAC is re-initiated, and the control program activated.
   5. Monitoring of internal faults and display:
      a. Internal PAC system status and faults shall be monitored and displayed:
         1) Monitored items shall include:
            a) Memory ok/loss of memory.
            b) Processor ok/processor fault.
            c) Scan time overrun.
   6. Control of programs: Protect access to PAC program loading with password protection or with locked, key operated selector switches.
   7. Design PAC system with high noise immunity to prevent occurrence of false logic signals resulting from switching transients, relay and circuit breaker noise or conducted and radiated radio frequency interference.
8. Operator intervention:
   a. Logic system failure shall not preclude proper operator intervention.
   b. Safety shutdown of equipment or a system shall require manual operator intervention before the equipment or system operation may be reestablished.

2.03 COMPONENTS

A. PAC System Central Processor Unit (CPU):
   1. CPU shall provide communications with other control systems and human-machine interfaces via Modbus communications protocol, no exception.
   2. Memory:
      a. Battery-backed RAM.
      b. EEPROM program back-up:
         1) Automatically download to RAM in the event RAM is corrupted.
   3. Memory battery backup shall be capable of 60 days memory retention with fresh battery.
      a. Provide visual indication of battery status and alarm low battery voltage.
      b. Memory battery backup shall be capable of 14 days memory retention after the "Battery Low" indicating LED is on.
   4. Plug-in card design to allow quick field replacement of faulty devices:
      a. Provide unit designed for field replacement and expansion of memory without requiring rewiring or use of special tools.
   5. 20 percent minimum spare useable memory capacity after all required programming is in place and operating.
   6. Capable of executing all control functions required by the Specifications and Drawings.
   7. Built-in three-mode (proportional-integral-derivative) control capabilities:
      a. As directly selectable algorithms requiring no user knowledge of programming languages.
   8. On-line reconfigurable.
   9. Lighted status indicators for "RUN" and "FAILURE."
   10. Capable of manual or automatic control mode transfer from the operating console stations or from within the control strategy:
        a. Transfer shall be bumpless and balanceless.

B. Input/output (I/O) Modules:
   1. Provide plug-in modular-type I/O with cables to connect to all other required PAC system components.
   2. Provide I/O system with:
      a. Ethernet-based analog, digital, and serial I/O and communications processor
      b. I/O solid state boards with status lights indicating I/O status.
c. Electric isolation between logic and field device.
d. Capability of withstanding low energy common mode transient to 1000 V without failure.
e. Incorporate noise suppression design.
f. Capable of meeting or exceeding electrical noise tests, NEMA ICS 1-109.60-109.66.
g. Capable of being removed and inserted into the I/O rack under power, without affecting any other I/O modules in the rack.
h. Install sufficient modules to provide the PAC with 20 percent spare I/O points.

3. Input/output connection requirements:
a. Make connections to I/O subsystem by terminating all field wiring on terminal blocks within the I/O enclosure.
b. Provide each I/O module with a color-coded multi-conductor cable of appropriate length with a pre-terminated connector. Terminate these wires to the terminal blocks.
c. Provide terminal blocks with continuous marking strip.
d. Size terminals to accommodate all active data base points and spares.
e. Provide terminals for individual termination of each signal shield.
f. Field wiring shall not be disturbed when removing or replacing an I/O module.

4. Discrete I/O modules:
a. Interface to ON/OFF devices.
b. I/O status indicator on module front.
c. Voltage rating to match circuit voltage.
d. Output module current rating:
   1) Match maximum circuit current draw.
   2) Minimum 1.0 continuous A/point for 120 Vac applications.
e. Isolated modules for applications where one (1) module interfaces with devices utilizing different sources of power.

5. Discrete inputs:
a. SNAP-IDC-32:
b. See Schedule for minimum quantities.

6. Discrete outputs:
a. SNAP-ODC-32-SRC:
b. See Schedule for minimum quantities.
c. Provide one (1) fuse per common or per isolated output.
d. Provide blown fuse indication.
e. Provide external fusing at the device being controlled.
f. Fuses provided external to output model shall be in accordance with module manufacturer's specifications.

7. Analog I/O modules:
   a. Analog Input:
      1) SNAP-ALMA-8 (Single-Ended Inputs).
      2) SNAP-AIV2i (for battery voltage monitoring).
      3) See Schedule for minimum quantities.
   b. Analog Output:
      1) SNAP-AOA-23-ISRC.
      2) See Schedule for minimum quantities.
   c. Input modules to accept signals indicated on Drawings or Specifications.
   d. Minimum 12 bit resolution.
   e. I/O chassis supplied power for powering connected field devices.
   f. Provide isolated analog inputs, either per input or per group of four inputs. May use separate I/O isolators for applications with small PAC's having less than four analog inputs.
   g. User configurable for desired fault-response state.
   h. Provide output signals as indicated on Drawings and Specifications.
   i. Individual D/A converter for each output module.
   j. Individual A/D converter for each input module.

C. Communication Modules:
   1. Modbus Network Communication Modules:
      a. SNAP-SCM-232.
      b. SNAP-SCM-485-422.
      c. See Schedule for minimum quantities.

2. Modbus Network Communication Gateway: See Section 40 97 00.

D. PAC power supply:
   1. SNAP-PS5-24VDC.
   2. See Schedule for minimum quantities.

E. SNAP Breakout Boards:
   1. Provide interface modules as specified herein for terminating field wiring to the I/O subsystem. Provide modules with system cables and front adapters.
   2. Discrete Inputs:
3. Discrete Outputs:
   a. SNAP-ODC-HDB with 6-ft header cable, SNAP-HD-BF6.
4. See schedule for minimum quantities.

F. PAC System Enclosure:
1. In accordance with Section 40 98 00.
2. Component placement:
   a. Mount all controller components within the enclosure to allow maximum convection cooling.
   b. Either install power supplies above all other equipment with at least 10 IN of clearance between the power supply and the enclosure top, or adjacent to other components, but with sufficient spacing for circulation of cooling air.
   c. Do not place I/O racks directly above the CPU or power supply.
   d. Locate incoming line devices (isolation or constant voltage transformers, local power disconnects, surge suppressors, etc.) so as to keep power wire runs within an enclosure as short as possible.
   e. Place circulating fans close to major heat generating devices.
   f. Segregate input/output modules into groups of identical type.
3. Wiring and grounding to be in accordance with Section 40 98 00.
4. Termination requirements:
   a. In accordance with Section 40 98 00.
   b. Make connections to I/O subsystem by terminating all field wiring on terminal blocks within the enclosure.
   c. Provide each I/O module with a color-coded multi-conductor cable of appropriate length with a pre-terminated connector. Terminate these wires to the terminal blocks.
   d. Size terminals to accommodate all active database points and spares.
   e. Provide terminals for individual termination of each signal shield.
   f. Field wiring shall not be disturbed when removing or replacing an I/O module.

G. PAC System Software and Programming:
1. SPU will provide programming software and application programming.
2. SPU will provide all application programming to accomplish all control and monitoring requirements of the Drawings and Specifications.
2.04 SCHEDULE
A. Provide the following PAC Installed Parts and Quantities:

<table>
<thead>
<tr>
<th>Description</th>
<th>PAC Model No.</th>
<th>MCP-0100</th>
<th>Spares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backplane (16-slot)</td>
<td>SNAP-PAC-RCK16</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>Power Supply Module</td>
<td>SNAP-PS5-24DC</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CPU Module</td>
<td>SNAP-PAC-S1</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>I/O processor/Ethernet Brain</td>
<td>SNAP-PAC-EB1</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>32-Point Discrete Input</td>
<td>SNAP-IDC-32</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>32-Point Discrete Output</td>
<td>SNAP-ODC-32-SRC</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8-Point Analog Input</td>
<td>SNAP-AIMA-8</td>
<td>3</td>
<td>1</td>
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<td>2-Point Analog Output</td>
<td>SNAP-AOA-23iSRC</td>
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<td>Modbus Network Module</td>
<td>SNAP-SCM-485-422</td>
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<tr>
<td>SNAP Breakout Boards (see note)</td>
<td>SNAP-IDC-HDB</td>
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<td>--</td>
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<td>SNAP-ODC-HDB</td>
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<tr>
<td>Breakout Board Cable</td>
<td>SNAP-HD-BF6</td>
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<tr>
<td>SNAP-PAC-S1 DIN Rail Mount</td>
<td>SNAO-PSDIN</td>
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</tr>
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NOTE: Maximum wire size on SNAP Breakout Boards is 18 AWG.

2.05 ACCESSORIES
A. Provide all accessories required to furnish a complete PAC control system to accomplish the requirements of the Drawings and Sections.

2.06 SOURCE QUALITY CONTROL
A. Provide a performance test after factory completion and prior to shipment as specified herein and in Section 40 98 00:

1. Conduct a test where the system is operated continuously and checked for correct operation including loop controls, displays, printing, keyboard functions, alarm responses, and on/off sequencing control.

2. Conduct testing with dummy I/Os to verify each control loop operation.

3. Allow for SPU and Engineer to load and test application software program:

a. Provide minimum of 15 days notice prior to testing.

4. Do not ship prior to successful completion of this testing program.

2.07 MAINTENANCE MATERIALS
A. Furnish SPU with the following extra materials:

1. One spare of each type of I/O card provided under this Contract.

2. One spare I/O processor/Ethernet Brain SNAP-PAC-EB1.
PART 3 - EXECUTION

3.01 INSTALLATION
A. Install PAC control system in accordance with manufacturer’s written instructions.

3.02 FIELD QUALITY CONTROL
A. Employ and pay for services of equipment manufacturer's field service representative(s) to:
   1. Inspect equipment covered by these Specifications.
   2. Supervise adjustments and installation checks.
   3. Maintain and submit an accurate daily or weekly log of all commissioning functions:
      a. All commissioning functions may be witnessed by the Engineer.
      b. All reports shall be cosigned by the Contractor and the Engineer if witnessed.
   4. Conduct startup of equipment and perform operational checks.
   5. Provide SPU with a written statement that manufacturer’s equipment has been installed properly, started up, and is ready for operation by SPU’s personnel.

3.03 DEMONSTRATION
A. Demonstrate system in accordance with Section 01 75 00 and Section 40 98 00.
B. On-Site Training:
   1. Provide employee of the manufacturer or certified representative to provide 4 hours of operating and maintenance training at the Project site after the system has successfully undergone all field testing and acceptance procedures.
      a. As a minimum, training shall cover:
         1) Hardware overview.
         2) Maintenance.
         3) Troubleshooting.

END OF SECTION 40 94 43
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Signal modules:
   a. Loop isolator.


3. Termination equipment:
   a. Terminal blocks.
   b. Fuse holders.

4. Power supplies:
   a. DC power supplies.
   b. DC Uninterruptible Power Supplies.

5. Voltage surge protection devices.

6. Operator Interface Unit (OIU).

7. Communication Switches:
   a. Ethernet Switch, Unmanaged.
   b. Modbus RS-485 to Modbus/TCP Gateway


12. Relays/Timers.


15. Temperature Transmitter.


B. Related Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.

2. Division 01 - General Requirements.

3. Section 40 90 00.

4. Section 40 99 00.

5. Seattle Public Utilities:
   a. SPU Design Standards and Guidelines.
      1) Section 10 – Instrumentation and Control - SCADA.
1.02 REFERENCES
A. Referenced Standards:
   1. The International Society of Automation (ISA):
      a. 18.1, Annunciator Sequences and Specifications.
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ICS 2, Industrial Control and Systems: Controllers, Contactors, and
      c. Overload Relays Rated 600 Volts.
   3. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS
(NOT USED)

1.04 QUALITY ASSURANCE
A. Miscellaneous:
   1. Assure units comply with electrical area classifications and NEMA enclosure type shown on Drawings.

1.05 SUBMITTALS
A. Shop Drawings:
   1. See Section 01 33 10 for requirements for the mechanics and administration of the submittal process.
   2. See Section 40 90 00 for I&C requirements for the submittal process.
B. Operation and Maintenance Manuals:
   1. See Section 01 33 10 for requirements for the mechanics and administration of the submittal process.
   2. See Section 00 72 00 for the contents of the Project Operation and Maintenance Manual.
   3. See Section 01 77 19 for closeout requirements.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
A. Subject to compliance with the Contract Documents, the manufacturers as listed in the articles describing the devices are acceptable.
B. Provide similar components from the same manufacturer for uniformity of appearance, installation, operations, and maintenance.
C. Submit request for substitution in accordance with Section 01 33 10.
2.02 SIGNAL MODULE

A. Loop Isolators (where required):
   1. Acceptable manufacturers:
      b. AGM Electronics.
      c. Or approved substitute.
   2. Design and fabrication:
      a. Solid state electronics.
      b. Transmit analog output signal directly proportional to measured input signal.
      c. Power source: 24 Vdc.
      d. Analog input: 4-20 mA DC.
      e. Output signal: 4-20 mA DC into 1400 ohms.
      f. Impedance:
         1) Voltage input: 10 Meg.
         2) Current input: 50 ohms.
         3) Voltage output: 1 ohm.
         4) Current output: 1650 ohms.
      g. Accuracy: Better than ± 0.10 percent of span.
      h. Isolation: Up to 500 V rms (input, output and case).
      i. Temperature effect: ±0.0025 percent of span per Deg F.
      j. Ambient temperature range: 0-140 Deg F.
      k. Factory calibrated.
      l. UL listed.

2.03 ALARM DEVICES

(Not used)

2.04 TERMINATION EQUIPMENT

A. Terminal Blocks:
   1. Acceptable manufacturers:
      a. Phoenix Contact.
      b. Allen-Bradley.
      c. Weidmuller.
      d. Or approved substitute.
2. Design and fabrication:
   a. Modular type with screw compression clamp.
   d. Thermoplastic insulation rated for -40 to +90 Deg C.
   e. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
   f. Install end sections and end stops at each end of terminal strip.
   g. Install machine-printed terminal markers on both sides of block.
   h. Spacing: 6 mm.
   i. Wire size: 22-12 AWG.
   j. Tiers/Levels: as required; 3 tier maximum.
   k. Rated voltage: 600 V.
   l. DIN rail mounting.
   m. UL listed.

3. Standard-type block:
   a. Rated current: 30 A.
   b. Color: Gray body.

4. Bladed-type block:
   a. Terminal block with knife blade disconnect which connects or isolated the two (2) sides of the block.
   b. Rated current: 10 A.
   c. Color:
      1) Panel control voltage leaves enclosure - normal: Gray body, orange switch.
      2) Foreign voltage entering enclosure: Orange body, orange switch.

5. Grounded-type block:
   a. Electrically grounded to mounting rail.
   b. Use to terminal ground wires and analog cable shields. Do not use for analog shield grounding.
   c. Color: Green and yellow body.
B. Fuse Holders:

1. Acceptable manufacturers:
   a. Phoenix Contact.
   b. Allen-Bradley.
   c. Weidmuller.
   d. Or approved substitute.

2. Design and fabrication:
   a. Modular-type with screw compression clamp.
   b. Screws: Stainless steel.
   d. Thermoplastic insulation rated for -40 to +105 Deg C.
   e. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
   f. Draw out type of fuse holder.
   g. Blocks can be ganged for multi-pole operation.
   h. Install end sections and end stops at each end of terminal strip.
   i. Install machine-printed terminal markers on both sides of block.
   j. Spacing: 9.1 mm.
   k. Wire size: 30-12 AWG.
   l. Rated voltage: 300 V.
   m. Rated current: 12 A.
   n. Fuse size: 1/4 x 1-1/4.
   o. Blown fuse indication, LED.
   p. DIN rail mounting.
   q. UL listed.

2.05 POWER SUPPLIES

A. DC Power Supplies:

1. Acceptable manufacturers:
   a. PULS, Model CS10.243.
   b. No equal, to match Owner’s standard.

2. Design and fabrication:
   a. Converts 120 Vac input to DC power at 24VDC.
   b. Output current: 10A continuous.
   c. DIN rail mount with enclosure.
   d. UL Listed for use in UL 508A industrial control panels.
e. Filtered and electronically regulated output.

f. Switching type.

g. AC input: 120 Vac +/-15 percent, nominal 60 Hz.

h. Efficiency: Minimum 90 percent.

i. Rated mean time between failure (MTBF): 500,000 HRS.

j. Voltage regulation:
   1) Static: Less than 1.0 percent Vout.
   2) Dynamic: +/-2 percent Vout overall.

k. Output ripple/noise: Less than 100 mV peak to peak (20 MHz).

l. Overload, short circuit and open circuit protection.

m. Temperature rating: -25 to 60 Deg C full rated, derated linearly to 75 percent at 70 Deg C.

n. Humidity rating: Up to 90 percent, non-condensing.

o. LED status indication for DC power.

p. Relay contacts to monitor the following:
   1) DC-OK.

q. 3 year warranty.

B. DC Uninterruptible Power Supplies:

1. Acceptable manufacturers:
   a. PULS, Model UB10.242.
   b. No equal, to match Owner’s standard.

2. Design and fabrication:
   a. Power supply with built-in charger for gel or lead acid batteries.
   b. Voltage in: 24VDC; voltage out: 24VDC.
   c. Battery voltage: 12VDC
   d. Battery Amp-Hour range: 17Ah-130Ah.
   e. Output current: 10A continuous.
   f. DIN rail mount with enclosure.
   g. UL Listed for use in UL 508A industrial control panels.
   h. Filtered and electronically regulated output.
   i. Rated mean time between failure (MTBF): 500,000 HRS.
   j. Temperature rating: -25C to 50C.
   k. Overload, short circuit and open circuit protection.
2.06 BATTERIES

A. Acceptable manufacturers:
   1. Power Sonic PG-12V103FR.
   2. Yukasa.
   3. Or approved substitute.

B. Design and fabrication:
   1. Voltage: 12 VDC, nominal.
   2. Amp-hours: 100.
   3. Characteristics:
      a. Rechargeable.
      b. Leak-free.
      c. Maintenance-free.
   4. Technology: Valve-Regulated Lead Acid (VRLA).
   5. UL-recognized.

C. Terminations and Interconnect Cabling:
   1. As required for complete, functional and code-compliant installation.

D. Mounting:
   1. Use shelving to keep batteries from resting directly on cabinet floor.
   2. Secure batteries to prevent tipping.

2.07 VOLTAGE SURGE PROTECTION DEVICES

A. See Section 40 99 00.

2.08 OPERATOR INTERFACE UNIT (OIU)

A. Acceptable manufacturers:
   1. For Main Control Panels: Red Lion, Graphite G10S0000 – 10-inch, Color Touchscreen, cables, and Crimson programming software.
   2. No equal, to match SPU’s standards.
B. Design and fabrication:
1. Input power: 24 VDC.

2. Display:
   a. 10-inch: TFT active matrix, SVGA, 16M color, 800 x 600 pixel.
   b. Resistive analog touchscreen.
   c. 30,000 hour backlight.
   d. NEMA 4/IP 65 rating.

3. Communication ports:
   a. Serial: Three (3) total (1-RS-232 (PGM), 1-RS-232 (COMMS), 1-RS-422/485), individually programmable up to 115,200 baud.
   b. Individually programmable up to 115,200 baud.

4. Memory:
   a. Unit configuration: Stored in non-volatile flash memory.
   b. SanDisk® or SimpleTech Compact Flash®, 2 GB, industrial grade, two million write cycles, minimum.

5. Cables:
   a. USB to RS-232 serial adaptor cable.
   b. Y-cable.


2.09 SWITCHES / GATEWAYS

A. Ethernet Switch, Unmanaged:
1. Acceptable manufacturers:
   a. Weidmuller, IE-SW-BL08-8TX.
   b. Or approved substitute.

2. Design and fabrication:
   a. Input power: 4VA for AC input, or 4W for DC input.
   b. Input voltage: 12-24 VAC, 10-35 VDC.
   c. Input frequency: 47 – 63 Hz.
   d. 8 each (minimum), RJ45 ports.
   e. Dimensions: 4.25” x 0.9” x 5.0” (LxWxH) or less.
   f. DIN-mounted.
   g. Operating temperature: -0C to 60C.
   h. Standard: IEEE 802.3, 3U and 3X.
   i. Protection class: IP20.
   j. Data rate: 10 Base-T/100 Base-TX (copper); 100 Base-FX (fiber).
k. Functionality: Auto negotiation and Auto crossing (RF45); redundant voltage supply.

l. Status indication: Data rate, Power, Connection/Activity.

m. Approvals: cULus, Class I, Division 2, CD, EN55024, EN 55022, Gost R.

n. Supported protocols: Profinet RT, Modbus TCP, TCP/IP, EthernetIP.

B. Modbus Gateway:

1. Acceptable manufacturers:
   a. Moxa, MB3480.
   b. Or approved substitute.

2. Design and fabrication:
   a. Input power: 24 VDC.
   b. Serial Ports: 4 serial RS-232/422/485, software selectable (Modbus RTU/ASCII Slave/Master)
      1) DB9
      2) 50 bps to 921.6 kbps
   c. Ethernet Ports: 1 Modbus TCP
      1) RJ45
      2) 10/100 Mbps
   d. Operating temperature: 0 deg C to 60 deg C.
   e. Mounting: DIN rail kit.
   f. Functionality: Auto negotiation and Auto crossing (RF45)
   g. Status indication: Power and Connection/Activity for each port.
   h. Approvals: UL

2.10 TAMPER SWITCHES

A. See Section 40 91 10-2.04.

2.11 PILOT DEVICES

A. Selector Switches:

1. Acceptable manufacturers:
   a. Allen-Bradley.
   b. Square D.
   c. Or approved substitute.

2. Design and fabrication:
   a. Heavy-duty type.
   b. Oil tight and NEMA 4X rated.
   c. Rotary cam units conforming to NEMA ICS 2-216.22.
d. Mounting hole: 30.5 mm.
e. Supply switches having number of positions required with contact blocks to fulfill functions shown and specified.
f. UL listed.
g. Maintained contact type.
h. Knob type operators.
i. Black colored operators.
j. Designed with cam and contact block with approximate area of 2-IN SQ.
k. Legend plate marked per Contract Documents.
l. Contact block requirements:
   1) Dry and indoor locations: Standard contact blocks rated for 10 A continuous current.
   2) Wet or outside locations: Hermetically sealed contact blocks.
   3) Hazardous location: Hermetically sealed contact blocks rated for Class I, Division 2 locations.

B. Pushbuttons:
1. Acceptable manufacturers:
   a. Allen-Bradley.
   b. Square D
2. Materials:
   a. Backing diaphragm: Buna-N.
3. Design and fabrication:
   a. Heavy-duty type.
   b. Oil tight and NEMA 4X rated.
   c. Conforming to NEMA ICS 2-216.22.
   d. Mounting hole: 30.5 mm.
   e. Diaphragm backed.
   f. UL listed.
   g. Emergency stop pushbuttons to have mushroom head operator and maintained contact.
   h. Non-illuminated type:
      1) Momentary contact with necessary contact blocks.
      2) Molded, solid color melamine buttons.
      3) Standard flush operators with full shroud.
      4) Emergency stop pushbuttons shall have mushroom head operators.
5) Red colored buttons for START or ON and black (or green?) color for STOP or OFF.

6) Appropriate contact blocks to fulfill functions shown or specified.

i. Contact block requirements:
   1) Dry and indoor locations: Standard contact blocks rated for 10 A continuous current.
   2) Wet or outside locations: Hermetically sealed contact blocks.
   3) Hazardous location: Hermetically sealed contact blocks rated for Class I, Division 2 locations.

j. Legend plate marked per Contract Documents.

C. Indicating Lights:

1. Acceptable manufacturers:
   a. Allen-Bradley.
   b. Square D.
   c. Or approved substitute.

2. Design and fabrication:
   b. Heavy duty type.
   c. Oil tight and NEMA 4X rated.
   d. Type allowing replacement of bulb without removal from control panel.
   e. LED type lamp.
   f. UL listed.
   g. 24 V lamp.
   h. Legends marked per Contract Documents.
   i. Nominal 2-IN SQ face.
   j. Mounting hole: 30.5 mm.
   k. Glass lens.
   l. Color code lights as follows:
      1) Green: OFF or stopped; valve closed.
      2) Amber: Fault/Trouble/Malfunction.
      3) Red: ON or running; valve open.
   m. Legend plate engraved for each light.
2.12 PILOT DEVICES, HAZARDOUS RATED

A. Selector Switches:

1. Acceptable Manufacturers:
   a. Furnas.
   b. Allen-Bradley.
   c. Or approved substitute.

2. Design and Fabrication:
   a. For installation on NEMA 7 & 9 enclosures.
   b. Heavy-duty. Corrosion resistant, copper-free aluminum alloy construction.
   c. Mounting: ¾-14 NPSM threaded hole. Bushing length as required for panel.
   d. UL listed for Class I, Groups C & D locations.
   e. Rotary cam units conforming to NEMA ICS 2-216.22.
   f. Supply switches having number of positioners required with contact blocks to fulfill functions shown and specified.
   g. Maintained contact type, unless noted otherwise.
   h. Knob type operators.
   i. Black colored operators.
   j. Designed with cam and contact block to fulfill functions shown or specified.
   k. Legend plate marked per Contract Documents.

B. Pushbuttons:

1. Acceptable manufacturers:
   a. Furnas.
   b. Allen-Bradley.
   c. Or approved substitute.

2. Design and fabrication:
   a. For installation on NEMA 7 & 9 enclosures.
   b. Heavy-duty. Corrosion resistant, copper-free aluminum alloy construction.
   c. Mounting: ¾-14 NPSM threaded hole. Bushing length as required for panel.
   d. UL listed for Class I, Groups C & D locations.
   e. Conforming to NEMA ICS 2-216.22.
   f. Diaphragm backed.
g. Momentary contact with necessary contact blocks.

h. Molded, solid color melamine buttons.

i. Standard flush or mushroom operators with full shroud.

j. Appropriate contact blocks to fulfill functions shown or specified.

k. Legend plate marked per Contract Documents.

l. Equipment stop pushbuttons to have mushroom-head operator and maintained contact where indicated (control diagrams).

2.13 RELAYS/TIMERS

A. Control Relays:

1. Acceptable manufacturers:
   a. Idec.
   b. Potter & Brumsfield.
   c. Allen-Bradley.
   d. Or approved substitute.

2. Design and fabrication:
   a. Plug-in general purpose relay.
   b. Blade connector type.
   c. Switching capacity: 10 A.
   d. Contact material: Silver cadmium oxide.
   e. Provide relays with a minimum of 3 SPDT contacts.
   f. Coil voltage: 120 Vac or 24 Vdc.
   g. Relay sockets are DIN rail mounted.
   h. Internal neon or LED indicator is lit when coil is energized.
   i. Clear polycarbonate dust cover with clip fastener.
   j. Check button.
   k. Temperature rise:
      1) Coil: 85 Deg F max.
      2) Contact: 65 Deg F max.
   l. Insulation resistance: 100 Meg min.
   m. Frequency response: 1800 operations/hour.
   n. Operating temperature: -20 to +150 Deg F.
   o. Life expectancy:
      1) Electrical: 500,000 operations or more.
      2) Mechanical: 50,000,000 operations or more.
   p. UL listed or recognized.
B. Time Delay Relays:
   1. Acceptable manufacturers:
      a. Eagle Signal Controls.
      b. Idec.
      c. Or approved substitute.
   2. Design and fabrication:
      b. Heavy-duty.
      c. Solid-state construction.
      d. External adjusting dial.
      e. Auxiliary relays as required to perform functions specified or shown on drawings.
      g. Operates on 120 Vac or 24 Vdc (±10 percent) power source.
      h. Contact rating: A150 per NEMA ICS 2-125.
      i. Furnish with "on" and "timing out" indicators.

2.14 INTRINSIC SAFETY DEVICES

A. Intrinsic Safety Isolators:
   1. Acceptable Manufacturers:
      a. Pepperl + Fuchs preferred or approved substitute.
   2. Acceptable Models:
      a. Analog signals (2-channel):
         1) KFD2-STC4-Ex2.
      b. Analog signal splitter (1 input and 2 outputs):
         1) KFD2-STC5-Ex1.2O.
      c. Discrete signals (2-channel):
         1) KFD2-SR2-Ex2W.
   3. Design and Fabrication:
      a. Uses a low-power, electrically isolated to safely interface with devices located in hazardous areas.
      b. Provided with green and red LED for indication of module and field circuit status.
      c. Interface as required by application.
      d. External power: 24 Vdc.
      e. Pole reversal protection.
g. Response time: less than 20ms.

h. Galvanic isolation:
   1) Input/Output: 375V (analog), 300V (discrete).
   2) Input/external supply: 375V (analog), 300V (discrete).
   3) Output/External supply: 300V (discrete).

i. Radio interference suppression: Class A.

j. Housing material: polymide.

k. Operating temperature: -20 to +60 DegC.

l. DIN rail mounting.

m. Grounding method: not required.

n. Testing laboratory approvals: FM and UL.

2.15 PROCESS INDICATORS

A. Process Indicators (Panel Mounted):
   1. Acceptable Manufacturers:
      b. Or approved substitute.
   2. Design and Fabrication.
      a. Input: 4-20 mA dc.
      b. Display: 3½ digits, 0.6" high, red backlight, negative image.
      c. Readout: Engineering units for level, temperature, pressure, as required.
      d. External power: 24 Vdc.
      e. Response time: 1.5 seconds to settle for a step change.
      f. Reading Rate: 2.5 per second.
      g. Housing: NEMA 4X.
      h. Operating temperature: 0 to 60 deg C.
      i. UL listed or recognized.

2.16 TEMPERATURE TRANSMITTER

A. Temperature Transmitter (Wall Mounted):
   1. Acceptable Manufacturers:
      a. Phoenix Contact, MINI MCR-RTD-UI-NC with MINCO, S614PAZ36T RTD.
      b. Or approved substitute.
2. Design and Fabrication.
   a. DIN rail mount.
   b. Input: 4-20 mA dc.
   c. 3-wire RTD Input.
   d. Factory calibrated for 32 degrees F to 120 degrees F.

2.17 VENT DRAINS
A. Panel Vent Drains:
   1. Acceptable Manufacturers:
      a. nVent/Hoffman, Inc.
      b. Or approved substitute.
   2. Design and Fabrication.
      a. UL Listed
      b. NEMA 4X
      c. Stainless Steel
      d. Mechanical means of preventing water and contaminants from entering the enclosure
      e. Equalizes air pressure to reduce moisture build-up.

PART 3 - EXECUTION

3.01 INSTALLATION
A. Install products in accordance with manufacturer’s instructions and SPU standards.
B. Provide as shown on Drawings and as required.
C. Demonstrate system in accordance with Section 40 98 00.

END OF SECTION 40 97 00
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Contractual requirements for control panels and enclosures utilized as follows:
      a. Unless noted otherwise, all control panels and enclosures housing control
         components that are specified in:
            1) Section 40 91 10.
            2) Section 40 94 43.
            3) Section 40 97 00.
            4) Section 40 99 00.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Division 26 - Electrical.
   4. Section 40 90 00.
   5. Section 40 91 10.
   6. Section 40 94 43.
   7. Section 40 97 00.
   8. Section 40 99 00.

1.02 REFERENCES

A. Referenced Standards:
   2. ASTM International (ASTM):
   3. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ICS 4, Industrial Control and Systems: Terminal Blocks.
      a. 70, National Electrical Code (NEC).
   5. Underwriters Laboratories, Inc. (UL):
      b. 913, Standard for Safety, Intrinsically Safe Apparatus and Associated
         Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified)
         Locations.
1.03 DEFINITIONS

A. The term "panel" refers to control panels or enclosures listed in the schedule included in this Specification Section.

B. Foreign Voltages: Voltages that may be present in circuits when the panel main power is disconnected.

C. Intrinsically Safe:
   1. A device, instrument or component that will not produce sparks or thermal effects under normal or abnormal conditions that will ignite a specified gas mixture.
   2. Designed such that electrical and thermal energy limits inherently are at levels incapable of causing ignition.

D. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or instrumentation wire.

E. Instrumentation Cable:
   1. Multiple conductors, insulated, twisted or untwisted, with outer sheath.
   2. Instrumentation cable is typically either TSP (twisted-shielded pair) or TST (twisted-shielded triad) and is used for the transmission of low current or low voltage signals.

F. Ground Fault Circuit Interrupter (GFCI): A type of device (e.g., circuit breaker or receptacle) which detects an abnormal current flow to ground and opens the circuit preventing a hazardous situation.

G. Programmable Automation Controller (PAC): A specialized industrial computer using programmed, custom instructions to provide automated monitoring and control functions by interfacing software control strategies to input/output devices.

H. Remote Terminal Unit (RTU): An industrial data collection device designed for location at a remote site, that communicates data to a host system by using telemetry such as radio, dial-up telephone, or leased lines.

I. Input/Output (I/O): Hardware for the moving of control signals into and/or out of a PAC or RTU.

J. Supervisory Control and Data Acquisition (SCADA): Used in process control applications, where programmable logic controllers (PLCs) or programmable automation controllers (PAC) perform control functions but are monitored and supervised by computer workstations.

K. Digital Signal Cable: Used for the transmission of digital communication signals between computers, PACs, RTUs, etc.

L. Uninterruptible Power Supply (UPS):
   1. A backup power unit that provides continuous power when the normal power supply is interrupted.
   2. Provided in each cabinet and panel.
3. Sized to provide a minimum of 8 hours of continuous operation of all connected components.

4. Provide monitoring and alarm points shown as shown on the Drawings and Specified in Specification Section 40 90 05 – Control Loop Descriptions.

M. Loop Calibrator: Portable testing and measurement tool capable of accurately generating and measuring 4-20ma DC analog signals.

1.04 SUBMITTALS

A. Shop Drawings:

1. See Section 01 33 10 for requirements for the submittal process.

2. See Section 40 90 00 for I&C requirements for the submittal process.

3. Prepared with computer aided design (CAD) software.

4. Printed on 11-inch by 17-inch sheets.

5. Provide the specified number of drawing sets, on 11-inch by 17-inch sheets, and CDROM’s, containing AutoCAD and PDF format drawings, for the submittal reviews per Section 01 33 10.

6. Drawings shall include a title block containing the following:
   a. Location where panel(s) are to be installed.
   b. Drawing title.
   c. Drawing number.
   d. Revision list with revision number and date.
   e. Drawing date.
   f. Drawing scale.
   g. Manufacturer name, address, and telephone number.

7. Cover sheet for each drawing set shall indicate the following:
   a. Location.
   b. Project name.
   c. Submittal description.
   d. Revision number.
   e. Issue date.
   f. SPU project number.

8. Table of contents sheet(s) shall indicate the following for each drawing in the set:
   a. Drawing number.
   b. Drawing title.
   c. Sheet number.
9. Legend and abbreviation sheet shall indicate the following:
   a. Description of symbols and abbreviations used.
   b. Panel construction notes including enclosure NEMA rating, finish type and color, wire type, wire color strategy, conductor sizes, and wire labeling strategy.
   c. Confirmation that the panel(s) are to be affixed with a UL 508A label prior to shipment from the factory.

10. Bill of Material (material, equipment, and component list) for each panel shall include the following component information:
   a. Instrument tag number.
   b. Quantity.
   c. Functional name or description.
   d. Manufacturer.
   e. Complete model number.
   f. Size or rating.

11. Panel exterior layout drawings to scale and shall indicate the following:
   a. Panel materials of construction, dimensions, and total assembled weight.
   b. Panel access openings.
   c. Conduit access locations.
   d. Front panel device layout.
   e. Nameplate schedule:
      1) Nameplate location, layout, and engraving details.
      2) Legend which indicates text, letter height and color, and background color.

12. Panel interior layout drawings shall be drawn to scale and shall indicate the following:
   a. Sub-panel or mounting pan dimensions.
   b. Interior device layouts.
   c. PAC general arrangement layouts.
   d. Wire-way locations, purpose, and dimensions.
   e. Terminal strip designations.
   f. Location of external wiring and/or piping connections.
   g. Location of lighting fixtures, switches and receptacles.

13. Wiring diagrams shall consist of the following:
   a. Panel power distribution diagrams.
   b. Control and instrumentation wiring diagrams.
c. PAC I/O information:
   1) Model number of I/O module.
   2) Description of I/O module type and function.
   3) Rack and slot number.
   4) Terminal number on module.
   5) Point or channel number.
   6) Programmed point addresses.
   7) Signal function and type.

d. Wiring diagrams shall identify each wire as it is to be labeled.

14. PAC I/O List
   a. Table indicating PAC I/O assignments for each PAC control panel. See Section 40 90 05A for I/O schedule with PAC I/O assignments.
   b. PAC I/O Information:
      1) PAC I/O point type.
      2) PAC Rack number.
      3) PAC Slot number.
      4) Channel or point number.
      5) Equipment tag number.
      6) Description/Function.
      7) Calibration:
         a) Signal Scale Range.
         b) N.O. or N.C. contact.
      8) Power:
         a) Signal type: 2-wire, 3-wire, or 4-wire.
         b) Control Voltage level.
         c) Foreign Voltage.
      9) Project P&ID Number.
      10) Panel Control Wiring Diagram Number

B. Manufacturer catalog cut sheets for enclosure, finish, panel devices, control auxiliaries, and accessories.

C. Electrical load calculations for each panel. Provide load calculations for AC and DC power sources and include:
   1. Total connected load for each panel.
   2. Peak electrical demand for each panel.
   3. Panel shall have an affixed voltage, amperage, and short circuit label.
D. Climate control calculations for each panel listed in Section 40 98 00-3.05 with exception of LCP-0116:
   1. Demonstrate that sufficient ventilation, dissipation and/or generation of heat is provided to maintain interior panel temperatures within the rated operating temperatures of panel components.

E. Miscellaneous:
   1. Record Drawings:
      a. Updated panel drawings delivered with the panel(s) from the Contractor's factory.
      b. Shop as built drawing set shall be bound and firmly installed in each panel.
      c. Replace shop as built drawings with Final As-Built drawings within 30 days after completion of operational testing.

F. Operation and Maintenance Manuals:
   1. See Section 01 33 10 for requirements for the submittal process.
   2. See Section 00 72 00 for the content of the Project Operation and Maintenance Manual.
   3. See Section 40 90 00 for basic I&C requirements.
   4. See Section 01 77 19 for close requirements.

1.05 QUALITY ASSURANCE

A. Miscellaneous:
   1. Approved supplier of Industrial Control Panels under provisions of UL 508A and 698A:
      a. Entire assembly shall be affixed with a UL 508A or 698A label "Listed Enclosed Industrial Control Panel" prior to shipment to the jobsite.
      b. Control panel(s) without an affixed UL 508A or 698A label will be rejected and sent back to the Contractor's factory for UL labeling by the Contractor, at no additional cost to SPU.
   2. Install the appropriate labeling on the interior and exterior of the equipment. Each panel shall have an affixed power, amperage and short circuit rating; UL Label; fuse identification list; and foreign voltage warning.

1.06 SYSTEM DESCRIPTION

A. The contractor shall provide custom enclosures (referred to as "Control Cabinet" or "Main Control Panel" in the contract documents), the intent of which is given in the contract drawings.
PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Enclosures:
   a. Pentair/Hoffman Enclosures, Inc.
   b. Skyline.
   c. Vulcan.
   d. Rittal.
   e. Hammond Manufacturing.
   g. Approved substitute.

2. Panel heaters:
   a. Pentair/Hoffman Enclosures, Inc.
   b. Rittal.
   c. Hammond Manufacturing.
   d. Approved substitute.

3. Heat exchangers and air conditioners:
   a. Ice Qube, Inc. Blade Series.
   b. Hoffman Enclosures, Inc.
   c. Rittal.
   d. Hammond Manufacturing.
   e. Approved substitute.

4. Internal corrosion inhibitors:
   a. Hoffman Enclosures, Inc.; Model A-HCI.
   b. Northern Technologies International Corporation (NTIC); Model Zerust VC.
   c. Model Zerust VC.
   d. Cortec Corporation; Model VpCl Emitting Systems.
   e. Approved substitute.

5. Thermostat:
   a. Pfannenberg, Model FLZ 541.
   b. Approved substitute.
6. Intrusion (Door) Switch:
   a. Hoffman Enclosures, Inc. Model ALFSWD or PLFSWD (as required by the application).
   b. Honeywell DPDT Plunger Limit Switch, 2DM.
   c. Approved substitute.

B. Submit request for substitution in accordance with Specification Section 01 33 10 - Submittals.

2.02 ACCESSORIES

A. Panel Nameplates and Identification:
   1. No screws shall be used to attach nameplates. Use double backed adhesive for nameplates.
   2. All fasteners listed as "screws" shall be corrosion-resistant machine screws with self-locking nuts and meet all UL requirements.
   3. Nameplates of embossed tape shall not be permitted for any application, not even for temporary use. No exceptions will be granted.

2.03 FABRICATION

A. General:
   1. Fabricate panels with instrument arrangements and dimensions identified in the Contract Documents.
   2. Provide panel(s) with the required enclosure rating per NEMA 250 to meet classifications identified in the Contract Documents. Only NEMA Type 4X will be accepted for installation outdoors. NEMA 12 will be acceptable in air-conditioned electrical rooms.
   3. Devices installed in panel openings shall have a NEMA enclosure rating at least equal to the panel enclosure rating.
   4. Short circuit current rating of panel:
      a. 10,000A, minimum.
   5. Panels and pedestals to be located outdoors shall be fabricated from 316 stainless steel and shall utilize appropriate hinge and locking components. Panel(s) shall be completely assembled at the Contractor’s factory:
      a. No fabrication other than correction of minor defects or minor transit damage shall be performed on panels at the jobsite.
   6. Painting:
      a. Panels fabricated from steel shall have their internal and external surfaces prepared, cleaned, primed, and painted:
         1) Mechanically abrade all surfaces to remove rust, scale, and surface imperfections.
         2) Provide final surface treatment with 120 grit abrasives or finer, followed by spot putty to fill all voids.
         3) Utilize solvent or chemical methods to clean panel surfaces.
4) Apply surface conversion of zinc phosphate prior to painting to improve paint adhesion and to increase corrosion resistance.

5) Electrostatically apply polyester urethane powder coating to all inside and outside surfaces.

6) Bake powder coating at high temperatures to bond coating to enclosure surface:
   a) Panel interior shall be white with semi-gloss finish.
   b) Panel exterior shall be ANSI #61 gray with flat finish.

7) Application of alkyd liquid enamel coating shall be allowed in lieu of polyester urethane powder for wall mounted NEMA 12 rated panels.
   b. Panels fabricated from stainless steel, aluminum, or fiberglass shall not be painted.

7. Finish opening edges of panel cutouts to smooth and true surface conditions:
   a. Panels fabricated from steel shall have the opening edges finished with the panel exterior paint.

8. Panel shall meet all requirements of UL 508A:
   a. If more than one (1) disconnect switch is required to disconnect all power within a panel or enclosure, unless otherwise required by UL 508A, provide a cautionary marking with the words "CAUTION" and the following or equivalent, "Risk of Electric Shock-More than one (1) disconnect switch required to de-energize the equipment before servicing."

9. Provide control panel in accordance with NEC Article 409 - Industrial Control Panels:
   a. In the event of any conflict between NEC Article 409 and UL 508A, the more stringent requirement shall apply.

10. Panel shall meet all requirements of UL 698A
  a. Provide intrinsically safe circuit extensions from panels in unclassified locations into hazardous classified locations in accordance with the NEC as required by UL 698A.

11. Panel door handles shall be lockable with a paddle lock. Verify acceptable shank diameter and lock sizes with SPU.

B. Free-Standing or Pedestal-Mounted Panels:
  1. Welded construction.
  2. Completely enclosed, self-supporting and gasketed dust-tight.
  3. Rolled lip around all sides of enclosure door opening.
  4. Seams and corners welded and ground smooth to touch and smooth in visual appearance.
  5. Full height, fully gasketed flush pan doors.
6. Full length piano hinges rated for 1.5 times door plus instrument weight.
7. Doors with L-shaped, quarter-turn pad lockable handles.
8. Appropriate conduit, wiring, and instrument openings shall be provided.
9. Lifting eyebolts:
   a. To allow simple, safe rigging and lifting of panel during installation.
   b. Removed, holes plugged, and eyebolts stored inside respective enclosure.
10. Enclosures shall be constructed of a minimum of 12 gauge stainless steel.
11. Where double doors are provided, provide removable center post.

C. Internal Panel Wiring:
1. Panel wire duct shall be installed between each row of components, and adjacent to each terminal strip:
   a. Route wiring within the panel in wire-duct as possible.
   b. Follow wire-duct manufacturer's recommended fill limits. In addition, raceways must meet fill requirements per UL 508A and NEC.
   c. Wire-duct shall have removable snap-on covers and perforated walls for easy wire entrance.
   d. Wire-duct shall be Panduit Type E or NE, constructed of nonmetallic materials, and rated in excess of the maximum voltage carried therein.
   e. Wire-duct shall be supported by appropriately sized plastic rivets or screws which have been tapped into the subpanel.
2. Wire bundles shall be secured using plastic tie wraps except within wiring ducts. The bundles shall be securely fastened to the steel structure at intervals not exceeding 12 inch using appropriately sized stainless steel machine screws.
3. Wires shall be supported by means other than the connectors or terminal strips. Wires shall be contiguous from connector to connector without wire splices between them.
4. Wiring shall be installed such that if wires are removed from one (1) device, source of power will not be disrupted to other devices.
5. Splicing and tapping of wires permitted only at terminal blocks.
6. Wire bunches to doors shall be secured at each end so that bending, or twisting will be around longitudinal axis of wire:
   a. Protect bend area with sleeve.
7. Arrange wiring neatly, cut to proper length, with surplus wire removed:
   a. Arrange wiring with sufficient clearance.
   b. Provide abrasion protection for wire bundles that pass through openings or across edges of sheet metal.
8. AC circuits:
   a. Routed separate from analog signal cables and digital signal cables.
   b. Separate by at least 6-inch, except at unavoidable crossover points and at device terminations.

9. Analog signal cables carrying low level signals of 100 millivolts or less shall not be run in the same bundle, duct, or wire duct as digital input or control output wiring.

10. Provide at least 6-inch of separation between intrinsically safe devices and circuits and non-intrinsically safe devices and circuits.

11. Wiring to pilot devices or rotary switches shall be individually bundled and installed with a "flexible loop" of sufficient length to permit the component to be removed from panel for maintenance without removing terminations.

12. Conductors for AC and DC circuits shall be type MTW stranded copper listed for operation with 600 V at 90 Deg C:
   a. Conductor size shall be as required for load and 16 AWG minimum. Conductors for power wiring shall be sized for load and 14 AWG minimum. OPTO SNAP Breakout Boards wire size shall be 18 AWG maximum with 20 AWG minimum.
   b. Internal panel wiring color code:
      1) 120 VAC circuits:
         a) Power wiring: Black.
         b) Control interconnections: Yellow.
         c) Neutral: White.
         d) Ground: Green.
         e) Control circuits: Red.
      2) Low voltage DC/AC circuits (typically 24 V):
         a) DC Power supply wiring: Blue.
         b) AC Power supply wiring: Red.
         c) DC Ground: Blue/White.
         d) AC Ground: White/Grey.
         e) Control interconnections: Violet.
      3) Foreign voltage circuits: Pink.
      4) Intrinsically safe circuits: Orange.
      5) Unless otherwise required by UL.

13. Provide each I/O module with a pre-terminated connector with a color-coded multi-conductor cable of appropriate length prewired to the terminal blocks.

14. Equipment requiring AC power shall be provided with an NFPA Number 70 Type SJ cord with a molded-on grounding type plug for the AC power connection.
15. Analog signal cables shall be of 600 V, 90 deg C rated insulation, with stranded copper wire in twisted-shielded pairs:
   a. The cable’s outer diameter shall be 0.25 inch maximum with 100 percent coverage aluminum foil mylar-lined shield and 22 AWG minimum stranded tinned copper drain. The cable shall be UL listed.
   b. Conductor size: 18 AWG minimum.
   c. Terminate shield drain conductors to ground only at one (1) end of the cable. The drain wire shall not be used as a control signal conductor. It shall be terminated at a terminal strip or trimmed back to the jacket of the shielded cable, as required by its application.
   d. Shields that are connected to ground shall either be tinned by solder or have heat shrink insulation installed over the wires to prevent stray strands from reaching ground or shorting to other terminals.
   e. See Section 26 05 19 for additional requirements.

16. Modbus Communication Twin axial Cable shall be 600V, 75 deg C rated insulation:
   a. The cable’s outer sheath shall be of flame-retardant Polyolefin insulation with blue sunlight resistant PVC jacket.
   b. Conductor shall be 18 AWG stranded tinned copper with overall Beldfoil (100%) shield plus TC Braid Shield (55%) plus TC drain wire.
   c. Wire devices similar in nature, in series and install proper terminating resistor at last device.
   d. See Section 26 05 19 for additional requirements.

17. Provide surge protection for analog inputs from field (remote) devices as specified in Specification Section 40 99 00.

18. Loop isolators as specified in Specification Section 40 97 00 - Control Auxiliaries.

19. Wire and cable identification:
   a. Wire and cables numbered and tagged at each termination.
   b. Wire tags:
      1) Slip-on, shrink fitted plastic wire sleeves with legible, machine-printed markings.
      2) Adhesive, snap-on, or adhesive type labels are not acceptable.
      3) Provide at both ends, except for pre-terminated cables with connectors.
      4) Markings as identified in the shop drawings.
c.  Tag 120 Vac power and control wires with a circuit type identification code followed by a hyphen and the wire number (i.e. L-01). Assign wire numbers using sequential numbers. Match wire numbers with interconnection wire numbers when they are electrically identical:

1) The identification letter shall be as follows:
   a) For power wires, use code: L.
   b) For 120 Vac control wires, use code: C.
   c) For neutral wires, use code: N.
   d) For ground wires, use code: PG.

d. Tag 24 Vdc and control signal wires with a three part wire number for identification, with each part separated by a hyphen (i.e. PS24-VDC-2):

1) The first part of the wire number shall be the instrument loop number. If an instrument loop number is not available, use the lowest mechanical equipment number of all final drives associated with the circuit.

2) For the second part, use one of the following codes to indicate the wire type:
   a) For 24Vdc power supply circuit, use code: 24Vdc.
   b) For analog signal wiring, use code: S.
   c) For signal common wires, use code: COM.
   d) For equipment ground, use code: PG.
   e) For discrete events and low voltage control circuits, use code: C.

3) The third part of the wire number shall identify wires in a circuit that are electrically identical. Assign wire numbers using sequential numbers.

4) For example, wire number PS24-VDC-2, indicates:
   a) PS24 = equipment number,
   b) VDC = VDC power supply with blue wire
   c) 2 = electrical identity wire number (sequential numbers).

D. Grounding Requirements:

1. Each panel shall be provided with two copper ground bars:
   a. One bar (central ground bus) shall be bonded to the panel frame or sheet metal and to the station ground system.
   b. The second (signal) ground (bus) bar shall be mounted on insulated stand-offs and shall be bonded to the frame ground bar at one point only.

2. Equipment grounding conductors shall be separated from incoming power conductors at the point of entry.
3. Minimize grounding conductor length within the enclosure by locating the ground reference point as close as practical to the incoming power point of entry.

4. Provide shrink tubing for shield wires to ensure the shield does not short to the panel ground.

5. Bond the PAC I/O module chassis and machine elements to a central ground bus:
   a. Nonconductive materials, such as paint, shall be removed from the area where the equipment contacts the enclosure.

6. Bond the enclosure to the ground bus:
   a. It is imperative that good electrical connections are made at the point of contact between the ground bus and enclosure.

7. Panel-mounted devices shall be bonded to the panel enclosure or the panel grounding system by means of locknuts or pressure mounting methods.

8. Sub-panels and doors shall be bonded to ground.

9. Provide a signal ground bar (bus), 1-inch wide by 0.25 inch thick, isolated from the central ground bus, to be run across the bottom of the sub-panel. The bus shall be insulated from the panel and have tapped holes to accommodate ground connections from instruments and low level signal devices in the chassis plus 100 percent spare tapped holes. Size the signal ground bus to allow proper termination of all shield drain wires and instrument grounds.

10. Connect the signal ground bus to the system ground bus in only one point, using a stranded, insulated copper wire of #8 AWG or larger.

11. Ground panel in a chassis to the signal ground bus. Use ring tongue connectors that bolt to the bus. Each different type of signal (i.e. low level sensor, high level output, or noisy switching circuits) shall have a separate line to the bus. Only circuits of the same voltage level shall share the same ground line.

12. Small PAC systems may use a grounding system consisting of a terminal strip with a common connection bar substituted for the copper bus bar. The common connection bar must be tinned and provide ample material for the compression style terminal strip to make low resistance connections.

13. Surge protectors and separately derived AC power supplies shall be bonded to the system ground plate.

E. Termination Requirements:

1. Wiring to circuits external to the panel connected to interposing terminal blocks.

2. Terminal blocks rigidly mounted on DIN rail mounting channels.

3. Terminal strips located to provide adequate space for entrance and termination of the field conductors.

4. Locating the terminal blocks where line-of-site is impaired or making insertion or removal of wires difficult shall not be accepted.

5. Terminal blocks shall be compression type with captive screws.

6. One (1) side of each strip of terminal blocks reserved exclusively for the termination of field conductors.
7. Terminal block markings:
   a. Mark one end of each terminal strip with a unique (for the panel) identifying alphanumeric code at one end.
   b. Provide a plastic marking strip running the entire length of the strip with a unique (for the terminal strip) number for each terminal.
   c. Legible, machine-printed markings with 1/8-inch high numbers.
   d. Markings as identified in the shop drawings.

8. Terminal block mechanical and electrical characteristics shall be in accordance with NEMA ICS 4.

9. Terminal blocks carrying power circuits shall include a transparent, hinged cover for personnel protection and access:
   a. Each terminal block shall be identified with machine printed labels.

10. Terminals shall facilitate wire sizes as follows:
    a. 120 Vac applications: Conductor size 14 AWG minimum.
    b. Other: Conductor size 16 AWG minimum.

11. Analog signal cable shield drain conductors shall be individually terminated on isolated ground bus.

12. RS485 communication cables shall be individually terminated on the Modbus serial gateway. See Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables for cable specifications.

13. Install minimum of 20 percent un-used spare terminals.

14. Bladed, knife switch, isolating type terminal blocks where control voltages enter or leave the panel.

15. Fused terminal blocks shall be used in the following circuits:
    a. Control voltage is used to energize a solenoid valve.
    b. Control voltage is used to wet a contact.
    c. DC power is connected to 2-wire, loop-powered instruments. Use fast acting glass tube type fuses rated 1/8 or 1/10 amp.
    d. AC or DC power is used to supply an instrument. For 120 Vac circuits, use ceramic tube type fuses with 25,000 amp interrupting capacity at 125 volts. For supplying 24 Vdc instruments, use fast acting glass tube type fuses rated 3 amps.

16. Fused terminal blocks shall be provided with LED blown fuse indicator lamps.

17. Circuit breakers shall be used in circuits supplying individual instruments or equipment with loads of 10 amps or greater at 120 Vac.

18. When control circuits require more than one (1) field conductor connected to a single wiring point, a sufficient number of terminal points shall be connected internally to allow termination of only one (1) field conductor per terminal block. Do not daisy-chain with wire. Use terminal manufacturers terminal jumpers.
19. DIN rail mounting channels shall be installed along full length of the terminal strip areas to facilitate future expansion.

20. Connections to devices with screw type terminals shall be made using ring type (not spade or fork), insulated, compression terminators.

21. All wire connections shall be complete using terminal strips. Wire splices are not allowed.

F. Component Mounting and Placement:

1. Components shall be installed per manufacturer instructions. Double-faced tape will not be permitted.

2. Control relays and other control auxiliaries shall be mounted on DIN rail mounting channels where practical.

3. Terminal blocks shall be mounted vertically in the enclosure with ample clearance to allow visual guidance for installing wires.

4. Front panel devices shall be mounted within a range of 40 to 70 inches above the finished floor or grade, unless otherwise shown in the Contract Documents.

5. PAC and I/O rack installation:
   a. Located such that the LED indicators and switches are readily visible with the panel door open.
   b. Located such that calibration, repair and/or replacement of component can be accomplished without the need to remove wire terminations or other installed components.

6. Locate power supplies with sufficient spacing for circulation of air.

7. Where components such as relays, and other electromagnetic devices are installed within the same enclosure as the PAC system components, provide a barrier of at least 6-inch of separation between the "power area containing the electromagnetic devices" and the "control area".

8. Components mounted in the panel interior shall be fastened to an interior sub-panel using machine screws:
   a. Fastening devices shall not project through the outer surface of the panel enclosure.
   b. Follow UL recommendations.

9. Excess mounting space of at least 20 percent for component types listed below to facilitate future expansion:
   a. Fuse holders.
   b. Circuit breakers.
   c. Control relays.
   d. Time delay relays.
   e. Intrinsically safe barriers and relays.
10. Components installed on sub-panels shall be provided with a minimum spacing between component and wire duct of 1-inch:
   a. Minimum of 2-inch separation between terminal strips and wire ducts.

G. Power Distribution:
1. Main incoming power circuits shall be protected with a thermal magnetic circuit breaker:
   a. Limit load to maximum of 80 percent of circuit breaker rating.
2. Component types listed below shall be individually fused so that they may be individually de-energized for maintenance:
   a. PAC power supply modules.
3. Each control cabinet and panel with PAC components shall be furnished with power protection in the form of a double conversion UPS.
4. Equip each panel with necessary power supplies with ratings required for installed equipment and with minimum 25 percent spare capacity.
5. Constant voltage transformers, balancing potentiometers, and rectifiers as necessary for specific instrument requirements.

H. Internal Panel Lighting and Service Receptacles:
1. One (1) electrical GFCI duplex receptacle for each 3-feet of panel face.
2. One (1) 12-inch 24 VDC LED strip light fixture with door-activated switch (es) per foot of panel face. Model: Banner WLB32C570PB with mounting accessories and connectors; or approved substitute.

I. Environmental Controls:
1. Outdoor panels:
   a. Outdoor temperature range of 0 Deg F through 110 Deg F.
   b. Thermostat controlled heaters to maintain temperature approximately 10 Deg F above ambient for condensation prevention inside the panels. Humidity inside the panel shall be maintained between 10 and 95 percent.
   c. Panel internal temperature range of 20 Deg F through 90 Deg F shall be maintained.
   d. Thermostat controlled closed-loop heat exchangers or closed-loop air conditioners if required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the panel and within the required panel internal temperature range per Item c above.
   e. Internal corrosion inhibitors.
2. Environmental control components:
   a. Panel heaters:
      1) Thermostat controlled.
      2) Fan driven.
3) Components mounted in anodized aluminum housing.
4) Designed for sub-panel mounting.
5) Powered from 120 Vac and protected with a dedicated circuit breaker.
6) Appropriately sized Hoffman type D-AH heater, or approved substitute, for panels 36-inch high or larger.

b. Heat exchangers and air conditioners:
1) Dual-loop design to isolate panel interior air from exterior air.
2) Designed and listed to maintain NEMA 4X enclosure rating.
3) Thermostat controlled.
4) Designed for use in areas of contamination and capable of running for 12 month periods without cleaning.
5) Operate from 120 Vac and protected with a dedicated circuit breaker.
6) Remote control kit with alarm output.
7) Replacement filters.
8) Sized appropriately.
9) Side-mounted.

c. Internal corrosion inhibitors:
1) Contains chemical which vaporizes and condenses on surfaces in the enclosure.
2) Inhibitor shall be applied in accordance with manufacturer instructions for the enclosure volume.
3) Inhibitor shall be applied in the panel(s) prior to shipment from the Contractor’s factory.

J. Thermostat:
1. Dual setting dials to control two separate devices, or to control the operation of the fan (turning it off and on based on set temperatures), or to control a heater (turn the heater on and off based on enclosure temperature).

K. Intrusion (Door) Switch:
1. Provide one switch for each door. If there are multiple doors, wire together to provide single intrusion input. Wired Normally Closed with door closed.

2.04 MAINTENANCE MATERIALS
A. Extra Materials:
1. Quantity of 25 percent replacement lamps for each type installed (minimum of 12 of each type).
2. Minimum 5 replacement fuses of each type and size installed.
3. Minimum 12 replacement filters for each type installed.
4. One (1) quart of exterior finish touch-up paint.
5. One (1) complete set of replacement corrosion inhibitors in sealed packages for each panel.
6. Replace all spares consumed prior to substantial completion.

PART 3 - EXECUTION

3.01 TEST PLANS AND REPORTS

A. Testing requirements shall be part of every PAC installation. The Contractor shall demonstrate the system was fully tested during development and installation. The control system must be demonstrated to be a functioning, integrated, and reliable control system before final payments are released. The basic testing requirements shall require a comprehensive series of Contractor conducted tests which will be witnessed by SPU and certified by the Contractor. SPU will provide the PAC application programs for the project. Coordinate all testing of software directly with SPU personnel as required.

B. The basic requirements shall include testing of all equipment and software. If specific tests were not defined in the contract documents for a piece of equipment or software, then the Contractor shall be required to develop the testing procedures. All software and all equipment related to the PAC system shall be tested.

C. The Contractor shall be required to prepare and submit for review and approval the following:
   1. Factory Acceptance Test Plan and procedures.
   2. Component, System, Operational Test (also known as Site Acceptance Test) Plans and procedures.
   3. Test Schedules.
   4. Test Reports.
   5. Instrument and (applicable) component calibration sheets.

D. Test Plans:
   1. The Contractor shall be required to prepare and document a separate test plans for each Factory Acceptance Test, Component Test, System Test, and Operational Test (also known as Site Acceptance Test). The actual test procedures shall be a formal submittal for review and approval 60 days before the start of the tests.
   2. The test procedures shall be structured in a step-by-step, building block, and efficient manner with checkpoints at critical functions. The procedures shall facilitate the reporting of test results and the re-creation of error conditions.
   3. Test data sheets shall be used to record applicable drawing numbers, test equipment, discrepancies, corrective action(s) required, and test data. Data entries shall be referenced to the applicable procedures and allowable limits for each entry shall be indicated on the data sheets.
E. Test Reports:

1. The Contractor shall be required to develop, maintain, and update Test Reports of all test results and conditions that were recorded during the course of the testing. The test results shall include:
   a. Identification of test being conducted.
   b. Date and time of test.
   c. Prerequisite tests and demonstrations.
   d. Brief statement of test objective(s) and scope.
   e. Brief test description.
   f. List of calibrated (within the past calendar year) test and monitoring equipment required to perform test.
   g. Test results.
   h. List of test deficiencies and their resolutions.
   i. Retesting requirements (if required).
   j. Failure events.
   k. Contractor’s certification (as applicable).

3.02 PREOPERATIONAL TESTING

A. A Factory Acceptance Test (FAT) and verification for all deliverable equipment, programs, and associated documentation shall be performed prior to shipment of the system. The tests shall verify that the equipment is manufactured and assembled correctly, is operating as designed, and is in compliance with the contractual requirements. The tests shall verify that the software and hardware meet the functional and performance requirements of the project. The FAT shall be performed at the Contractor’s factory and shall be witnessed by SPU personnel.

B. The FAT shall include the following major test and verification activities:

1. Verification of the system’s configuration. Prior to the beginning of the FAT, the system will be subjected to system deliverable configuration verification. A copy of the configuration and record of quantities of part numbers are to be included with the FAT report. No equipment replacement or substitutions shall be permitted without rigorous quality control accounting and re-testing of affected equipment.

2. Since SPU is providing the application software, coordination between the Contractor and SPU is required. The Contractor is responsible for proper functioning of the hardware, while SPU is responsible for proper functioning of the software. The FAT shall primarily test the control cabinet hardware, and the Contractor is responsible for developing and administering the testing procedure which was approved in the submittal process. In addition to the hardware test, the Contractor shall allow SPU up to 5 days of access (either before or after the hardware test) to the control cabinet at the Contractor’s fabrication facility in which SPU will load the software onto the PAC and confirm proper configuration and hardware-software interface. During this time, SPU may perform functional testing of the software to verify proper operation; provide up to 16 hours of support during this 5 day period.
3. Equipment testing and verification shall be performed:
   a. During the FAT, a visual inspection will be performed to verify the equipment was assembled in accordance with the approved drawings. As a minimum, the structural integrity of the enclosure will be verified, as well as the subpanel structure, paint work and finish, and the cabinet dimensions.
   b. A visual inspection of the wiring and connections will be performed, including the termination of wires, labeling, wiring installation and wire stripping.
   c. The fuses and circuit breaker ratings and locations in the panel will be confirmed.
   d. The grounding strips, including layout, cables, connection security and correct size will be confirmed.
   e. Additionally, the inspection will include the verification of card wiring support, I/O rack clearances, I/O and equipment labeling, I/O card type verification, I/O card layout, power supply mounting, power cable routing, and data cable routing.

C. The FAT shall include a functional test of the system after a burn-in test has been performed. The panel shall be fully energized for a minimum period of 48 hours prior to the functional test. The test shall then exercise every specified system function and shall include, but not be limited to, the following:
   1. Exercise all inputs and outputs, both individually and collectively, by measuring or connecting circuits at the field terminal blocks.
   2. Demonstrate analog input and analog output accuracy.
   3. Test all indicators.
   4. Verify all control operations to ensure they result in the correct sequence of operation at the PAC (SPU responsibility).
   5. Simulate PAC communication error conditions and demonstrate error detection and handling.
   6. Demonstrate PAC power supply failure and recovery.
   7. Demonstrate the ability to remove and insert each I/O module.
   8. Demonstrate the correct operation of all digital communication devices.
   9. Allow time required by SPU to test operation of all SPU-provided application programs and control strategies using whatever simulations are necessary. Provide SPU with all materials and components required for the duration of their testing (at no additional cost to SPU).
   10. Provide certified test results for the deliverable equipment.
   11. Test shall be fully documented and signed by the Contractor’s factory supervisor.
12. Make the following documentation available to the Engineer at test site during the tests:
   b. Factory Demonstration Testing procedures.
   c. List of equipment to be testing including make, model, and serial number.
   d. Shop Drawing submittal data for equipment being tested.
13. Deficiencies shall be corrected prior to shipment from the Contractor’s factory.
14. The system shall be packaged and shipped to the Contractor at the site for installation.

D. Test location: Within 50 miles of downtown Seattle.

3.03 INSTALLATION
A. Install control panels only in non-hazardous areas. Install free-standing panels on 4-inch high concrete housekeeping pads.
B. Anchor panels in a manner to prevent the enclosure from racking, which may cause the access doors to become misaligned.
C. Obtain approved panel layouts prior to installation of conduits.
D. Install products in accordance with manufacturer’s instructions.
E. Provide sunshields where required per the contract documents.

3.04 FIELD QUALITY CONTROL (TESTING AND COMMISSIONING)
A. Demonstrate testing and commissioning in accordance with Section 01 75 00.
B. Component Test, System Test, Operational Test, and Commissioning shall be performed at the site. The final documentation will then be reviewed for completeness. Site Testing shall be witnessed by SPU personnel.
C. Since SPU is providing the PAC application programs, coordinate and schedule directly with SPU personnel a minimum of two months prior to the start of any testing. Provide all labor as required to support SPU's testing, at no additional cost to SPU.
D. Component and system testing shall include the following requirements:
   1. After the installation of the panel and all associated wiring, but prior to making final terminations to the field components, send dummy discrete and analog signals that duplicate the signals at the site to the Operations Control Center (OCC) and verify the communication path and the software are working.
   2. Verify all indication devices.
   3. Verify communications to the SCADA system is operational. Verify analog and discrete points are functional and transmission control from the OCC is operating where applicable.
   4. The component test shall verify that the equipment and all cables have been properly installed, have not been damaged, and have not failed in shipment or storage.
5. The component and system tests shall demonstrate stable operation of all PAC I/O modules, wiring, and data transmission to the OCC under actual operating conditions. The test shall also demonstrate proper operation of all digital or sequential control.

6. All start/stop, open/close, raise/lower and similar commands and all discrete status inputs shall be tested for proper operation. In addition, all alarms, both analog and discrete, shall be tested.

7. After one week of operation without notable events or failures, finalize the wiring between the new PAC and the I/O. Organize unused wiring to provide a neat and clean appearance.

E. The Operational Test shall require the testing of system functions, software, and performance after completion of all site installation tests. These tests shall verify complete operation of the system or site, including additional tests required to verify field-installed equipment, which was not available at the factory. The Contractor shall be required to perform the following:

1. Verify the facility installation / Component Test.
2. Verify the System Test.
3. Verify operation of any local operator interface device.

F. Final Documentation Acceptance shall follow the completion of all system testing previously described. Final acceptance of any work shall be linked to the proper operation and documentation of the controls installed by the Contractor. The following actions shall be defined in the contract documents and shall be a prerequisite for final acceptance of the control system:

1. Successful completion of the Operational Test.
2. Delivery of all “as-built” documentation and drawings. Replace shop as built drawings with Final As-Built drawings inside the panels.
3. Resolution of all outstanding system deficiencies.

3.05 SCHEDULE

A. Schedule:

<table>
<thead>
<tr>
<th>TAG NUMBER</th>
<th>LOCATION</th>
<th>TYPE</th>
<th>MATERIAL</th>
<th>SUN/RAIN HOOD</th>
<th>LATCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP-0100</td>
<td>Inside Electrical Building</td>
<td>NEMA 12</td>
<td>Painted Steel</td>
<td>No</td>
<td>Pad lockable</td>
</tr>
<tr>
<td>LCP-0110</td>
<td>Outside Pump Station Wet Well Entry</td>
<td>NEMA 4X</td>
<td>Stainless Steel</td>
<td>Yes</td>
<td>Pad lockable</td>
</tr>
<tr>
<td>LCP-0116</td>
<td>Outside Pump Station Wet Well Entry</td>
<td>Actuator Vendor</td>
<td>No</td>
<td>Pad lockable</td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION 40 98 00
PART 1 – GENERAL

1.01  SUMMARY

A. Section Includes:
   1. Type IC1 SPD - Dedicated 120 Vac circuit, series connection, control panel mounted.
   2. Type IC4 SPD - Dedicated 24 Vdc circuit, series connection, control panel mounted.
   3. Type IC8 SPD - Data line, control panel mounted.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 40 90 00.

1.02  REFERENCES

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. LS 1, Low Voltage Surge Protection Devices.
   3. Underwriters Laboratories, Inc. (UL):
      b. 1283, Standard for Safety Electromagnetic Interference Filters.
      c. 1363, Standard for Safety Relocatable Power Taps.
      d. 1449, Standard for Safety Transient Voltage Surge Suppressors.

1.03  DEFINITIONS

A. Clamping Voltage: The voltage measured at the end of the 6 IN output leads of the SPD and from the zero voltage reference to the peak of the surge when the applied surge is induced at the 90 degree phase angle of the applied system frequency voltage.

B. Let-Through Voltage: The voltage measured at the end of the 6 IN output leads of the SPD and from the system peak voltage to the peak of the surge when the applied surge is induced at the 90 degree phase angle of the applied system frequency voltage.

C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which the SPD device can operate and meet its specification within its rated temperature.
D. Maximum Surge Current:
   
   1. The maximum 8 x 20 microsecond surge current pulse the SPD device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10 percent deviation of clamping voltage at a specified surge current.
   
   2. Listed by mode, since number and type of components in any SPD may vary by mode.

E. Protection Modes: This parameter identifies the modes for which the SPD has directly connected protection elements, i.e., line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

F. Surge Current per Phase:
   
   1. The per phase rating is the total surge current capacity connected to a given phase conductor.
   
   2. For example, a wye system surge current per phase would equal L-N plus L-G; a delta system surge current per phase would equal L-L plus L-G:
      
      a. The N-G mode is not included in the per phase calculation.

G. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e., for a 120 V system the L-N peak voltage is 170 V).

1.04 SUBMITTALS

A. Shop Drawings:
   
   1. See Section 01 33 10 for requirements for the submittal process.
   
   2. For named products, submit only a catalog cut sheet:
      
      a. For all other products, submit the data required as specified in Paragraph 1.04.A.4 of this Specification Section.
      
   3. See Section 40 90 00 for I&C requirements for the submittal process.
   
   4. Product technical data for non-specified models:
      
      a. Manufacturer's experience.
      
      
      c. Electrical and mechanical drawing showing unit dimensions, weights, mounting provisions, connection details and layout diagram of the unit.
      
      d. Create a Product Data Sheet for each different model number of SPD provided:
         
         1) Data in the Product Data Sheet heading:
            
            a) SPD Type per PART 2 of this Section.
            
            b) Manufacturer’s Name.
            
            c) Product model number.
2) Data in the Product Data Sheet body:
   a) Column one: Specified value/feature of every paragraph of
      PART 2 of this Specification Section.
   b) Column two: Manufacturer’s certified value confirming the
      product meets the specified value/feature.

3) Data in the Product Data Sheet closing:
   a) Signature of the manufacturer’s official (printed and
      signed).
   b) Title of the official.
   c) Date of signature.

B. Operation and Maintenance Manual:
   1. See Section 01 33 10 for requirements for the submittal process.
   2. See Section 40 90 00 for basic I&C requirements.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Provide devices from a manufacturer who has been regularly engaged in the
      development, design, testing, listing and manufacturing of SPDs of the types and
      ratings required for a period of 10 years or more and whose products have been
      in satisfactory use in similar service.
   2. Upon request, suppliers or manufacturers shall provide a list of not less than
      three (3) customer references showing satisfactory operation.

1.06 WARRANTY

A. The manufacturer shall provide a minimum of a five (5) year Limited Warranty from date
   of shipment against failure when installed in compliance with applicable national/local
   electrical codes and the manufacturer’s installation, operation and maintenance
   instructions.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers model numbers
   listed in the individual product paragraphs below are acceptable.

2.02 TYPE IC1 SPD

A. Approved Products:
   1. Eaton (Cutler-Hammer) AGPH12020.
   2. ASCO (EDCO) HSP121BT-1RU.
   3. Approved Substitute.

B. Standards: UL 1449.
C. Design:

1. General:
   a. Mounted internally to control panels for point-of-use loads.
   b. MOV based or multi-stage hybrid solid state high performance suppression system.
   c. Designed for series connection.
   d. Enclosure: Metallic or plastic, flange or DIN rail mounting.
   e. Field connection: Provide unit with external terminal screws for each phase, neutral and ground that will accept #14 through #12 conductors.
   f. Device monitoring: Long-life, solid state, externally visible indicators that monitors the on-line status of the unit’s suppression filter system or power loss in any of the phases.

2. Operating voltage: 120 Vac.
3. Operating current: 15 A minimum.
4. Operating frequency: 47 to 63 Hz.
5. Modes of protection: All modes, L-N, L-G and N-G.
6. Maximum continuous operating voltage: Less than 130 percent of system peak voltage.
7. Maximum surge current: 20,000A per phase, 10,000A per mode minimum.
8. Fusing: Optional integral unit level and/or component level short circuit and/or thermal overload protection:
   a. External protection as recommended by manufacturer.
9. Maximum clamping voltages, dynamic test with voltages measured from the zero voltage reference and 90 degree phase angle:

<table>
<thead>
<tr>
<th>SYSTEM VOLTAGE</th>
<th>TEST MODE</th>
<th>IEEE C62.41</th>
<th>UL 1449</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-N = 120 V</td>
<td>L-N</td>
<td>400 V</td>
<td>300 V</td>
</tr>
<tr>
<td></td>
<td>L-G</td>
<td>500 V</td>
<td>400 V</td>
</tr>
<tr>
<td></td>
<td>N-G</td>
<td>500 V</td>
<td>400 V</td>
</tr>
</tbody>
</table>

2.03 TYPE IC4 SPD

A. Approved Products:
1. Eaton (Cutler-Hammer) AGCF02410.
2. Citel DS2xx-24DC.
3. Eaton (Bussman) BSPH2A24D24LV.
4. Approved Substitute.
B. Standards: UL 1449.

C. Design:
   1. General:
      a. Mounted internally to control panels for low voltage DC loads.
      b. MOV based or multi-stage hybrid solid state high performance suppression system.
      c. Designed for series connection.
      d. Enclosure: Metallic or plastic, DIN rail mounting.
      e. Field connection: Provide unit with external terminal screws for each DC+, DC- and PE that will accept #18 through #12 conductors.
      f. Device monitoring: Long-life, solid state, externally visible indicators that monitors the on-line status of the unit’s suppression filter system.

   2. Operating voltage: 24 Vdc.
   3. Operating current: As required by application with 1 amp minimum.
   4. Maximum continuous operating voltage: 30 Vdc.
   5. Maximum current: 6 kA, 8kA or 10 kA.
   6. Standards: Meet UL508A requirements.
   7. Fusing: Optional integral unit level and/or component level short circuit and/or thermal overload protection:
      a. External protection as recommended by manufacturer.

2.04 TYPE IC8 SPD

A. Approved Products:
   1. Eaton (Bussmann) BSPD Series.
   2. ASCO 100 Series (EDCO PC642 Series)
   3. Eaton (MTL) SD Series.
   5. Approved Substitute.

B. Standards: UL 497B.

C. Design:
   1. General:
      a. Mounted internally to control panels for protection of equipment connected to data lines (RS485, RS232, telephone line, 4-20mA, etc.).
      b. Multi-stage hybrid solid state high performance suppression system.
      c. Designed for series connection.
d. Enclosure: Metallic or plastic, flange or DIN rail mounting.
e. Field connection: Provide unit with external terminal screws for line and ground conductors.

2. Operating voltage: Nominal unit operating voltage and configuration as specified or as indicated on the Drawings.

3. Modes of protection: All modes.

4. Maximum continuous operating voltage: Less than 130 percent of system peak voltage.

5. Maximum surge current: 20,000 A.

6. Minimum repetitive surge current capacity:
   a. The SPD shall meet one (1) of the following:
      1) 1000 occurrences of a 200A, 10 x 1000 microsecond waveform.
      2) 400 occurrences of a 500A, 10 x 1000 microsecond waveform.
      3) 100 occurrences of a 400A, 10 x 700 microsecond waveform.
      4) 100 occurrences of a 2000A, 8 x 20 microsecond waveform.
      5) 10 occurrences of a 10,000A, 8 x 20 microsecond waveform.

7. Maximum clamping voltages, L-L (Pos-Neg):
   a. The SPD shall meet one (1) of the following:
      1) 400A, 10x700 microsecond waveform: 400 percent of system voltage.
      2) 10,000A, 8x20 microsecond waveform: 400 percent of system voltage.
      3) IEEE B3 combination wave: 250 percent of system voltage.

8. Maximum clamping voltages, L-G:
   a. The SPD shall meet one (1) of the following:
      1) 400A, 10x700 microsecond waveform: 200 percent of system voltage.
      2) 10,000A, 8x20 microsecond waveform: 200 percent of system voltage.
      3) IEEE B3 combination wave: 300 percent of system voltage.

2.05 SOURCE QUALITY CONTROL

A. Performance tests to be performed or independently verified by a certified testing laboratory.

B. The SPD are to be tested as a complete SPD system including: Integral unit level and/or component level fusing.
PART 3 – EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer’s instructions.

B. Demonstrate system in accordance with Section 40 98 00.

C. Type IC1 SPD:
   1. Provide on the following applications:
      a. Incoming 120 V power to all control panels.
      b. Line side of 120 V power terminals to equipment (e.g., PACs, transmitters).
   2. Connected in series with the panel's or equipment's branch circuit.
   3. Provide fuse protection as recommended by manufacturer.
   4. Flange mount or DIN rail mount in control panel.
   5. Connect all SPDs in the panel to the same grounding point.

D. Type IC4 SPD:
   1. Provide on the following applications:
      a. Incoming 24 V power to all control panels.
      b. Line side of 24 V power terminals to equipment (e.g., PACs, transmitters, indicators).
   2. Connected in series with the panel's or equipment’s branch circuit.
   3. Provide fuse protection as recommended by manufacturer.
   4. DIN rail mount in control panel.
   5. Connect all SPDs in the panel to the same grounding point.

E. Type IC8 SPD:
   1. Provide on the following applications:
      a. On both ends of data lines that interconnect devices that are located outdoors or in remote buildings or structures where the conductors are routed above grade or underground:
         1) Frame relay system.
   2. Connect in series with the equipment.
   3. Flange mount or DIN rail mount in control panel.
   4. Connect all SPDs in the control panel to the same grounding point.
   5. Verify SPDs series resistance and capacitance does not interfere with the data line signal.

END OF SECTION 40 99 00
PART 1 - GENERAL

1.01 SUMMARY

A. Scope:

1. This section specifies submersible pumps suitable for pumping surface water runoff at infinitely variable speed. Pumps furnished under this specification shall have discharge nozzles greater than 4 inches in diameter and shall have motors 7.5 horsepower and larger.

2. Each pump will be driven by a single variable speed drive provided under Section 26 24 19. The pump vendor shall submit a letter of confirmation on the suitability for use of the Contractor's proposed drive selection.

3. Pumps will be installed in a wet-pit configuration.

4. Pump units shall be complete with motor, inlet nozzle, discharge fitting, guide bar and brackets, chain and cable hooks and other accessories as specified. Each submersible pump will have a sump access frame, hatch and fall protection system as provided under Section 08 31 20.

5. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001. Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized.

6. Equipment shall additionally conform to the requirements of Section 40 05 05 with the exception that provisions of Section 40 05 05-1.05 and Section 40 05 05-1.07 do not apply unless of specifically called out in this project specification.

B. Type:

1. Pumps shall be of the heavy-duty, submersible, vertical shaft, centrifugal nonclog type, suitable for pumping surface water runoff. The pumps shall be designed for continuous or cyclic operation under submerged, partially submerged or totally dry condition without damage to the pump and motor. Special attention shall be devoted to the shaft design to limit deflection under all operating conditions, as specified in this section.

C. Equipment List:

<table>
<thead>
<tr>
<th>Item</th>
<th>Equipment Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood Control Pump 1</td>
<td>P-0111</td>
</tr>
<tr>
<td>Flood Control Pump 2</td>
<td>P-0112</td>
</tr>
<tr>
<td>Flood Control Pump 3</td>
<td>P-0113</td>
</tr>
<tr>
<td>Flood Control Pump 4</td>
<td>P-0114</td>
</tr>
</tbody>
</table>
1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. References shall be as listed in Section 40 05 05.

1.03 DEFINITIONS

A. Terminology used in this section conforms to the following definitions:

1. Equipment Pad: concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade

2. Mounting Pads: thickened or raised areas of baseplates and soleplates where the feet or mounting surfaces of mounted equipment and drivers rest on the baseplate or soleplate

1.04 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 08 31 20
2. Section 26 24 19
3. Section 40 05 01
4. Section 40 05 02
5. Section 40 05 05
6. Section 40 05 06

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. See Section 00 72 00.

2. Coordinate pump and motor operational and starting characteristics with adjustable-frequency drive settings used for control of this equipment. A system curve is available upon request from the Construction Manager. Include the following:

   a. Motor minimum operational speed
   b. Motor maximum operational speed
   c. Motor ramp-up and ramp-down speed, voltage, and hertz requirements
   d. Other operating limits that are imposed by the driven equipment for operation and warranty
B. Unit Responsibility:

1. Assign unit responsibility, as specified in Section 40 05 01, to the manufacturer of the vertical, nonclog submersible pumps provided for all equipment and accessories under this section. Have all mechanical equipment components, at least, of this entire equipment assembly furnished by the pump’s manufacturer. Provide a completed, signed, and notarized Certificate of Unit Responsibility (Form 11000-C, Section 01900). Additionally, the manufacturer shall review submittal data for the variable speed drive units that are proposed by the Contractor under Section 26 24 19. The manufacturer shall submit a letter indicating whether the proposed units are satisfactory or not for use with the pumps in this section.

1.06 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 10.

2. Submittals shall conform to the requirements of Section 40 05 05. A copy of this Section, addendum updates included, along with the sections listed below shall be submitted with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.

a. This Section (43 23 80.15)

b. Section 40 05 01

c. Section 40 05 02

d. Section 40 05 05

e. Section 40 05 06

3. The specification copies shall be complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

4. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
5. Unit Responsibility Certification form (Form 11000-C) attesting that unit responsibility has been assigned in accordance with the requirements of this Section and Section 40 05 01. No other submittal material will be reviewed until the certificate has been found in conformance with this requirement.

6. Predicted pump performance curves for each condition point specified showing head, power, efficiency, and NPSH3 on the ordinate plotted against capacity on the abscissa. Curves shall be provided to demonstrate operation at all speeds required to achieve the specified reduced speed operating conditions. All curves shall clearly display the specified operating conditions, POR and the manufacturer's limits for the AOR.

7. Drawings showing general dimensions and confirming the size of pumps, motors, drives and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; and weight of equipment.

8. Manufacturer's data including materials of construction and equipment weight.

9. Motor Data Form 40 05 06 -A.

10. Proof of service of previously installed units of similar size and configuration in wet wells of the type specified in this Section.

11. Written factory tests report, as specified in paragraph 2.09.


13. Anchorage calculations and required documentation.


15. Manufacturer's operation and maintenance information in accordance with Section 01 78 23.

16. Installation Forms in accordance with Section 40 05 01.

17. 5-Year warrantee in accordance with paragraph 1.09.

18. Testing Forms in accordance with Section 01 75 00.


20. Field discharge connection leakage test video files in accordance with paragraph 3.03.

B. Informational Submittals:

1. Procedures: Section 01 33 10

2. Submittals shall conform to the requirements of Section 40 05 05.

3. Letter of confirmation of suitability of variable frequency drives being provided by the Contractor for this equipment in accordance with Section 26 24 19.

4. Coordination items required for proper setup of the variable frequency driver as specified in paragraph 1.05.A. Coordination.
C. Closeout Submittals:
   1. Operating and maintenance submittals:
      a. Procedures: Section 00 72 00.
   2. Spare parts:
      a. Procedures: Section 40 05 01. Provide the following spare parts for each model and size of pump furnished for this Section:
      b. One complete set of all gaskets and seals
      c. Two complete sets of all bearings
      d. Two complete sets of mechanical seals
      e. Two complete sets of discharge connection sealing devices
      f. One removable cable seal chamber cap with cable length as required in this Section.
      g. If oil-filled motor is furnished, provide spare oil in sufficient quantity to allow for one-time flushing and replacement of coolant for all installed pumps.
      h. One impeller

1.07 QUALITY ASSURANCE
A. Qualifications:
   1. Independent testing agent hired by the Contractor for field vibration testing: Section 40 05 05.
B. Critical Speeds: Critical Speeds shall be in accordance with Section 40 05 05-1.04 except when the title of the detailed section includes “Custom Engineered” in which case Section 40 05 05-1.05 applies.
C. Vibration Limits: Vibration limits for submersible pumps shall be in accordance with ANSI/HI 11.6. Field testing shall be in accordance with paragraph 3.03 of this section.

1.08 DELIVERY, STORAGE, AND HANDLING
A. Procedures: Section 00 72 00
B. Block shaft and prevent damage to bearings during shipment

1.09 SPECIAL WARRANTY
A. Provide a Special 5-Year Warranty. The manufacturer shall warrantee the pumps provided under this section against defects in materials and workmanship for 5 years.
PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer’s standard product may require modification to conform to specified requirements:
   1. Xylem - Flygt
   2. KSB
   3. Approved Equal

2.02 TYPE
A. Heavy-duty, submersible, vertical shaft, centrifugal nonclog type, suitable for pumping fluids containing unscreened wastewater solids.

2.03 PERFORMANCE/DESIGN CRITERIA
A. Service Conditions:

<table>
<thead>
<tr>
<th>Description</th>
<th>Equipment number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid type</td>
<td>Screened surface runoff.</td>
</tr>
<tr>
<td>Fluid temperature</td>
<td>40 to 75 degrees F</td>
</tr>
</tbody>
</table>

B. Operating Conditions:
1. The performance requirements presented in tabular form below are intended to describe the results of hydraulic calculations developed using a mathematical modeling program specifically developed for the purpose. The model was intentionally used to develop the limits of expected extremes in variation of static head, coefficients for pipeline resistance and turbulence losses through fittings and valves.
2. Equipment furnished under this section shall be fully suitable for continuous operation at any specified condition or any condition lying between the extremes of the operating conditions specified in the following table. The total head in the information below is the total system head at the operating capacity, essentially a summation of the head of the two pumps at that capacity. The notes presented at the end of the table are intended to be complimentary to the information presented in the table.
### C. Table of Operating Conditions:

<table>
<thead>
<tr>
<th>Operating Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment number</td>
<td>P-0111</td>
</tr>
<tr>
<td></td>
<td>P-0112</td>
</tr>
<tr>
<td></td>
<td>P-0113</td>
</tr>
<tr>
<td></td>
<td>P-0114</td>
</tr>
<tr>
<td>Full-speed operation, Condition A</td>
<td></td>
</tr>
<tr>
<td>Capacity, mgd</td>
<td>11.4</td>
</tr>
<tr>
<td>Total head, feet</td>
<td>23.1</td>
</tr>
<tr>
<td>NPSHA, feet</td>
<td>42.9</td>
</tr>
<tr>
<td>Full-speed operation, Condition B</td>
<td></td>
</tr>
<tr>
<td>Capacity, mgd</td>
<td>From pump H/Q curve</td>
</tr>
<tr>
<td>Total head, feet</td>
<td>25.1</td>
</tr>
<tr>
<td>NPSHA, feet</td>
<td>40.5</td>
</tr>
<tr>
<td>Runout to High-High alarm, Condition C</td>
<td></td>
</tr>
<tr>
<td>Capacity, mgd</td>
<td>12.0</td>
</tr>
<tr>
<td>Total head, feet</td>
<td>22.2</td>
</tr>
<tr>
<td>NPSHA, feet</td>
<td>44.31</td>
</tr>
<tr>
<td>Reduced-speed operation, Condition D</td>
<td></td>
</tr>
<tr>
<td>Capacity, mgd</td>
<td>9.7</td>
</tr>
<tr>
<td>Total head, feet</td>
<td>24.6</td>
</tr>
<tr>
<td>NPSHA, feet</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. Condition A shall be taken as the rated operating condition. Performance at the rated condition shall be guaranteed in accordance with Section 40 05 05. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this section shall be selected to achieve Condition A performance, and also shall operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and published in the manufacturer’s published application data for the specific model proposed for this application.

2. Condition B head is presented to indicate operating conditions when the pump is operating at maximum speed against maximum anticipated system head, assuming a hypothetical head-capacity curve. Condition B shall be used for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer’s published application data for the specific model proposed for this application. Condition B shall be located to the right of BEPQ and shall be not less than (Insert minimum percent) percent of BEPQ. Pumps with head-capacity curves steeper than that assumed will produce somewhat less flow at somewhat lower head. The reverse will occur with pumps having a shallower head-capacity curve. Proposed pump selections meeting this discharge head requirement by operating the equipment at less than full speed will be rejected.

3. Condition C is the anticipated continuous duty minimum speed condition. Pumps furnished under this specification shall be capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 40 05 05. Condition C shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer’s published application data for the specific model proposed for this application.
4. Condition D represents the expected momentary (startup/shutdown) condition. Pumps furnished under this specification will operate for no more than 30 seconds at this condition when initiating or terminating a service cycle. The maximum anticipated number of service cycles is 12 per day.

5. Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 1.1 – 1.6. Net positive suction head available (NPSHA) in the above tabulation is referred to the pump inlet piping at centerline elevation as shown and is calculated in accordance with ANSI/HI 1.3 for average barometric pressure and maximum temperature conditions. NPSHA at the pump impeller eye can be determined by adjusting the given value by proposed pump dimensions and the indicated requirements for pump installation details. An allowance of five feet has been included for the presence of volatile constituents in the pumped fluid. Required NPSHA margin shall be as specified in Section 40 05 05.

D. Design Requirements:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment number</td>
<td>P-0111</td>
</tr>
<tr>
<td></td>
<td>P-0112</td>
</tr>
<tr>
<td></td>
<td>P-0113</td>
</tr>
<tr>
<td></td>
<td>P-0114</td>
</tr>
<tr>
<td>Pump</td>
<td></td>
</tr>
<tr>
<td>Rigid sphere, inches diameter (min.), capable of passing through the</td>
<td>4/3</td>
</tr>
<tr>
<td>pump from inlet to discharge (Impeller Alternate 1/Alternate 2)</td>
<td></td>
</tr>
<tr>
<td>Minimum efficiency at best efficiency point (BEP) at maximum speed,</td>
<td>70</td>
</tr>
<tr>
<td>percent ^1</td>
<td></td>
</tr>
<tr>
<td>Piping connection size, inches, minimum</td>
<td></td>
</tr>
<tr>
<td>Pump inlet</td>
<td>24</td>
</tr>
<tr>
<td>Pump discharge</td>
<td>20</td>
</tr>
<tr>
<td>Inlet bell outer diameter, minimum ^2</td>
<td>26</td>
</tr>
<tr>
<td>Operating speed, rpm, maximum</td>
<td>710</td>
</tr>
<tr>
<td>Operating speed, constant or variable</td>
<td>variable</td>
</tr>
<tr>
<td>Approximate pump suction centerline elevation, feet, NAVD 88</td>
<td>-6.5</td>
</tr>
<tr>
<td>Suction specific speed, dimensionless, maximum ^3</td>
<td>9,000</td>
</tr>
<tr>
<td>Motor</td>
<td></td>
</tr>
<tr>
<td>Maximum Horsepower</td>
<td>60</td>
</tr>
<tr>
<td>Type</td>
<td>Submersible, explosion proof</td>
</tr>
<tr>
<td>Inverter duty</td>
<td>Yes</td>
</tr>
<tr>
<td>Maximum inverter rated input current</td>
<td>118 amps</td>
</tr>
<tr>
<td>Space heater</td>
<td>No</td>
</tr>
<tr>
<td>Over temperature protection</td>
<td>Yes</td>
</tr>
<tr>
<td>Moisture sensors</td>
<td>Yes</td>
</tr>
<tr>
<td>Operating speed, rpm, maximum</td>
<td>710</td>
</tr>
<tr>
<td>Voltage/Phase</td>
<td>460 VAC, 3 Phase</td>
</tr>
</tbody>
</table>
Notes:
1. The minimum acceptable efficiency at best efficiency point (BEP) at the speed required to achieve the performance specified under Condition Points A and B. The minimum acceptable efficiency is not necessarily required to be associated with any operating condition specified in paragraph 2.03 Operating Conditions.
2. The inlet velocity shall not exceed 6 feet per second at Condition Point B as specified in this Section. A suction nozzle will be required to reduce the suction velocity to 6.0 feet per second or less, and the nozzle length must exceed the difference between the inlet and outlet diameter of the nozzle.
3. The suction specific speed limitation listed applies only to pump selections where both Operating Conditions A and B reside within the proposed pump selection’s POR. Proposed selections with Operating Condition A residing in the AOR shall be limited to designs with suction specific speed less than 8500. Suction specific speed shall be calculated for the maximum pump design speed and impeller diameter, using the capacity in gallons per minute and NPSH3 at Best Efficiency in accordance with the procedures set forth in the standards of the Hydraulic Institute.

2.04 SYSTEM OPERATION

A. The pumps will be installed in a ventilated reinforced concrete structure designed to provide sufficient space for access to install and remove the equipment. The pumps will obtain the pumped fluid from a trench-type self-cleaning wet well designed in accordance with ANSI/HI 9.8. In this application, the pumps will be operated at variable speed, responding to a control system that will cycle and vary the speed of the pumps in accordance with the specified program. Under normal operation, there will be no cascade into the wet well and the wet well level will vary between the levels indicated.

B. The pumps will be operated by a control system configured to control wet well liquid surface elevation. This objective will be achieved by adjusting pump speed to match the pumping rate to the rate of inflow into the wet well. The pump drives will be adjusted to establish minimum speed when the wet well is at preset low elevation. Pump speed control increments and sequenced starts of additional pumps will be initiated based on rising wet well level. Pumps will be at maximum speed when the liquid level is at the preset maximum level.

C. System controls allow for wet well cleaning. At intervals estimated to be nominally one week in length, but possibly as little as three days, operating staff will manipulate station wet well level controls to lower the wet well level to clean the wet well of accumulated solids. Solids will be removed from the wet well by operating the pumps until they break suction. Equipment furnished under this section shall be specifically certified by the pump manufacturer as suitable for operation in trench type wet wells where the wet well will be cleaned using the pumping equipment.

2.05 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Provide materials of construction in accordance with the following table:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump and motor casing</td>
<td></td>
</tr>
<tr>
<td>Rated head &lt; 100 feet</td>
<td>Cast iron, ASTM A48, Class 30 or 35</td>
</tr>
<tr>
<td>Rated head &gt; 100 feet</td>
<td>Cast ductile iron, ASTM A 536, Class 65-45-12</td>
</tr>
<tr>
<td>Discharge elbow</td>
<td>Cast iron, ASTM A48, Class 30 or 35</td>
</tr>
</tbody>
</table>
### COMPONENTS

#### A. General:

1. The motor and rotating parts shall be removable from the motor end of the pump. All motor mating surfaces where watertight sealing is required shall be machined and fitted with nitrile O-rings. The pump shall be fitted with a dynamically balanced nonclog impeller designed to pass coarse solids and stringy materials. The pump shall be listed by Factory Mutual or Underwriters Laboratory as conforming in all respects to the requirements in UL 1207.

#### B. Casing:

1. The volute casing shall be a one-piece casting with a tangential or center discharge nozzle. The volute shall be designed for efficient conversion of kinetic to potential energy and shall have clear passageways designed to pass the solid sphere specified in this Section. The solids passing capability of the furnished equipment will be subjected to a field test in accordance with this Section. The solids passing capability of the furnished equipment will be subjected to a field test in accordance with paragraph 3.03.

2. The cutwater shall be specifically designed for use in fluids with stringy solids and rags. The volute casting shall be specifically designed to bear the loads associated with removal and placement of the pump when submerged or exposed and to withstand the loads imposed by the operations specified in this Section. The discharge nozzle shall be not less than the diameter specified in this Section and shall be reinforced for the loads imposed by the specified conditions of service. The nozzle flange face shall be designed to mate with the discharge fitting specified in this Section. The volute casing shall be drilled and tapped or otherwise fitted with an inlet nozzle conforming to the requirements specified in this Section.
C. Shaft:
   1. The pump shaft shall be turned, ground and polished, of proportions suitable for use in the specified application. The shaft shall be of sufficient section to limit deflection at the shaft seal to not more than 4.0 mils when the pump is operating at any continuous-duty point defined by the envelope of conditions specified in this Section. The method for calculating shaft deflection shall be as established in Section 40 05 05. Additionally, under no circumstances shall the distance from the lower bearing and the hub of the impeller exceed two times the diameter of the shaft. The documentation required under Section 40 05 05 shall be included as a submittal.

D. Bearings:
   1. Bearings shall be heavy-duty, oil lubricated or permanently greased lubricated anti-friction type double shielded and factory sealed. Bearings shall be designed for an L-10 rating life of at least 50,000 hours at any operating condition specified in this Section. Loads for radial bearing calculations shall be calculated in accordance with this Section. Bearings isolators in accordance with 40 05 05 are not required for submersible pumps.

E. Impeller:
   1. Alternate 1: The impeller shall be dynamically balanced with a non-clogging design capable of passing solids, fibrous materials, heavy sludge, and other matter found in normal sewage applications through to the discharge nozzle. Impellers for pumps with discharge nozzles 4 inches in diameter and greater shall be not less than two-vane design. Fit between the impeller and the shaft shall be a sliding fit with a taper-lock bushing pressed by a screw that is threaded into the end of the shaft, or a slip fit onto the shaft and drive key and fastened to the shaft by an impeller nut having cover for protection from pumped fluid. A wearing ring system designed for abrasion resistance shall provide efficient sealing between the volute and impeller.

   2. Alternate 2: The impeller shall be statically balanced, semi-open, multi-vane, back-swept, non-clog design. The impeller vane leading edges shall be mechanically self-cleaned upon each rotation as they pass across a spiral groove located on the volute suction which shall keep them clear of debris, maintaining an unobstructed leading edge. The impeller(s) vanes shall have screw-shaped leading edges capable of handling solids, fibrous materials, heavy sludge and other matter found in waste water. The screw shape of the impeller inlet shall provide an inducing effect for the handling of sludge and rag-laden wastewater. Impellers shall be locked to the shaft and shall be coated with alkyd resin primer.
F. Mechanical Seals:

1. The pump shall be provided with a tandem double mechanical seal running in an oil reservoir, composed of two separate lapped face seals. The lower seal unit, between the pump and oil chamber, shall consist of one stationary and one positively driven, rotating tungsten-carbide or silicon-carbide ring, with each pair of rings held in contact by a separate spring. The upper seal unit, between the oil sump and the motor housing, shall consist of one stationary tungsten-carbide or silicon-carbide ring and one positively driven tungsten carbide, or silicon-carbide ring. Ceramic seals will not be acceptable. The seals shall require neither maintenance nor adjustment and shall be easily replaceable. Conventional double mechanical seals with a single or a double spring between the rotating faces, or that require constant differential pressure to effect sealing and are subject to opening and penetration by pumping forces, will not be acceptable. The pump shall be capable of continuous submergence without loss of watertight integrity to a depth of 65 feet. The mechanical seal shall accommodate the manufacturer’s shaft deflection at the seal face and shaft angularity with a safety factor of 3.

2. Each pump shall be provided with a seal lubricant chamber for the shaft sealing system. The seal lubricant chamber shall be designed to assure that an air pocket is provided in the seal lubricant chamber, to absorb the expansion of the seal lubricant due to temperature variations. The drain and inspection plug with positive anti-leak seal shall be easily accessible from the outside.

G. Motor:

1. The pump motor shall be a squirrel-cage induction, shell type design, housed in an air-filled or an oil-filled, watertight chamber, NEMA B type Inverter Duty with a service factor of 1.15 based upon nameplate rating. Motor shall be rated for operation with VFD. The manufacturer shall furnish an unqualified warranty guaranteeing (full replacement at no cost to the City) the performance of the motors furnished under this project for a period of five years when operating under the specified conditions.

2. The stator winding and stator leads shall be insulated with moisture resistant Class H insulation, which shall be rated at a temperature of 180 degrees C. Motor shall be provided with thermal sensors to protect the motor from excessive heating. Thermal sensors shall be as specified in this Section. The temperature rise of the motor shall not be in excess of that specified in NEMA MG-1 for class B insulating materials when operating continuously under load.

3. Motors shall be Factory Mutual or UL listed in accordance with UL 674 and 1207 for Class I, Group D hazardous atmospheres.

4. The motor shall be designed for continuous duty in air and in 95 degree Fahrenheit water, capable of sustaining a minimum of 20 starts per hour when operated with variable frequency motor controllers.

5. The junction chamber, containing the terminal board, shall be hermetically sealed from the motor. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to a terminal board.
H. Cooling system:
   1. The cooling system may rely on radiation of excess heat energy to the fluid in the
      wet well or, alternatively, shall be provided a closed circuit circulating system
      utilizing glycol or heat transfer oil, which shall in turn circulate to a heat
      exchanger incorporated into the cavity behind the pump impeller. It is specifically
      required that the cooling system be compatible with the contemplated control
      schedule, which may require that the motor case to be exposed continuously or
      intermittently.
   2. The cooling jacket shall encircle the stator housing to provide cooling for the
      motor under all conditions (i.e., submerged or non-submerged).
   3. The cooling system shall not employ the pumped fluid to directly cool the motor
      through wastewater passageways incorporated into the motor shell.
   4. The system shall be designed to prevent clogging by virtue of dimensions and
      configuration and shall be specifically configured to maintain motor temperatures
      within conservative limits.

I. Temperature Sensors:
   1. The stator shall be equipped with three thermal sensors, embedded in the end
      coils of the stator winding (one sensor in each stator phase). These shall be
      wired to the specified motor protection relay for motor protection.

J. Moisture Detection:
   1. Provide motors with a moisture detection system.
      a. A primary moisture detector shall be provided in the stator housing
         leakage chamber.
      b. A second moisture detector shall be located in the motor junction box or
         inspection chamber.
   2. All moisture detectors shall be wired to the motor junction box for connection to
      the specified motor protection relay.
   3. Moisture detectors shall be either mechanical float switch or capacitance probe
      type as recommended by the manufacturer.

K. Motor Protection Relay:
   1. Provide motor protection relay to protect motor from high temperature and
      moisture.
   2. During normal pump operation, the temperature switch shall be closed and the
      leakage switch shall be normally open. Sensor circuit shall operate on 12 or 24
      VDC feed from the main relay body. The relay shall be provided with LEDs to
      indicate status of relay on face for leakage, temperature, and supply voltage.
   3. Latch detection of open temperature switch. An external reset shall be required
      to clear alarm. Retain relay state during power failures for temperature.
   4. Moisture detection shall auto reset.
   5. Power supply shall be 120 VAC.
   6. Provide one SPDT contact for remote over-temperature alarming. Provide one
      SPDT contact for remote moisture detection alarming.
7. Relay shall be UL or UR approved, suited for panel installation.

8. Relay shall be mounted inside the associated pump's motor controller panel. Mounting shall be DIN rail mount or back panel mount. Coordinate to provide relay for installation at the shop where the associated motor controller is being fabricated. Coordinate size, wiring, and mounting of the relay into the motor controller.

9. Relay manufacturer shall be Xylem-Flygt, ATC Diversified Electronics, Dwyer, or approved substitute.

L. Variable Frequency Drives:

1. The variable frequency drive will be provided by the Contractor under Section 26 24 19 and will conform to the requirements of Section 26 24 19, the Contract electrical one-line diagrams, and the Contract wiring diagrams.

M. Cables:

1. Cable:
   a. The pump shall have two cables. One cable shall be for power, and one cable shall be for control (the motor thermal sensors and moisture detector). The cable design shall be suitable for installation in a municipal wastewater pumping station. The cable length shall not exceed the product manufacturer’s recommended length. The Contractor shall be responsible for determining the length of cable required to wire the motors and sensors from the wet well to the terminal boxes. The Contractor shall provide additional cable length for slack to allow the pumps to be removed from the wet well. The length of cable for slack shall be based on the pump manufacturer’s recommendation.

2. Cable Seal:
   a. The cable entry water seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall be comprised of individual cylindrical elastomer clamps having a close tolerance fit against the cable conductor insulation and the entry inside diameter and compressed by the entry body containing a strain relief function, separate from the function of sealing the cable. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland, potting chamber or terminal board, which shall isolate the motor interior from foreign material gaining access through the pump top. If a potting chamber is used, the potting procedure shall employ an epoxy-potting compound combined with a procedure that insures penetration of the compound into the individual cable conductor strands to prevent development of wicking pathways for entrance of water into the motor.
3. Cable Disconnection:
   a. The pump shall be designed such that power/ control cable can be removed from the pump motor without breaking the cable seal. The power/ control cable shall be sealed to a removable motor chamber cap that shall be universally mateable to the same manufacturer’s pump series. The pump shall be able to be removed from the wet well and disconnected from the cable by removing the motor chamber cap. A spare removable chamber cap with 15 feet of cable shall be provided.

N. Terminal Boxes: A terminal box shall be provided for each submersible pump. Cords from the pumps shall be connected to the terminal boxes with plugs. The contractor shall terminate submersible cables into plugs to mate up with receptacles located in the terminal boxes per this section.

1. Boxes, Plugs, and Receptacles:
   a. Class I, Division 1, Group D.
   b. Water tight.
   c. The receptacle/plug shells shall be machined from Stainless Steel type 316.
   d. See the drawings for information about boxes, conduits, and cords.
   e. Terminals per specification Section 26 05 33.

2. Pump terminal box:
   a. Contain a ground stud bonded to the enclosure and support four #8 AWG crimped one hole standard barrel terminal lugs.
   b. Box shall have two receptacles/plugs on the bottom. One receptacle/plug for motor power and one receptacle/plug for motor sensors.

3. Acceptable plug/receptacle manufacturers:
   a. Vantage Technologies
   b. Or approved substitute

O. Inlet Nozzle:

1. The wet well design has been developed on the basis of a limiting velocity at the pump inlet of 4 feet per second and a confined inlet designed for cleaning by operating the pump until it breaks suction. Inlet nozzles are required for all pumps with entrance velocities exceeding this limitation. If a nozzle is required, the pump casing shall be drilled and tapped to receive an inlet nozzle and bell fitting to extend the pump inlet connection into the confines of the wet well or sump to achieve the floor separation required by the Hydraulic Institute Intake Standard (ANSI/HI 9.8). The inlet nozzle may be of commercially available forged steel fittings or cast iron and shall have a smooth, flared transition from a bell fitting at the entrance to the nozzle and a smooth, direct entry to the connection at the impeller inlet. The final configuration of the inlet bell and nozzle shall be selected to efficiently convey the pumped fluid into the impeller eye. Dimensions shall be as specified in this Section.
P. Pump Discharge Connection Seal:

1. The connection between the pump discharge connection shall be fitted with a means of sealing. The seal may be either a replaceable dynamic seal or a metal-to-metal seal to effect a complete closure between the pump discharge flange and the mating connection on the anchor fitting described in this Section. Leakage through the seal shall not exceed 1.5 percent of the flow specified for Condition Point A when operating at pump shutoff head and not more than 1 percent of total pump flow at Condition Point B. The seal shall be subject to field test for acceptance in accordance with the requirements of this Section.

2. The dynamic type of seal shall affect a seal meeting the requirements of this paragraph using the head developed by the pump when in operation to expand the sealing device, which may be of metallic or elastomeric construction, against the inner contours of the discharge fitting. The design of the seal shall incorporate features to protect the integrity of the seal during the pump removal/setting process.

Q. Pump Anchorage, Guide System and Access Cover:

1. The pump shall be provided with a guide system to allow easy removal of the pump without entering the wet well. The guide rail system may be of either the single or dual rail type. The discharge connection shall be bolted to the structure as indicated and shall serve as a lower attachment for the guide rails. The discharge connection shall be either horizontal or elbow discharge type, as indicated. The anchorage system shall be designed to transmit the forces specified in this Section safely to the structure. Calculations and supporting documentation justifying the support design shall be provided with the submittals required under Section 40 05 05.

2. The pump and guide rail system shall be designed to automatically connect the pump to the discharge piping when lowered into place on the discharge connection. The design shall be non-sparking and shall conform to UL requirements for installation in a location classified in accordance with NFPA 70, Article 500 for Class 1, Group D, Division 1 locations. The pump shall be easily removable for inspection or service, requiring no bolts, nuts, or other fastenings to be removed for this purpose, and no need for personnel to enter the pump wet well or sump. Sealing of the pumping unit to the discharge connection shall be accomplished by a simple linear downward motion of the pump with the entire weight of the pumping unit guided to and pressing tightly against the discharge connections. No portion of the pump shall bear directly on the floor of the sump and no rotary motion of the pump shall be required for sealing. Guide bars provided for directing the pump into position or for removing the pump for maintenance shall steer the pump into proper contact with the discharge elbow. Once the pump has been positioned on its support fitting at the discharge fitting, the guide bar system shall not be required for pump support.

3. Access frames and covers furnished by the Contractor shall be as specified in Section 08 31 20 and as shown on drawings. Hardware and miscellaneous attachments shall all be constructed out of ASTM A276, Type 316 stainless steel. Dielectric isolation shall be provided for dissimilar metals.
R. Accessories
   1. Pumps shall be provided with lifting chains, guide bars, upper guide bar brackets, intermediate guide bar brackets, cable holder assemblies, safety chain hook assemblies, discharge elbow connections, metric to english pipe increaser, anchor bolts, and all other accessories necessary to complete the installation as specified. All connecting hardware and miscellaneous attachments shall be constructed out of ASTM A276, Type 316 stainless steel. Dielectric isolation shall be provided for dissimilar metals.

2.07 EQUIPMENT AND SYSTEM CONTROLS
A. Section 40 90 05 specifies control system requirements.

2.08 FINISHES
A. Procedures: Section 09 90 00
B. Prime Coat: Shop applied, coating material per Section 09 90 00.
C. Finish Coat: Field applied, coating material per Section 09 90 00.

2.09 SOURCE QUALITY CONTROL
A. Provide non-witnessed factory testing at a location in the Continental United States and in accordance with Section 40 05 05-1.06
B. Submit factory testing results report in accordance with Section 40 05 05.
C. Hydrostatic tests:
   1. Factory-test all pressure-sustaining parts in accordance with Section 40 05 05.
D. Performance and NPSH tests:
   1. Subject each pump to performance and NPSH testing in accordance with Section 40 05 05 to verify the full range of operating condition
E. Motor tests:
   1. First check impeller, motor rating, and electrical connections for compliance with the specifications
   2. Subject all motor circuits to electrical resistance tests to confirm functionality

PART 3 - EXECUTION
3.01 EQUIPMENT MOUNTING
A. Procedure: Section 40 05 02
B. Position equipment pad and equipment anchors for final placement of equipment
C. Use a bolting template to position equipment anchors
D. Level mounting plates
E. Pour grout bed supporting each mounting plate
F. Eliminate grout voids below mounting plate
G. Tension equipment anchors
H. Provide the manufacturer’s written inspection report, completed standard installation checklists, and a written statement from the equipment manufacturer certifying that the installation of the equipment is in accordance with the manufacturer’s recommendations and the requirements of this Section and Section 40 05 02.

3.02 COATINGS

A. Finish Coating: see paragraph 2.08.

3.03 FIELD QUALITY CONTROL

A. Field Testing

1. Procedures: Section 01 75 00

2. Static Solid Pass Test:

a. Upon arrival and before installation in the project, each pump shall be given a solids pass test. The test shall consist of inserting a rigid ball of the diameter specified in paragraph 2.03 in the pump discharge opening. The Contractor shall demonstrate that the ball will pass clear though the pump to the inlet bell with no force other than the weight of the ball used to demonstrate compliance with the requirements of this Section.

3. Vibration Test:

a. Vibration levels shall be determined by affixing suitable sensors to the top of the motor housing in both the x-x (parallel to the nozzle) and y-y (perpendicular to the nozzle) directions. The Contractor or his designated testing agent shall provide all sensors and monitoring equipment.

b. As a condition precedent to final acceptance of the equipment, the pumps shall be individually operated at all specified operating conditions. The Contractor shall provide the means to recirculate pumped fluid or alternatively throttle the pumps to achieve the specified head at specified flow.

c. Vibration levels shall not exceed that specified in paragraph 1.07 when the pump is operating within the manufacturer’s listed POR as determined in accordance with Section 40 05 05. When operating at conditions outside the POR, vibration levels shall be no more than 125 percent of that specified in paragraph 1.07.
4.  Leakage Test:
   a. Leakage testing for each wet-pit pumps shall include five sets of tests, each set consisting of two tests, one with the pump operating against a closed discharge valve and one with the pump operating at Condition B, as specified in paragraph 2.03. Testing shall be scheduled with and witnessed by the Construction Manager. For each test the wet well shall be drawn down such that the pump discharge elbow is clearly visible prior to the test. Additional lighting shall be provided if necessary to clearly see leakage discharge, if any, from the discharge elbow connection. Each test shall be not less than 30 seconds in duration. Between each test set, the pump shall be lifted clear of its support bracket and re-lowered to connect again. The tests results shall be video recorded. The apparent average rate of leakage shall not exceed that specified in paragraph 2.06 Pump Discharge Connection Seal. If the discharge connection leakage rate at either against a closed valve or at Condition Point B exceeds the specified allowance, the Contractor shall cause the pump manufacturer to correct the defect and the pump shall be tested again as described in this paragraph. If the pump should fail the second test, the pump shall be removed from the site and the Contractor shall furnish a replacement which in turn shall be tested for acceptance in accordance with this paragraph. Video files shall be submitted.

B.  Manufacturer Services:
   1. On-Site Inspections and Training: Provide a factory-trained manufacturer’s representative at the Site for the following activities. Specified durations do not include travel time to or from the Site.
      a. Installation Inspections: Assist, supervise, and inspect the Contractor’s activities during installation. Provide 8 inspection hours. Provide a completed Form 40 05 01-A, Section 01 75 00.
      b. Component Test Phase Inspections: Assist, supervise, and inspect the Contractor’s activities during the system test phase specified in Section 01 75 00 and this Section. Provide 8 inspection hours.
      c. System Test Phase Inspections: Assist, supervise, and inspect the Contractor’s activities during the system test phase specified in Section 01 75 00. Provide 8 inspection hours.
      d. Operational Test Phase Inspections: Assist, supervise, and inspect the Contractor’s activities during the operational test phase specified in Section 01 75 00. Provide 8 inspection hours.
      e. Training Sessions: Procedures Section 01 75 00. Provide a minimum of 4 hours classroom training for each training session. Conduct two training sessions, one training session per week on two consecutive weeks to accommodate the shift schedules of operation and maintenance staff. Certify completion of training on Form 40 05 01-B, Section 01 75 00.

3.04 SYSTEMS START UP
   A. Procedures: Section 01 75 00.
   B. Preoperational (factory) testing; See paragraph 2.09.
C. Component testing: Perform the following tests.

1. During initial pump installation, verify on one pump that the crane system has the clearance and capacity to lift the wetted-end from the field mounted pump to accommodate routine pump maintenance. Provide or modify spreader bar or lifting assemblies as necessary to accomplish this task.

2. During initial pumping system installation, verify with clean water that the common pump discharge header can be readily drained to the pump room sump for maintenance or pump de-ragging without spilling on to the pump room floor.

3. Complete field testing in accordance with paragraph 3.03.

3.05 SYSTEM TESTING: PERFORM THE FOLLOWING TESTS

A. Submit a draft surge testing plan that will measure surge pressures for station pumping rates between station minimum and maximum design capacities in 10 increments starting with 10 percent above minimum and rising. Incorporate client review comments into final plan.

1. Perform surge testing in the presence of the engineer and construction manager. Cease testing if so directed.

2. If vibration and surge testing reveal that operation is impaired by poor operation of ancillary equipment (sticking check valves, plugged air/vacuum reliefs, improperly torqued flanges, etc.), repair ancillaries and retest pumps if directed by the owner.

3. After owner/engineer review of the vibration design professional’s draft and final reports for lateral vibration, participate with the owner and engineer in making any required adjustments to the pumping control strategy that may be required to avoid damaging vibrations, to protect the pumps and meet performance requirements.

END OF SECTION 43 23 80.15