TABLE OF CONTENTS

General Technical Specifications

TABLE OF CONTENTS
General Technical Specifications

SECTION 01045: EXISTING FACILITIES

PART - 1 GENERAL

A. **Description**

This section includes requirements for connection to and abandonment of existing water and sewer facilities.

B. **Related Work Specified Elsewhere**

1. Trenching, Backfilling and Compacting: 02223
2. Chlorination for Disinfection: 15041
3. Hydrostatic Testing of Pressure Pipelines: 15042
4. Leakage and Infiltration Testing: 15043
5. Manual Valves: 15100

C. **Location**

The Contractor shall be responsible for determining in advance the location of all existing pipelines to which connections are to be made.

PART 2 - MATERIALS

All materials used in making the connection or removing the facility from service shall conform to the applicable sections of these specifications.

PART 3 - EXECUTION

A. **Connection to Existing Waterlines**

1. Notification: The Contractor shall give the District a minimum of four (4) working days notice before the time of any proposed shutdown of existing mains or services.
2. Notice to Proceed: Connections shall be made only in the presence of the District Representative and no connection work shall proceed until the District Representative has given notice to proceed.
3. Material: The Contractor shall furnish all pipe and materials including as may be required: labor and equipment necessary to make the connections, all required excavation, backfill, pavement replacement, lights, and barricades, water truck, highline hose, and fittings for making the connections. In addition, the Contractor shall assist the District in alleviating any hardship incurred during the shutdown for connections.

4. Temporary Work: Where connections are made to existing valves, the Contractor shall furnish and install all temporary blocking, steel clamps, shackles, and anchors as required by the District Representative. Valve boxes and covers shall be replaced and adjusted to the proper grade in accordance with Section 15100.

5. Dewatering: The Contractor shall dewater existing mains, as required, in the presence of the District Representative.

6. Inadequate Progress: If progress is inadequate during the connection operations to complete the connection in the time specified, the District Representative shall order necessary corrective measures. All costs for corrective measures shall be paid by the Contractor.

7. Tapping Sleeves and Valves: Tapping sleeves and valves shall be installed in accordance with Section 15100.

8. Connections: Connections shall be made with as little change as possible in the grade of new main. If the grade of the existing pipe is below that of the new pipeline, a sufficient length of the new line shall be deepened so as to prevent the creation of any high spot or abrupt changes in grade of the new line. Where the grade of the existing pipe is above that of the new pipeline, the new line shall be laid at specified depth, except for the first joint adjacent to the connection, which shall be deflected as necessary to meet the grade of the existing pipe. If sufficient change in direction cannot be obtained by the limited deflection of the first joint, a fitting of the proper angle shall be installed. Where the connection creates a high or low spot in the line, a standard air release or blowoff assembly shall be installed as directed by the District Representative.

9. Testing: The new pipeline shall NOT be connected to an existing facility until the new pipeline has successfully passed all pressure and water quality tests following disinfection in accordance with Sections 15041 and 15042.

B. Removal From Service of Existing Mains and Appurtenances

1. General: Existing mains and appurtenances shall be removed from service at the locations shown on the plans or as directed by the District Representative.

2. Method of Abandonment: Existing pipe and appurtenances shall be filled with one-sack sand cement slurry, or removed from the ground, in which case all backfill and repair of surface shall be in accordance with Section 02223, Trenching, Backfilling, and Compacting.

   Where connections or stub-outs are abandoned, all valves shall be removed and the remaining flanged fitting shall be closed / plugged using a blind-flange fitting.

3. Storage of Removed Material: Removed pipe and appurtenances may be temporarily stockpiled on the job in a location that will not disrupt traffic or be a safety hazard, or it may be delivered to the District yard as directed by the District Representative.

4. Maintenance of Service: Prior to performing any work to replace existing pipes and/or services, the Contractor shall make proper provisions for the maintenance and continuation of service as directed by the District Representative.

5. <u>Abandoned Water Services</u>: For a water service to be considered abandoned, all surface fittings, meter, meter box and customer service valve shall be removed. The service line and corporation stop shall be removed and the service saddle plugged with a brass plug. If there is no corporation stop on the service, the adapter shall be removed and a brass plug installed in the service saddle. With special permission of the District representative, the horizontal portions of the service line may be abandoned in place by cutting and crimping the ends closed

6. <u>Abandoned Sewer Laterals</u>: Sewer laterals to be removed from service shall be cut and plugged at the main.

7. <u>Abandoned Sewer Manholes</u>: For sewer manholes to be abandoned, the manhole cover, ring, grade rings and manhole cone shall be removed and properly disposed of. All portions of the manhole to be abandoned shall be removed to a point eight (8) feet below finished ground surface. The remaining portions of the manhole shall be filled with one-sack sand cement slurry.

8. <u>Abandoned Meter Vaults, PRV Vaults and Other Structures and Boxes</u>: For meter vaults, PRV vaults and other structures to be abandoned, the top hatch or covers, cover slab or hatch or box grade ring, grade rings and other structural elements shall be removed and properly disposed of. All portions of the vault or structure to be abandoned shall be removed to a point eight (8) feet below finished ground surface. The remaining portions of the manhole shall be filled with one-sack sand cement slurry.

END OF SECTION

SECTION 02100: CLEARING AND PREPARATION

PART 1 - GENERAL

A. Description

This section includes clearing, grubbing and preparation required prior to rough grading.

B. Related Work Specified Elsewhere

1. Earthwork and Grading: 02201

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.

2. Submit a schedule of work and a detailed description of removal and disposal techniques.

PART 2 - MATERIALS

Not applicable.

PART 3 - EXECUTION

A. Meeting

Prior to the start of clearing and grubbing operations, a field meeting shall be held with the District Representative to discuss limits and disposal of material.

B. Limits

Clearing and preparation operations shall be confined to the limits shown on the construction plans. Only specified access roads shall be used for operation.

C. Disposal

All brush, stumps, roots, vegetation and debris shall be removed from the site and disposed of in a manner acceptable to agencies having jurisdiction over the work, the soils consultant, and the District.

D. Stockpiling

Topsoil shall be stockpiled at the location shown on the plans, or as directed by the District Representative. Stockpile shall be placed, graded, and shaped to promote proper drainage of stockpile area.

E. Permits

All permit requirements shall be complied with during the course of the work, both for transportation and disposal of materials.

END OF SECTION

SECTION 02201: EARTHWORK AND GRADING

PART 1 - GENERAL

A. <u>Description</u>

This section presents general procedures and requirements for grading and earthwork as shown on the approved grading plans, including preparation of areas to be filled, placement of fill, installation of subdrains, and excavations.

B. <u>Related Work Specified Elsewhere</u>

1. Clearing and Preparation: 02100

C. <u>Submittals (for Contracts between District and Contractor)</u>

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.

2. Material samples and grain size analyses shall be submitted for any imported fill material used.

3. Compliance with all applicable shall be supplied for any subdrain pipe installed.

D. <u>Measurement and Payment</u>

Payment for the work in this section shall be in accordance with the General Provisions and the following.

Payment for any additional cut yardage or removal/recompaction yardage shall be at the unit-price bid amount for these items. Additional cut yardage or removal/recompaction yardage may be required when field conditions dictate modifications to the original scope of the construction plans and when required by the District Representative. Measurement of additional yardage shall be made by the District Representative after consultation with the soils consultant, Engineer, and Contractor.

PART 2 - MATERIALS

A. <u>Fill Material</u>

1. <u>General</u>: Material to be placed as fill shall be free of organic matter and other deleterious substances, and shall be approved by the District Representative. Expansive soils, or soils of poor gradation or strength characteristics shall either be removed from the site, and disposed of in accordance with all local regulations, placed in areas designated by the District Representative, or mixed with other soils to serve as satisfactory fill or soil material.

2. Oversize Material: Oversize material, defined as rock or other irreducible material with a maximum dimension greater than 12 inches, shall not be buried or placed in fills, unless the location, materials, and disposal methods are specifically approved by the District Representative. Oversize disposal operations shall be such that nesting of oversize material does not occur, and such that the oversize material is completely surrounded by compacted or densified fill. Oversize material shall not be placed within 10 feet vertically of finish grade or within the range of future utilities or underground construction, unless specifically approved by the District Representative.

3. Imported Fill Material: If importing of fill material is required for grading, the import material shall meet the requirements above.

B. Subdrain Pipe

Subdrain pipe shall be ASTM D2751, SDR 23.5 or ASTM D1527, Schedule 40 Acrylonitrile Butadiene Styrene (ABS), ASTM D3034 SDR 23.5 or ASTM D1785, Schedule 40 Polyvinyl Chloride Plastic (PVC) pipe, or for contracts between District and Contractor, approved equal.

C. Filter Material

Filter material shall be Class 2 permeable material per State of California Department of Transportation Standard Specifications. Class 2 grading shall be as follows:

Sieve Size	Percent Passing
1"	100
3/4"	90 - 100
3/8"	40 - 100
No. 4	25 - 40
No. 8	18 - 33
No. 30	5 - 15
No. 50	0 - 7
No. 200	0 - 3

D. Filter Fabric Material

Unless specified otherwise, filter fabric shall be non-woven polyester material conforming to the following requirements:

Property	ASTM Method	Property Value
Weight, oz. per sq. yd., min.	D 1910	4
Elongation, %, min.	D 4632	30
Grab Tensile Strength, lbs., min.	D 4632	90
Permittivity, Sec^{-1}, min.	D 4491	.05
Toughness, lbs., min. (Percent Elongation x Grab Tensile Strength)	-	4000

PART 3 - EXECUTION

A. Earthwork Observation Testing

1. Access: Adequate access shall be provided at all times to allow the District Representative to make observations and conduct tests to verify that the work complies with the requirements of the specifications. The District Representative shall be given assistance as necessary for performing test, and shall be kept apprised of work schedules.

2. Methods: Adequate equipment and methods shall be employed to accomplish the work in accordance with applicable grading codes or agency ordinances, these specifications and the approved grading plans. If, in the opinion of the District Representative, unsatisfactory conditions, such as questionable soil, poor moisture condition, inadequate compaction, adverse weather, etc., have resulted in a quality of work less than required in these specifications, the District may reject the work and recommend that construction be stopped until the conditions are rectified.

3. Compaction Testing: Maximum dry density test used to determine the degree of compaction will be performed in accordance with ASTM Test Method D1557.

B. Preparation of Areas to be Filled

1. Clearing and Grubbing: All brush, vegetation and debris shall be removed or piled and otherwise disposed of per Section 02100, Clearing and Preparation.

2. Processing: The existing ground which is determined to be satisfactory for support of fill shall be scarified to a minimum depth of 6 inches. Existing ground which is not satisfactory shall be overexcavated as specified in the following subsection. Scarification shall continue until the soils are broken down and free of large clay lumps or clods and until the working surface is reasonably uniform and free of uneven features which would inhibit uniform compaction.

3. Overexcavation: Soft, dry, spongy, highly fractured or otherwise unsuitable ground, extending to such a depth that surface processing cannot adequately improve the condition, shall be overexcavated down to firm ground, as directed by the District Representative.

4. Moisture Conditioning: Overexcavated and processed soils conforming to "Fill Material" specified herein shall be watered, dried-back, blended, and/or mixed, as required to attain a uniform moisture content near the optimum moisture content prior to placement and compaction.

5. Recompaction: Overexcavated and processed soils which have been properly mixed and moisture-conditioned shall be recompacted to a minimum of 90 percent of maximum dry density.

6. Benching: Where fills are to be placed on ground with slopes steeper than 5:1 (horizontal to vertical units), the ground shall be stepped or benched. The lowest bench shall be a minimum of 15 feet wide, shall be at least 2 feet deep, shall expose firm material, and shall be approved by the District Representative. Other benches shall be excavated in firm material for a minimum width of 4 feet. Ground sloping flatter than 5:1 shall be benched or otherwise over-excavated when considered necessary by the District Representative.

7. Approval: All areas to receive fill, including processed areas, removal areas and toe-of-fill benches shall be approved by the District Representative prior to fill placement.

C. Fill Placement and Compaction

1. Fill Lifts: Approved fill material shall be placed in areas prepared to receive fill in near-horizontal layers not exceeding 6 inches in compacted thickness. The District may approve thicker lifts if testing indicates the grading procedures are such that adequate compaction is being achieved with lifts of greater thickness. Each layer shall be spread evenly and shall be thoroughly mixed during spreading to attain uniformity of material and moisture in each layer.

2. Fill Moisture: Fill layers having a moisture content less than optimum shall be watered and mixed. Fill layers having a moisture content greater than optimum shall be aerated by scarification of shall be blended with drier material. Moisture-conditioning and mixing of fill layers shall continue until the fill material is plus or minus two percent of the optimum moisture content.

3. Compaction of Fill: After each layer has been evenly spread, moisture-conditioned, and mixed it shall be uniformly compacted to not less than 90 percent of maximum dry density. Compaction equipment shall be adequately sized and shall be either specifically designed for soil compaction or of proven reliability, to efficiently achieve the specified degree of compaction.

4. Fill Slopes: Fill slopes shall be overfilled and compacted, then blade cut to a firm surface. Compacting of fill slopes shall be accomplished, in addition to normal compacting procedures, by back- rolling of slopes with sheepsfoot rollers at frequent increments of 2 to 3 feet in fill elevation gain, or by other methods producing satisfactory results. At the completion of grading, the relative compaction of the slope out to the slope face shall be at least 90 percent of maximum dry density.

5. Compaction Testing: Field testing to check the fill moisture and degree of compaction shall be performed by the District Representative. The location and frequency of tests shall be at the District Representative discretion. In general, the tests will be taken at an interval not exceeding 2 feet in vertical rise and/or 1,000 cubic yards of embankment. In addition, on slope faces, at least one test shall be taken for each 5,000 square feet of slope face and/or each 10 feet of vertical height of slope.

D. Subdrain Installation

Subdrains shall consist of drain pipe, compacted pipe trench backfill aggregate, and filter fabric material to prevent migration of soil fines into the subdrain system. Subdrain systems shall be installed in approved ground to conform to the size and alignment, and to the details as may be shown in the Contract Documents. The subdrain location or materials shall not be changed or modified without the approval of the District Representative. All subdrains shall be surveyed for line and grade after installation and sufficient time shall be allowed for the surveys, prior to commencement of filling over the subdrains.

E. Excavation

Excavations and cut slopes will be examined during grading. If directed by the District Representative, further excavation or overexcavation and refilling of cut areas shall be performed, and/or remedial grading of cut sloped shall be performed. Where fill-over-cut slopes are to be graded, unless otherwise approved, the cut portion of the slope shall be made and approved by the District Representative prior to placement of materials for construction of the fill portion of the slope.

F. Grading Code

All work shall be in accordance with the grading code requirements of the agencies having jurisdiction over the work. A copy of grading codes and manuals shall be retained on the job site while work is in progress.

G. Maintenance

1. Protection of Graded Areas: Newly graded areas shall be protected from traffic and erosion. Settled, eroded, and rutted graded areas shall be repaired and re-established to specified tolerances.

2. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, these areas shall be scarified, re-shaped, and compacted to required density prior to further construction.

3. Settling: Where settling is measurable or observable at excavated areas during the project or warranty period, the surface (pavement, lawn or other finish), shall be removed, backfill material added and compacted, and surface treatment replaced. The appearance, quality, and condition of surface or finish shall be restored to match adjacent work.

END OF SECTION

SECTION 02220: STRUCTURE EARTHWORK

PART 1 - GENERAL

A. Description

This section describes excavation, backfilling, materials, testing, and shoring for underground structures including control valve vaults, wet wells, dry well vaults, meter vaults, valve vaults, and pump vaults.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223
2. Pavement Removal and Replacement: 02578
3. Concrete Formwork: 03100

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Submit drawings of excavation and shoring, sheeting or bracing for worker protection in accordance with the General Provisions.
3. Submit six copies of a report from a testing laboratory verifying that gravel base and structural backfill conforms to the specified gradations or characteristics.
4. Test reports on borrow material.
5. Other tests and material reports as required.

D. Protection of Existing Utilities and Facilities

1. General: The Contractor shall be responsible for the care and protection of all existing sewer pipelines, water pipelines, gas mains, storm drains, culverts, or other facilities and structures that may be encountered in or near the area of work.
2. Notification: It shall be the duty of the Contractor to notify each agency of jurisdiction and make arrangements for locating each agency's facilities prior to beginning construction.
3. Damage: In the event of damage to any existing facilities during the progress of the work due to the failure of the Contractor to exercise the proper precautions, the Contractor shall be responsible for the cost of all repairs and protection to said facilities. The Contractor's work may be stopped until repair operations are complete.

E. Protection of Landscaping

The Contractor shall be responsible for the protection of all the trees, shrubs, fences, and other landscape items adjacent to or within the work area, unless directed otherwise on the plans. In the event of damage to landscape items, the Contractor shall replace the damaged items in a manner satisfactory to the District Representative.

PART 2 - MATERIALS

A. Definition of Zones

1. Pavement and Street Zones: Pavement and street zones shall be as defined in Section 02223: Trenching, Backfilling and Compacting.

2. Upper Backfill Zone: The upper backfill zone is defined as the backfill to the full width of the excavation from the top of the structure to the bottom of the street zone in paved areas or to the finished surface in unpaved areas.

3. Structural Backfill Zone: The structural backfill zone is defined as backfill from the top of the structure to the bottom of the excavation, extending the full width of the excavation.

B. Native Earth Backfill-Upper Backfill Zone

Native earth backfill shall be excavated fine-grained non-organic materials free from peat, roots, debris, and rocks larger than 3 inches, and which can be compacted to the specified relative compaction.

C. Structural Backfill - Structural Backfill Zone

Structural backfill materials shall consist of hard, durable, and clean sand, gravel, or crushed stone which is free of organic material, clay balls, and other deleterious substances, and shall have the following gradation:

Sieve Size	Percent Passing by Weight
2 inches	100
1-½ inches	95 to 100
¾ inch	50 to 100
⅜ inch	15 to 55
No. 4	0 to 25
No. 8	0 to 5
No. 200	0 to 3

D. **Crushed Rock Base**

Crushed or natural rock with the following gradation shall be provided as base under the structure.

Sieve Size	Percent Passing by Weight
3 inches	100
1-½ inches	0 to 100
¾ inch	60 to 100
No. 4	25 to 55
No. 30	10 to 30
No. 200	0 to 5

E. **Water for Compaction**

Water used to assist in compaction shall conform to Section 02223, Trenching, Backfilling, and Compacting.

PART 3 - EXECUTION

A. **Testing for Compaction**

Testing for compaction shall conform to Section 02223, Trenching, Backfilling, and Compacting.

B. **Compaction Requirements**

1. Backfill in Street Zone: 95% relative compaction.

2. Upper Backfill Zone: 90% relative compaction.

3. Structural Backfill Zone: 90% relative compaction.

4. Crushed Rock Base: 80% relative density.

C. **Dewatering**

1. General: Dewatering operations shall continuously remove and dispose of all water entering the excavation during construction of the structure and all backfill operations. Water shall be disposed of in a manner to prevent damage to adjacent property and pipe trenches in conformance with all local regulations. Water shall not be allowed to rise in the excavation until backfilling around and above the structure is completed.

2. Notification: The District shall be notified 48 hours prior to commencement of dewatering operations. Methods employed shall be in conformance with the District's existing NPDES permit for contracts between District and Contractor. A copy of the NPDES permit is generally included in the appendix of the Project Manual with the project specifications.

D. **Structure Excavation**

1. Removal of Material: Structure excavation shall include the removal of all material necessary for the construction of underground structures and foundations.

2. Clearance: Unless noted otherwise on the plans, the sides of excavations for structures shall be sufficient to leave at least a 2-foot clearance, as measured from the extreme outside of formwork or the structure. Excavation side slopes shall be as specified in Subsection E.

3. Overdepth Excavations: Overdepth excavations shall be corrected by backfilling with crushed rock or concrete, as directed by the District Representative. No native earth backfill will be permitted to correct overdepth excavation beneath structures.

4. Surplus Material: Surplus material shall be disposed of in accordance with Section 02223, Trenching, Backfilling, and Compacting.

E. **Support for Excavations for Structures**

1. Safety: A safe working area shall be provided for workers. The services of a Registered Civil Engineer shall be obtained to design sheeting, shoring and bracing, or side slopes. The requirements of CAL/OSHA and of these specifications shall be used as minimum design criteria. Sufficient geotechnical data shall be obtained to provide safe design.

2. Side Slopes: Minimum side slope shall be per CAL/OSHA but not steeper than:

   a. Clayey soil up to 12-foot depth: 3/4 horizontal to 1 vertical (3/4:1).

   b. Clayey soil more than 12-foot depth: vary from 3/4:1 for 12-foot depth to 3:1 for 20-foot depth.

   c. Gravelly soil: 2 horizontal to 1 vertical (2:1).

   d. Flatten above slopes if groundwater is present.

3. Traffic Safety: Methods of support or side slopes shall be selected to provide sufficient clearance for public traffic safety and convenience.

4. Design Loads: The characteristics of the soil exposed in the excavation, the groundwater conditions, traffic, and other surcharge loads shall be considered when selecting lateral pressures to be used for design of soil supporting systems.

5. Design Criteria: The following minimum design criteria for allowable lateral passive soil pressure expressed in pounds per square foot (psf) shall be used to calculate depth of penetration of isolated soldier piles or solid sheet piles. Where needed for safety, these values shall be increased.

	Predominant Soil Type	
	Clayey	Granular
Isolated Soldier Piles	200 Z + 1,870	467 Z
Solid Sheet Piles	67 Z + 633	300 Z

Where Z = depth in feet below bottom of excavation.

6. Verification of Soil Types: Prior to design and submittal of support system, verification of the type of soil below the bottom of the excavation shall be made.

F. Backfill Against Walls and Over Roof Slabs

1. Precautions

   a. Backfill over structure shall be placed in a manner so as to not damage the roof membrane and protective cover.

   b. Backfill shall not be placed against walls or above buried roof slabs until the concrete has obtained a comprehensive strength equal to the specified 28-day compressive strength. Where backfill is to be placed on both sides of the wall, the backfill shall be placed uniformly on both sides. Where backfill is to be placed around a structure, the backfill shall be placed at a uniform rate around the structure.

   c. Backfill shall not be placed against the walls of structures that are laterally restrained or supported by suspended slabs or slabs on grade until the slab is poured and the concrete has reached the specified compressive strength.

   d. When backfill is to be placed before 7-day concrete strength tests have been conducted on concrete arches for VCP sewers or thrust blocks, the concrete shall have achieved 50 percent of the specified minimum 28-day strength. An additional test cylinder shall be made for this test.

2. Equipment: Equipment for placing and compacting backfill over structures shall not exceed 15 tons total weight and a maximum wheel load of 10,000 pounds. Equipment weighing more than 10,000 pounds shall not be used closer to walls and structures than a horizontal distance equal to the depth of fill at the time.

G. Compaction

1. Compaction for Zones: Compaction shall be controlled to the percentage of density specified for each zone.

2. Moisture Control: Moisture shall be controlled as follows:

    a. Where subgrade or soil material layers must be moisture conditioned before compaction, water shall be uniformly applied to the subgrade surface or soil layer material in order to prevent free water from appearing on the surface during or subsequent to compaction operations. The moisture content of the compacted soil shall be within 3 percentage points of the optimum.

    b. Soil material that is too wet to permit compaction to specified density shall be removed and replaced or scarified and air dried.

    c. Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread within an approved area and allowed to dry. Drying may be assisted by discing, harrowing or pulverizing, until moisture content is reduced to satisfactory value.

    d. Backfill or fill material shall not be placed on surfaces that are muddy, frozen, or contain frost or ice.

3. Requirements Prior to Backfilling: Excavations shall be backfilled as work permits, but not until completion of the following:

    a. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.

    b. Inspection, testing, approval, and recording locations of underground utilities.

    c. Removal of concrete formwork per Section 03100, Concrete Formwork.

    d. Removal of shoring and bracing, and backfilling of voids with satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure or utilities, or leave in place, if required.

    e. Removal of trash and debris.

    f. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

4. Backfill Layers: Backfill and fill materials shall be placed in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

5. Jetting: Unless specified otherwise, jetting techniques shall not be employed to densify granular fill materials.

6. Uniform Backfill Lifts: Backfill and fill materials shall be placed evenly adjacent to structures, to required finish elevations. Care shall be taken to prevent wedging action of backfill against structures by carrying material uniformly around structure to approximately same elevation in each lift.

END OF SECTION

SECTION 02223: TRENCHING, BACKFILLING AND COMPACTING

PART 1 - GENERAL

A. Description

This section describes materials, testing, and performance of trench excavation, backfilling and compacting.

B. Related Work Specified Elsewhere

1. Pavement Removal and Replacement: 02578

2. Concrete: 03300.

3. Hydrostatic Testing of Pressure Pipelines: 15042

4. Cathodic Protection and Joint Bonding: 16640

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted showing excavation and shoring, bracing, or sloping for worker protection in accordance with the General Provisions, and the following:

2. Six copies of a report from a testing laboratory shall be submitted verifying that backfill material conforms to the specified gradations or characteristics for pea gravel, granular material, imported sand, rock refill for foundation stabilization, and water.

D. Measurement and Payment

1. Payment for the work in this section shall be in accordance with the General Provisions and the following:

   A. Foundation Stabilization

   Payment for foundation stabilization shall be made in accordance with the unit-price bid amount for any quantity of refill material from 0 to 1,000 cubic yards, based on the trench details shown on the plans. These items have been included in the bid form for work that may possibly be required to complete the project, but which cannot be reasonably predicted, and shall be the basis of payment for refill material for foundation stabilization if authorized in writing by the District. The unit price shall be for any quantity installed, complete in place, including all additional earthwork, disposal of all excess or waste material, and placing of the refill material. The District Representative shall be the sole judge as to the necessity, the amount, and depth that may be required in any given situation. No additional payment shall be made for foundation stabilization that is not authorized by the District.

   B. Drying / Blending / Transporting

   All costs of drying, blending, transporting, and/or importing backfill material and all costs for the removal and disposal of unsuitable material and excess excavated material shall be included in the prices bid for the various items of work.

C. Protection of Existing Utilities / Services & Pot-holing

Full compensation for protection of utilities or replacement of utilities and street improvements including, but not limited to removal and disposal and reconstruction of existing curb, gutter, spandrels, cross-gutters, sidewalks, driveway aprons, and handicapped ramps shall be included in the contract unit prices for which such work is appurtenant thereto, and no additional allowance or payment will be made therefore. Said various contract unit prices shall include all labor, materials, tools, and equipment necessary or incidental to the replacement work. The same shall apply to all costs incurred in exposing or excavating existing utilities and service lines, and no additional allowance will be made therefore, as they shall be included in the prices bid for the various items of work.

E. Protection of Existing Utilities and Facilities

1. General: The Contractor shall be responsible for the care and protection of all existing sewer pipelines, water pipelines, gas mains, storm drains, culverts, or other facilities and structures that may be encountered in or near the area of work. Unless otherwise indicated on the plans or specifications, all utilities shall be protected in place and service shall be continuously maintained.

   The Contractor shall be responsible for the location of and protect in place, all service connections whether or not shown on the plans. Utilities crossing the proposed pipeline alignment (where shown in "plan" and "profile" view) on the plans are plotted from the information obtained from the respective utility's owner or from available pot-hole information. In accordance with Section 8 of the General Provisions, the accuracy of the utilities is not guaranteed. Actual locations (not depth) will be provided by utilities through the Underground Service Alert (USA) process.

   It shall be the contractor's responsibility to make exploratory excavations (by "hand" where prudent) to determine the true location and depth of all utilities shown on the plans. The contractor shall also determine the type of material and condition of any utility which may be affected by or affect the work. The contractor shall conduct exploratory excavations at least 1,500 feet ahead of a pipe trench heading (a minimum of five (5) days in advance of the planned construction) to provide sufficient lead-time to resolve utility conflicts.

2. Notification: It shall be the duty of the Contractor to notify each agency of jurisdiction and make arrangements for locating each agency's facilities prior to beginning construction.

3. Damage: In the event of damage to any existing facilities during the progress of the work due to the failure of the Contractor to exercise the proper precautions, the Contractor shall be responsible for the cost of all repairs and protection to said facilities. The Contractor's work may be stopped until repair operations are completed to the satisfaction of the District.

F. Protection of Landscaping

1. General: The Contractor shall be responsible for the protection of all the trees, shrubs, fences, and other landscape items adjacent to or within the work area, unless directed otherwise on the plans. In the event of damage to landscape items, the Contractor shall replace the damaged items in a manner satisfactory to the District Representative.

2. Restoration: After the completion of work in planted or improved areas within public or private easements, the Contractor shall restore such areas to original condition. Restoration shall include regrading, placement of 5-inches of topsoil, reseeding, and replacement of landscaping.

G. Definition of Zones

1. Pavement Zone: The pavement zone shall include the asphaltic concrete and aggregate base pavement section placed over the street zone. This zone is often referred to as the "structural section" of the street or highway.

2. Trench Zone: The trench zone shall include the portion of the trench from the top of the pipe zone to the bottom of the pavement zone in paved areas or to the existing surface in unpaved areas.

3. Pipe Zone: The pipe zone shall include the full width of trench from the bottom of the pipe or conduit to a horizontal level 12-inches above the top of the pipe. Where multiple pipes or conduits are placed in the same trench, the pipe zone shall extend from the bottom of the lowest pipes to a horizontal level above the top of the highest or topmost pipe. This zone is also part of the "pipe bedding zone" and as such it shall be filled with bedding material identical to that which is placed in the pipe base.

4. Pipe Base: The pipe base shall be defined as a layer of material immediately below the pipe zone and extending over the full trench width. This is also part of the "pipe bedding zone".

5. Pipe Bedding Zone: The pipe bedding zone shall include the zones defined as the "pipe base" and the "pipe zone". It shall include the full width of the trench from the bottom of the trench to a point 12-inches above the top of the pipe. Unless specified otherwise the pipe bedding zone shall be from 6-inches under the pipe to 12-inches over it.

H. Testing for Compaction

1. Methods: The density of soil shall be determined in place by the sand cone method, ASTM D 1556, or by the nuclear method, ASTM D 2922 or D 3017.

2. Soil Moisture-Density Relationship: The laboratory moisture-density relations of soils shall be determined per ASTM D 1557.

3. Cohesionless Materials: The relative density of cohesionless materials shall be determined by ASTM D 4253 and D 4254.

4. Sampling: Backfill materials shall be sampled per ASTM D 75.

5. Relative Compaction: "Relative compaction" shall be expressed as the ratio, expressed as a percentage, of the in place dry density to the laboratory maximum dry density.

6. Compaction Compliance: Compaction shall be deemed to comply with the specifications when none of the tests falls below the specified relative compaction. When tests are conducted by the District, the Contractor shall notify the District 24-hours in advance of when backfill lifts are ready for testing, and shall pay the costs of any retesting of work not conforming to the specifications.

7. Testing Intervals: Unless noted otherwise, compaction tests shall be performed at random depths and at 200-foot intervals, and as directed by the District Representative.

   The presence of marginal materials, poor soil conditions or a prevalence of failed test results will be cause for substantially increasing the frequency and intervals of required testing. Alternatively, with approval of the District Representative, the trench zone may be backfilled with a 2-sack sand-cement slurry at no additional cost to the District.

PART 2 - MATERIALS

A. Pavement Zone Materials

Pavement zone materials shall be as specified in Section 02578, Pavement Removal and Replacement.

B. Native or Imported Backfill for Trench Zone

Native or imported backfill shall be excavated, fine-grained non-organic materials free from peat, roots, debris, and rocks larger than 3-inches, and which can be compacted to the specified relative compaction.

C. Backfill Material for Pipe Bedding Zone

1. Ductile iron pipe, welded steel pipe, PVC pressure pipe, and copper pipe: Unless otherwise specified or shown on the plans, the pipe base and pipe zone (a.k.a., pipe bedding zone) backfill material shall be imported sand of a gradation and composition as specified herein.

2. Vitrified clay pipe and PVC gravity pipe: Unless otherwise specified or shown on the plans, pipe base and pipe zone backfill shall be 3/4-inch crushed aggregate base rock (or by special permission from the District) crushed miscellaneous of a gradation and composition as specified herein.

D. Imported Sand--Pipe Zone and Pipe Base

Imported sand used in the pipe bedding zone (pipe zone and pipe base) shall conform to the California Standard Specifications for Public Works Construction, Section 200-1.5.1 and shall meet the following gradation:

Sieve Size	Percent Passing by Weight
3/8 - inch	100
No. 4	75 – 100
No. 30	12 – 50
No. 100	5 – 20
No. 200	0 – 11

Minimum sand equivalent shall be 30 for natural imported material and shall be 40 for screened recycled materials per ASTM D 2419.

E. Crushed Rock--Pipe Zone and Pipe Base

Crushed rock shall be crushed aggregate base material and shall conform to the California Standard Specifications for Public Works Construction, Section 200-1.2 and shall meet the following gradation:

Designated Material Size Percent Passing by Weight				
Sieve Sizes	1-1/2-inch	1-inch	3/4-inch	3/8-inch
2-inches	100	---	---	---
1-1/2-inches	90 - 100	100	---	---
1-inch	20 - 55	90 - 100	100	---
3/4-inch	0 – 15	30 – 60	90 – 100	---
1/2-inch	---	0 – 20	30 – 60	100
3/8-inch	0 – 5	---	0 – 20	90 - 100
No. 4	---	0 - 5	0 – 5	30 - 60
No. 8	---	---	---	0 - 10

Crushed aggregate base materials used for pipe bedding shall be 3/4 - inch unless otherwise called for by the project plans and specifications or as directed by the District Representative.

Crushed miscellaneous base materials may be substituted for crushed aggregate base materials by special permission from the District. In such cases, materials shall conform to the requirements of the California Standard Specifications for Public Works Construction, Section 200-2.4, except that gradation of the materials shall still comply with the percentages by weight on the table above.

F. Re-fill Material for Foundation Stabilization

Refill material below the pipe shall be either material conforming to the 1-1/2 - inch size requirement for gravel or crushed rock, or naturally occurring rock having the following gradation:

Sieve Size	Percent Passing by Weight
3-inches	100
1-1/2-inches	70 – 100
3/4-inch	60 – 100
No. 4	5 – 55
No. 30	0 – 30
No. 200	0 – 10

G. Sand-Cement Slurry Refill Material for Foundation Stabilization in Pipe Base & Pipe Zone

Sand-Cement slurry shall consist of one sack (94 pounds) of portland cement per cubic yard of sand and sufficient moisture for workability.

H. Water for Compaction

Water used in compaction shall have a maximum chloride concentration of 500 mg/l, a maximum sulfate concentration of 500 mg/l, and shall have a pH of 7.0 to 9.0. Water shall be free of acid, alkali, or organic materials injurious to the pipe coatings or the environment.

PART 3 - EXECUTION

A. Compaction Requirements

Unless otherwise shown on the drawings or otherwise described in the specifications for the particular type of pipe installed, relative compaction in pipe trenches shall be as follows:

1. Material Testing: All imported or native materials shall be tested before the start of compaction operations to determine the moisture density relationship for materials with cohesive components, and the maximum density for cohesionless materials. Variations in imported or native earth materials may require a number of base curves of the moisture-density relationship.

2 Trench Zone: Backfill in trench zone greater than 18 inches below the pavement zone shall be compacted to not less than 90% relative compaction. Backfill less than or equal to 18 inches below the pavement zone shall be compacted to not less than 95% relative compaction.

3. Pipe Bedding Zone (Pipe Base and Pipe Zone): Materials placed as pipe bedding material in the pipe base and pipe zone shall be consolidated to 90% relative optimum compaction. Note that 95% relative optimum compaction shall be required in specific areas shown on the plans and profile drawings. From time to time this higher density will be deemed necessary by the District, their representative or the local jurisdiction.

4. Foundation Stabilization: Rock refill material for foundation stabilization, where required shall be placed and consolidated to 90% relative optimum density.

5. Over-excavation: Rock refill for over-excavation shall be placed and consolidated to 90% relative optimum density.

B. Material Replacement

Trenching and backfilling material, which does not meet the specifications, shall be removed and replaced at no additional expense to the District.

C. Sheeting, Shoring and Bracing of Trenches

Trenches shall have sheeting, shoring and bracing conforming to CAL/OSHA requirements and General Provisions. Lateral pressures for design of trench sheeting, shoring, and bracing shall be based on type of soil exposed in the trench, groundwater conditions, surcharge loads adjacent to the trench, and type of shoring that will be used in the trench.

D. **Sidewalk, Pavement and Curb Removal**

Bituminous and concrete pavements regardless of the thickness and curbs and sidewalks shall be cut prior to excavation of the trenches in accordance with Section 02578, Pavement Removal and Replacement. Pavement and concrete materials shall be removed from the site and shall not be used for trench backfill.

E. **Trench Widths**

1. Trench Width Limits: Unless shown otherwise on the drawings, trench widths in the pipe zone shall be as shown on Standard Drawing Nos. W-17 or S-6. Trench width at the top of the trench shall not be limited except where width of excavation would undercut adjacent structures and footings. In such cases, width of trench shall be such that there is at least 18-inches between the top edge of the trench and the structure or footing.

   Excavation and trenching shall be true to line so that a clear space is provided in the pipe zone on each side of the largest outside diameter of the pipe. The largest outside diameter shall be the outside diameter of the bell on bell and spigot pipe.

2. Over-width Trench: Where the trench width in the pipe zone, is wider than the maximum set forth above, the trench area around the pipe shall be backfilled in accordance with the directive of the Engineer and at the discretion of the District Representative.

F. **Grade**

Trenches shall be excavated to the lines and grades shown on the drawings with allowance for the thickness of the pipe and for pipe base. If the trench is excavated below the required grade, the portion of the trench excavated below the grade shall be refilled with refill material at no additional cost to the District. Refill material shall be placed over the full width of trench in compacted layers not exceeding 6-inches deep to the required grade with allowance for the pipe base. Hard spots that would prevent a uniform thickness of pipe base shall be removed. Before laying pipe sections, the grade shall be checked and any irregularities corrected. The trench bottom shall form a continuous and uniform bearing and support for the pipe at every point.

G. **Pipe Base Thickness**

Thickness of the pipe base shall be as shown on the drawings or as otherwise described in the specifications for the particular type of pipe installed, but in no cases shall the thickness be less than 6-inches.

H. **Dewatering**

1. Means and Devices: Suitable means and devices shall be provided and maintained to continuously remove and dispose of all water entering the trench excavation during the time the trench is being prepared for the pipe laying, during the laying of the pipe, and until the backfill at the pipe zone has been completed. Water shall be disposed of in a manner to prevent damage to adjacent property. Trench water shall not be drained through the pipeline under construction. Groundwater shall not be allowed to rise around the pipe until jointing compound has firmly set.

2. Notification: The District shall be notified 48 hours prior to commencement of dewatering. Methods employed shall be in conformance with the District's existing NPDES permit. For contracts between District and Contractor, a copy of the permit is included in the Appendix of the Project Manual.

I. Storage of Excavated Material

During trench excavation, excavated material shall be stored only within the working area. Roadways or streets shall not be obstructed. The safe loading of trenches with excavated material shall conform to federal, state, and local codes.

J. Length of Open Trench

The length of open trench shall be limited to 600 feet in advance of pipe laying or amount of pipe installed in one working day. Backfilling and temporary or first layer paving shall be completed so that not more than 500 feet of trench is open in the rear of pipe laying. Sidewalks, driveways and other traveled ways shall be backfilled or adequately bridged to provide safe access and egress at the completion of each day's work.

K. Foundation Stabilization

After the required excavation has been completed, the District Representative shall inspect the exposed trench subgrade to determine the need for any additional excavation. It is the intent that additional excavation shall be conducted in all areas within the influence of the pipeline where unacceptable materials exist at the exposed subgrade. Overexcavation shall include the removal of all such unacceptable material that exists directly beneath the pipe base and to the depth required. The presence of unacceptable material may require excavating a wider trench. The width and depth of known areas to be overexcavated shall be shown on the drawings. The overexcavated portion of the trench shall be backfilled to the subgrade of the pipe base with refill material for foundation stabilization. Foundation stabilization material shall be placed over the full width of the excavation and compacted in layers not exceeding 6-inches in depth, to the required grade.

L. Trench Backfilling and Compaction

1. General: Trench backfill shall conform to requirements of the detailed piping specification for the particular type of pipe and following.

2. Pipe Base: The specified thickness of pipe base material shall be placed over the full width of trench. The top of the pipe base shall be graded ahead of the pipe laying to provide firm, uniform support along the full length of pipe.

3. Bell Holes: Bell holes shall be excavated at each joint to permit proper assembly and inspection of the entire joint.

4. Pipe Zone: After the pipe has been bedded, pipe zone material shall be placed simultaneously on both sides of the pipe, keeping the level of backfill the same on each side. Material shall be carefully placed around the pipe so that the pipe barrel is completely supported and that no voids or uncompacted areas are left beneath the pipe. Particular care shall be taken in placing material on the underside of the pipe to prevent lateral movement during subsequent backfilling. Material placed within the pipe zone shall be compacted by hand tamping only.

5. Trench Zone: Backfill material shall be carefully deposited onto the backfill previously placed in the pipe zone. Free fall of the material shall not be permitted until at least 2 feet of cover is provided over the top of the pipe. Sharp, heavy pieces of material shall not be dropped directly onto the pipe or the tamped material around the pipe.

6. Trench Backfill: Trench backfill shall be compacted to the specified relative compaction. Compaction shall be performed by using mechanical compaction or hand tamping equipment. Unless specified otherwise, consolidation by jetting or flooding shall not be permitted. High impact hammer-type equipment shall not be used except where the pipe manufacturer warrants in writing that such use will not damage the pipe.

7. Equipment: Axle-driven or tractor-drawn compaction equipment shall not be used within 5 feet of walls and structures.

8. Street Zone Backfill: Street zone backfill shall be done in accordance with the requirements and to the satisfaction of the County or City agency having jurisdiction.

M. Compacted Embankment

Earthwork for construction of compacted embankment shall be as specified in Section 02201, Earthwork and Grading.

N. Import or Export of Backfill Material

1. Excess Material: Excess excavated soil material shall be removed and disposed of off the project site at no additional expense to the District. Excess soil material shall be disposed of in accordance with local regulations.

2. Imported Material: Any additional backfill material necessary to return all grades to plus or minus 0.2 feet from the grade encountered at the beginning of construction or as shown on the contract drawings shall be imported, placed, and compacted at no additional expense to the District.

O. Moisture Content of Backfill Material

During the compacting operations, optimum practicable moisture content required for compaction purposes shall be maintained in each lift of the backfill material. Moisture content throughout the lift shall be maintained at a uniform level. If placement is discontinued and proper moisture content not maintained, the upper layer shall be brought back to proper moisture content by sprinkling, cultivating and rolling the backfill material before placing new material. At the time of compaction, the water content of the material shall be at optimum water content plus or minus two percentage points. Material which contains excessive moisture shall not be worked to obtain the required compaction. Material having excessive moisture content may be dried by blading, discing, or harrowing to hasten the drying process.

END OF SECTION

SECTION 02315: JACKED CASING

PART 1 - GENERAL

A. Description

This section describes tunneling using jacked steel casing for highway, culvert, utility and structure crossings and other shallow depth tunnels less than 500 feet in length. This section also describes carrier pipe installation within the steel casing.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223
2. Concrete: 03300
3. Hydrostatic Testing of Pressure Pipelines: 15042
4. Leakage and Infiltration Testing: 15043
5. Installation of Pressure Pipelines: 15051

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Submit manufacturer's mill specification sheet listing diameter, thickness, and class of steel used in making the casing, and the mill certification.
3. Submit drawings showing the location of approach trench, jacking pit, tunnel and receiving pit, and joint type for both casing and carrier pipe. Include the details of all grout couplings and other attachments and appurtenances to the casing.
4. Submit a tunnel construction schedule which includes casing installation, carrier pipe installation, approach trench backfill, and receiving pit backfill.
5. Submit an engineered shoring plan for the bore-pit and receiving-pit. Shoring submittals shall be wet-signed and stamped by a California-licensed Civil or Structural Engineer.

D. Permits

All work shall conform to the specifications and requirements of the State of California Department of Transportation, the Orange County Planning & Development Services Department, the City, or the railroad company involved. The Contractor shall secure all required permits for construction of casing pipe installation.

E. Scheduling

If the pipeline is not installed within the casing as a continuous operation following completion of the jacking of the casing, the casing portals shall be bulkheaded and the approach trenches backfilled and later reopened for pipe installation.

F. Line and Grade

Contractor shall continuously survey jacked casing for conformance with design line and grade. Survey data shall be taken at a maximum of 40-foot intervals.

PART 2 - MATERIALS

A. Steel Casing

1. Materials: Steel casing shall be ASTM A 283, Grade C, ASTM A 570 Grade 30, 33, and ASTM A-36 unless noted otherwise. The minimum inside diameter and wall thickness of the casing shall be as follows, or shall be as shown on the drawings. Greater casing thickness and diameter may be used as convenient for the method of work and loadings involved, as suitable for the site and as limited by possible interferences, but at no additional cost to District.

   The Contractor shall choose a size of casing at or above the minimum specified, in order that the jacking may be done with a sufficient degree of accuracy to permit installation of the carrier pipe to the grades shown on the plans and to properly accommodate the largest dimension of the carrier pipe.

2. Joints & Welding: Casing sections shall be joined by full circumference welding. Field welds shall be full-penetration bevel welds in accordance with the standards of quality as set forth in the specifications of the American Welding Society. All welding shall be performed by skilled welders qualified under the provisions of ANSI/AWS D1.1. Welder qualifications shall be certified by an independent local, approved testing agency not more than 6 months prior to commencing work. Prepare ends of casings for proper bevel weld by providing a 45-degree bevel on the end of one of the two casing pieces being joined.

3. Wall Thickness: Minimum size and thickness of casing pipes for insertion of various sizes of carrier pipes shall be as shown in the IRWD Standard Drawings unless a larger or heavier wall casing pipe is required by the agency having jurisdiction over the road or railroad crossing or the contractor requests use of a thicker wall pipe.

B. Casing Seals

Casing seals shall be 1/8-inch-thick synthetic, rubber, designed to fit snugly around pipe and casing. Casing seals may be one piece with no field seams or the wrap-around style to facilitate installation after the casing and carrier pipe are already installed. Seamless style are preferred. Bands and hardware for attachment to pipe and casing OD shall be stainless steel.

C. Grout

1. Grout shall consist of one part portland cement, four parts sand, 2% bentonite by weight of the cement, and sufficient water to produce a workable mixture.

2. Portland cement, water and sand shall conform to the applicable requirements of Section 03300: Concrete, except that sand shall be of such fineness that 100% will pass a standard No. 8 sieve and at least 45%, by weight, will pass a standard No. 40 sieve.

3. Bentonite shall be a commercially-processed powdered bentonite, Wyoming type, Black Hills, or for Contracts between District and Contractor, approved equal.

D. Grout Connections

The contractor shall provide 1-inch diameter threaded steel half-couplings on the inside of the casing pipe at the locations, spacing and orientation called for in the Standard Drawings. Unless noted otherwise in the plans or specifications, grout connections on the casing pipe shall be provided near the top of the casing. Longitudinal spacing between grout connections along the axis of the casing pipe shall be 60 inches. This spacing may be decreased to provide more frequent grouting, but in no case shall the spacings shown on the drawings or specifications be exceeded.

PART 3 - EXECUTION

A. Safety

For contracts between the Contractor and an entity other than the District, the Contractor shall obtain from the Division of Industrial Safety a classification for each bore exceeding 30-inches in diameter. For contracts between the Contractor and the District, the District has obtained from the Division of Industrial Safety a classification for each bore where required. The boring and jacking work shall be done in conformance with the State of California's requirements. It shall be the Contractor's responsibility to call the required safety meeting with representatives from the State Division of Industrial Safety prior to beginning of construction of each bore.

B. Jacking Pit

1. Excavation Protection: The approach trench for jacking or boring operations shall be adequately shored to safeguard existing substructures and surface improvements and to ensure against ground movement in the vicinity of the casing portal.

2. Structural Support for Jacking Equipment: Heavy guide timbers, structural steel, or concrete cradle of sufficient length shall be placed in the approach trench of the jacking pit and firmly bedded on the required line and grade to provide accurate control of jacking alignment. Adequate space shall be provided to permit the insertion of the lengths of casing to be jacked. The structure of timbers and structural steel sections shall be anchored to ensure action of the jacks in line with the axis of the casing. A bearing block consisting of a timber or structural steel framework shall be inserted between the jacks and the end of the casing to provide uniform end bearing over the perimeter of the casing and distribute the jacking pressure evenly.

C. **<u>Sectional Shield or Jacking Head</u>**

1. <u>Equipment</u>: A sectional shield or steel jacking head shall be attached to the leading section of the casing to extend around the outer surface of the upper two-thirds of the casing and to project at least 18 inches beyond the driving end of the casing. The sectional shield or jacking head shall not protrude more than 1/2-inch outside of the outer casing surface. The head shall be anchored to prevent any wobble or alignment variation during the jacking operation.

2. <u>Removal of Excavated Material</u>: To avoid loss of ground outside the casing, excavation shall be restricted to the least clearance necessary to prevent binding, and shall be carried out entirely within the jacking head and not in advance of the head. Excavated material shall be removed from the casing as jacking progresses and no accumulation of excavated material within the casing will be permitted.

D. **<u>Control of Alignment and Grade</u>**

Application of jacking pressure and excavation of material ahead of the casing as it advances shall be controlled to prevent the casing from becoming earthbound or deviating from the required line and grade shown on the Plans. Allowable grade deviations in horizontal and vertical alignments shall be no greater than 0.2 feet per 100 feet in any direction over the length of the jacking and boring operation. A maximum cumulative deviation shall not exceed 0.5 feet overall. Do not encroach upon the minimum annular space detailed. The District will check line and grade at intervals not exceeding 40-feet to ensure compliance with plans.

E. **<u>Grouting Exterior of Casing</u>**

Immediately after completion of the jacking or boring operation, grout shall be injected through the grout connections of casings 30-inches in diameter and larger in such a manner as to completely fill all voids outside the casing pipe resulting from the jacking or boring operation. Where loss of ground outside the casing is suspected, additional grout connections shall be welded to the casing. Grout pressure shall be controlled so as to avoid deformation of the casing and/or avoid movement of the surrounding ground. After completion of grouting, the grout connections shall be closed with extra heavy black steel threaded plugs.

F. **<u>Installation of Carrier Pipe</u>**

1. <u>Insertion of Carrier Pipe</u>: After grouting the exterior of the casing pipe, the interior shall be cleaned and the carrier pipe installed. The carrier pipe shall be installed on two (2) skids of sufficient dimension to prevent the pipe bells from touching the casing pipe and to allow for proper alignment of the carrier pipe to meet the specified grade.

2. <u>Securement</u>: The top of-the carrier pipe shall be blocked to prevent flotation. The carrier pipe shall be secured in a manner satisfactory to the District Representative to prevent floating and subsequent change of grade.

3. Pipe Skids and Blocking: Skids and blocking shall be manufactured stainless steel casing spacers with composite runner skids.

   Casing spacer skids and blocking shall be bolt-on style with a shell made of at least two halves. The band material shall be manufactured of a minimum 14 gauge T-304 stainless steel and 10 gauge T-304 stainless steel risers when needed. All welds are to be chemically passivated. The runners shall be at least 11 inches long and shall be manufactured of high abrasion resistant and low coefficient of friction, glass filled polymer. Fasteners and hardware for securing the spacers and runners shall be stainless steel. Spacers shall be installed at mid-sections if the carrier pipe segment is over ten (10) feet long. Detailed product submittals showing all dimensions shall be provided. Casing spacers shall have a flexible EPDM liner having a minimum thickness of 0.090-inches with a hardness of Durometer "A" 85-90. The liner shall have a rating of no less than 60,000 VPM and water absorption of 1% maximum.

   Casing spacers shall be as manufactured by Advance Products & Systems, Inc., Cascade Waterworks Mfg. Co., or Pipeline Seal & Insulator, Inc.

4. Grade Adjustment: The carrier pipe grade shall be adjusted as required by changing the height of the casing spacer riser and / or the thickness of the runner pad skids to compensate for any grade variations of the casing pipe. Care should be taken to ensure that the carrier pipe does not come in contact with and is insulated from the casing pipe.

5. Failure to Achieve Required Grade: If the alignment of the casing pipe is such that the carrier pipe grade cannot be met, the grade of the casing pipe shall, if required by the District, be adjusted. If realignment is not deemed feasible by the District, another casing pipe meeting the required grade shall be installed. The abandoned casing pipe shall be filled with sand and the ends plugged with twelve (12) inch thick masonry plugs. Realignment or replacement work shall in no way result in additional costs to the District.

6. Testing: Before backfilling the jacking and receiving pits, the carrier pipe shall have passed an initial pressure or leakage test in accordance with Section 15042 or Section 15043.

H. Closing the Jacking Pit and Receiving Pit

1. Closing the Jacking Pit and Receiving Pit: After jacking equipment and muck from the tunnel have been removed from the approach trench of jacking pit, the bottom of the jacking pit shall be prepared as for a pipe foundation. Remove all loose and disturbed material below pipe grade to undisturbed earth.

2. Backfill: The jacking pit and receiving pit represent overwidth trench conditions. Backfill shall either be Provisions as called for on the contract drawings, in the Special Provisions, or in Section 02223, Trenching, Backfilling and Compacting.

END OF SECTION

SECTION 02528: CONCRETE CURBS, GUTTERS AND SIDEWALKS

PART 1 - GENERAL

A. Description

This section describes materials and construction of concrete curbs, gutters and sidewalks.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223
2. Concrete Formwork: 03100
3. Concrete Reinforcement: 03201
4. Concrete: 03300
5. Concrete Finishing, Curing and Waterproofing: 03345

C. Submittals (for Contracts between District and Contractor)

Shop drawings shall be submitted in accordance with the General Provisions and the requirements of Section 03300, Concrete, Part 1-C.

PART 2 - MATERIALS

A. Forms

1. General: Forms shall be as required in Section 03100, Concrete Formwork. Stakes and braces shall be provided to hold forms securely in place.
2. Sidewalk Forms: Sidewalk forms shall be 2-inch dressed lumber, straight and free from defects, or standard metal forms. Where short-radius forms are required, 1-inch dressed lumber of plywood may be used.

B. Aggregate Base Course

Crushed rock base shall be clean 3/4-inch and smaller crushed rock or crushed gravel, free from foreign material, and conforming to Crushed Aggregate Base as specified by Standard Specifications of Public Works Construction: Section 400-2, latest edition.

C. Expansion Joint Filler

Premolded expansion joint filler shall be 1/4-inch thick for curbs and 1/4-inch thick for sidewalks, or as required or allowed by the permitting agency.

D. Concrete

Conform to Section 03300, Concrete.

E. Reinforcing Steel

Conform to Section 03201, Concrete Reinforcement.

F. Curing Compound

Conform to Section 03345, Concrete Finishing, Curing, and Waterproofing.

G. Excavation and Backfill

Conform to Section 02223, Trenching, Backfilling, and Compacting.

PART 3 - EXECUTION

A. Preparation of Subgrade

Subgrade shall be excavated and shaped to line, grade, and cross section. The top 12-inches of subgrade shall be compacted to 90% relative compaction. All soft material disclosed by excavating shall be removed and replaced with aggregate base as directed. The finished subgrade shall be within a tolerance of +/-0.02 of a foot of the grade and cross section shown and shall be smooth and free from irregularities at the specified relative compaction. The subgrade shall extend over the full width of the construction. The District Representative's approval of finished subgrades must be received prior to continuance of the work.

B. Placing Aggregate Base

After the subgrade for curbs, sidewalks, and roadway slabs is compacted and accepted, the Contractor shall place and spread aggregate base material, sprinkle with water, and compact to 90% relative density. The surface of the compacted base shall be at the proper level to receive concrete. Curbs and sidewalks shall be underlain by 4-inches or more of compacted aggregate base material.

C. Setting Forms

Forms shall conform to Section 03100, Concrete Formwork. Forms for a face-of-curb shall not have any horizontal joints within 7-inches of the top of the curb. Forms shall be braced to prevent change of shape or movement in any direction resulting from the weight of the concrete. Short-radius curved forms shall be constructed to exact radius. Tops of forms shall not depart from gradeline more than 1/8-inch when checked with a 10-foot straightedge. Alignment of straight sections shall not vary more than 1/8-inch in 10-feet.

D. Curb Construction

1. Jurisdictional Requirements: Curbs shall be reconstructed to original line and grade if removed. Curbs shall conform to the requirements of the respective jurisdictional agency.

2. Expansion Joints: Preformed asphalt-impregnated expansion joints shall be placed at 20-foot intervals, at the beginning and end of curved portions of the curb, at each change in thickness of section, at the end of curbs at buildings and other structures, and at connections to existing curbs.

3. Notification: The District Representative shall be notified one day in advance of planned concrete placement.

4. Concrete Finish: When the concrete has set sufficiently to support its own weight, the front form shall be removed and exposed surfaces finished. The formed face shall be finished by rubbing with a burlap sack or similar device to produce a uniformly textured surface, free of form marks, honeycomb, and other defects. Defective concrete shall be removed and replaced at no expense to the District. Upon completion of the finishing, curing compound shall be applied to exposed surfaces of the curb. Curing shall continue for a minimum of five days.

5. Backfill: Seven days (minimum) after pouring the concrete, the curb shall be backfilled with earth free from rocks, 2-inches and larger, and other foreign material. Backfill shall be tamped firmly in place.

6. Alignment and Grade: Finished curb shall have a uniform grade and alignment. Any section of curb showing abrupt changes in alignment or grade, or which is more than 1/4-inch away from its intended location, as staked, shall be removed and reconstructed at no additional cost to the District.

7. Protection of Work: All concrete surfaces and/or structures shall be protected until the project containing the work is accepted.

E. Sidewalk Construction

1. General Requirements: Unless shown otherwise, sidewalks shall be placed in a single pour, 4-inches thick. Walks shall slope 1/4-inch per foot upward from the top of curb. Concrete shall be placed, processed, finished, and cured in conformance with the applicable requirements of ACI 614, latest edition.

2. New Sidewalk: Where new sidewalk is to abut existing concrete, the existing concrete shall be sawcut to a depth of 2-inches and the concrete chipped out to sound material and a plane surface. The surface shall be cleaned and a neat cement paste applied just prior to pouring the new sidewalk.

3. Expansion Joints: Preformed expansion joints shall be placed at 20-foot intervals or less to match those in the adjacent curb, where the sidewalk ends at a curb, and around posts, poles, or other facilities located within the sidewalk. Expansion joints shall be placed between sidewalks and buildings or other structures.

4. Contraction Joints: Contraction joints shall be provided transversely to the walks at locations opposite the contraction joints in the curb and at 10-foot intervals along the sidewalk. These joints shall be 3/16-inch by 1-inch weakened plane joints. They shall be straight and at right angles to the top of the walk.

5. Notification: The District Representative shall be notified one day in advance of planned concrete placement.

6. Concrete Finish: The top surface of the sidewalk shall receive a broom finish with a fine-hair broom in line with the length of the walk. All edges, joints, and markings shall be tooled. The walk shall be scored transversely at 5-foot intervals with a jointing tool. Upon completion of the finishing, an approved curing compound shall be applied to exposed surfaces. Sidewalks shall be protected from damage until final acceptance.

END OF SECTION

SECTION 02578: PAVEMENT REMOVAL AND REPLACEMENT

PART 1 - GENERAL

A. Description

This section describes materials, testing, removal, and replacement of asphalt concrete pavement, seal coat, aggregate base course, prime coat, tack coat, and portland cement concrete surfaces.

This revision reflects incorporation of the new California and CalTrans standards for specifying performance grade (PG) asphalt versus the previous aged-residue (AR) system.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223
2. Concrete Curbs, Gutters, and Sidewalks: 02528
3. Standard Specifications for Public Works Construction, latest edition.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Submit information on material sources, designs, and quality certifications.

PART 2 - MATERIALS

A. Asphalt Concrete Paving

Asphalt concrete paving shall be Type III-C2-PG 64-16 as listed in Section 400-4 of the Standard Specifications for Public Works Construction for dense grade paving.

B. Asphalt

Asphalt shall be performance grade PG 64-16. Asphalt content in the pavement shall be 5.5% to 6.5%.

C. Aggregate for Asphalt Concrete

Aggregate shall be in accordance with Sections 400-1.1 and 400-1.2 of the Standard Specifications for Public Works Construction.

D. Seal Coat

Seal coat shall be a slow-setting emulsified asphalt, SS1 anionic emulsion per Table 203-3.2 (A) of the Standard Specifications for Public Works Construction.

E. **<u>Aggregate Base Course</u>**

Aggregate base shall be crushed aggregate base as specified in Section 400-2 of the Standard Specifications for Public Works Construction.

F. **<u>Prime Coat</u>**

All aggregate base areas to be paved over shall receive prime coat. Prime coat shall be medium curing (MC-70) in accordance with Section 302-5.3 of the Standard Specifications for Public Works Construction.

G. **<u>Tack Coat</u>**

Tack coat shall conform with Section 302-5.4 of the Standard Specifications for Public Works Construction.

PART 3 - EXECUTION

A. **<u>Pavement Removal</u>**

1. <u>Asphalt Concrete Pavement Cutting Requirements</u>:

   Asphalt concrete pavement shall initially be cut with a pavement cutter or other equipment at the limits of the excavation before the pavement is removed. After backfilling and compacting the excavation, asphalt concrete pavement shall be saw cut to a minimum depth of 2-inches at a point not less than 9-inches outside the limits of the excavation or the previous pavement cut, whichever is greater, and the additional pavement removed. If the cut is within 3-feet of an existing joint or curb and gutter, the asphalt concrete pavement shall be replaced to the joint or curb and gutter.

2. <u>Portland Cement Concrete Pavement Cutting Requirements</u>:

   Concrete pavement, cross gutters, curbs and gutters, sidewalks, or driveways, shall be saw cut to a minimum depth of 1-1/2-inches at a point 1-foot beyond the edge of the excavation and the strip of improvement removed. Concrete pavement may initially be cut at the limits of the excavation by other methods prior to removal and the saw cut made after backfilling the excavation. If the saw cut falls within 3-feet of a concrete joint or pavement edge, the concrete shall be removed and replaced to the joint or edge.

3. <u>Disposal of Material</u>:

   All pavement and other improvements removed shall be disposed of off the site. The cost of such disposal shall be included in the appropriate bid item.

4. Final Pavement Saw Cuts:

Final pavement saw cuts shall be straight along both sides of the trench, parallel to the pipeline alignment, and provide clean, solid, vertical faces free from loose material. Adjoining pavement which has been damaged or disturbed shall also be saw cut and removed. Saw cuts shall be parallel to the pipeline alignment or the roadway centerline or perpendicular to same.

B. Pavement Replacement

1. General:

Producing, hauling, placing, compacting, and finishing of asphalt concrete shall conform to Section 302-5 of the Standard Specifications for Public Works Construction. Seal coat shall be applied to all new asphalt concrete paving, except open grade asphalt concrete.

2. Base Course, Final Course and Striping:

Base course paving shall be complete at all times to a point not to exceed 1,000 feet behind any working heading. The final asphalt surface course shall be at least 1-inch thick and shall be placed within a period of two weeks after traffic has been returned to that portion of the street. Temporary striping shall be applied after the base course of asphalt concrete pavement has been placed, in the same configuration as the existing permanent striping, so that traffic can be returned to normal patterns. Temporary striping shall be maintained until permanent striping is applied.

C. Preparation of Subgrade

Subgrade shall be excavated and shaped to line, grade, and cross section. The top 18-inches of subgrade shall be removed and recompacted to 95% relative compaction. All soft material disclosed by the compacting effort shall be removed and replaced. The finished subgrade shall be within a tolerance of ±0.08 of a foot of the grade and cross section shown, smooth and free from irregularities and at the specified relative compaction. The subgrade shall be considered to extend over the full width of the aggregate base course.

D. Placing Aggregate Base

Aggregate base shall be placed to thickness shown on the plans, to match existing, or per the applicable permit. Aggregate base shall be compacted to 95% relative compaction and installed in accordance with Section 301-2 of the Standard Specifications for Public Works Construction.

E. Placing Prime Coat

Prime coat shall be applied to the surface of the final aggregate base course at the rate of 1/4 gallon per square yard per Section 302-5 of the Standard Specifications for Public Works Construction.

F. **Placing Tack Coat**

Tack coat shall be applied at the rate of 0.05 gallons per square yard to the surfaces to receive finish pavement per Section 302-5.4 of the Standard Specifications for Public Works Construction. Tack coat shall be applied to existing asphalt, metal, or concrete surfaces that will be in contact with new asphalt concrete paving.

G. **Placing Asphalt Paving**

Asphalt paving shall be applied to the thickness shown on the plans, as listed above, or per the applicable permit. Asphalt paving shall be installed in accordance with Section 302-5 of the Standard Specifications for Public Works Construction.

H. **Applying Seal Coat**

Seal coat shall be applied at the rate of 0.05 to 0.10 gallons per square yard.

I. **Compaction of Base and Leveling Courses**

Compaction and rolling of base and leveling courses shall begin at the outer edges of the surfacing continue toward the center. Water shall be applied uniformly throughout the material to provide moisture for obtaining the specified compaction. Each layer shall be compacted to the specified relative compaction before the next layer is placed.

J. **Surface Tolerance**

Finished grade shall not deviate more than 0.02 foot in elevation from the grade indicated on the drawings. Slopes shall not vary more than 1/8-inch in 10 feet from the slopes shown on the drawings.

K. **Concrete Curbs, Gutters, and Sidewalks**

Concrete curbs, gutters, and sidewalks shall be replaced in accordance with Section 02528, Concrete Curbs, Gutters, and Sidewalks.

L. **Emulsion-Aggregate Slurry**

Certain street sections where shown on the plans or where required by the jurisdictional agency may be required to receive an asphaltic slurry seal in conformance with Section 302-4, Standard Specifications for Public Works Construction after the final asphalt surface course. The composition and aggregate grading for slurry shall be Type II of Subsection 203-5.3.

END OF SECTION

SECTION 02701: INSTALLATION OF GRAVITY SEWER PIPELINES

PART 1 - GENERAL

A. Description

This section describes the installation of gravity sewer pipelines fabricated of vitrified clay pipe (VCP) and polyvinyl chloride (PVC).

B. Related Work Described Elsewhere

1. Trenching, Backfilling and Compacting: 02223
2. Jacked Casing: 02315
3. Vitrified Clay Pipe: 02710
4. PVC Gravity Sewer Pipe: 02715
5. Concrete: 03300
6. Precast Concrete Manholes and Bases: 03461
7. Leakage and Infiltration Testing: 15043

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following:
2. An installation schedule (tabulated layout) shall be submitted which includes:
   a. Order of installation and closures.
   b. Pipe centerline station and elevation at each change of grade and alignment.
   c. Locations of manholes.

PART 2 - MATERIALS

A. Installation Material

Refer to Section 02710, Vitrified Clay Pipe for Gravity Sewers and Section 02715, PVC Pipe and Fittings for Gravity Sewers for material requirements.

B. Piping Schedule

Unless noted otherwise on the plans or in the specifications, pipe shall be furnished in accordance with the following materials schedule.

DIAMETER	GRAVITY SEWER
4-inch through 10-inch	Extra-Strength VCP PVC SDR-35 (Class 200 C-900*)
12-inch through 20-inch	Extra-Strength VCP Class 200 C-900 & C-905 PVC
24-inch through 42 inch	Extra-Strength VCP Class 200 C-905 PVC (thru 36" dia.) CCFRPM Pipe (Hobas®) Polymer Concrete Pipe (Meyer®) Fiber-Reinforced Plastic
42-inch and larger	CCFRPM Pipe (Hobas®) Polymer Concrete Pipe (Meyer®) Fiber-Reinforced Plastic

Notes: *Class 200 C-900 or C-905 PVC pipe in special circumstances per Section 15064.
PVC SDR-35 - PVC gravity sewer pipe per Section 02715.
VCP - Vitrified clay pipe per Section 02710.
Polymer Concrete Pipe per ASTM D-6783-02 and Meyer & Amitech USA LTD. recommendations for installation.
Centrifugally Cast Fiberglass Reinforced Polymer Mortar (CCFRPM) Pipe per ASTM D-3262 & D-4161 and Hobas Pipe USA, Inc. "Guide Specifications" and recommendations for installation.
Fiber Reinforced Plastic per Section 02715.

PART 3 - EXECUTION

A. Delivery and Temporary Storage of Pipe at Site

1. Onsite Storage Limitation: Onsite pipe storage shall be limited to a maximum of one week, unless exception is approved by District.

2. Care of Pipe: At times when the pipe laying is not in progress, the open end of the pipe shall be closed with a tight-fitting cap or plug to prevent the entrance of foreign matter into the pipe. These provisions shall apply during the noon hours as well as overnight. In no event shall the sewers be used as drains for removing water which has infiltrated into the construction trenches.

B. Handling of Pipe

1. Moving Pipe: Pipes shall be lifted with handling beams or wide belt slings as recommended by the pipe manufacturer. Cable slings shall not be used. Pipe shall be handled in a manner to avoid damage to the pipe. Pipe shall not be dropped or dumped from trucks or into trenches under any circumstances.

2. Inspection Pipe: The pipe and accessories shall be inspected for defects prior to lowering into the trench. Any defective, damaged or unsound pipe shall be repaired or replaced. All foreign matter or dirt shall be removed from the interior of the pipe before lowering into position in the trench.

C. Placement of Pipe in Trench

1. General: All pipe shall be laid without a break, upgrade from structure to structure, with the bell ends of the pipe upgrade. Pipe shall be laid to the line and grade given so as to form a close concentric joint with the adjoining pipe and prevent sudden offsets of the flow line.

2. Trench Excavation: Dewatering, excavation, shoring, sheeting, bracing, backfill material placement, material compaction, compaction testing, and pipe laying requirements and limitations shall be in accordance with Section 02223, Trenching, Backfilling, and Compacting.

3. Pipe Base Thickness: Unless shown otherwise on the drawings, pipe base material shall be 3/4-inch crushed rock as specified in Section 02223, Trenching, Backfilling, and Compacting.

4. Subgrade at Joints: At each joint in the pipe, the pipe subgrade shall be recessed in firm bedding material so as to relieve the bell of the pipe of all load and to ensure continuous bearing along the pipe barrel.

5. Cleaning: The interior of the sewer pipe shall be cleaned of all dirt and superfluous materials as the work progresses.

6. Joints: The mating surfaces of the pipe to be joined shall be wiped clean of all dirt and foreign matter and a lubricant applied that is approved by the pipe manufacturer. Then, with the surfaces properly lubricated, the spigot end of the pipe shall be positioned inside the bell and the joint shoved home. For larger diameter pipe where a lever attachment is required, the necessary precautions shall be taken to insure an undamaged pipe installation.

7. Pipe Alignment: Unless specified otherwise, pipeline line and grade shall be as shown on the plans. Grade shall be measured along the pipe invert.

8. PVC Pipe Curvature: Construction of curved reaches of PVC pipe may be accomplished by deflecting joints. Pipe deflection to achieve horizontal curves shall be limited by the manufacturer's maximum recommended limit or as follows, whichever provides the largest radius and the least deflection:

Diameter (Inches)	Minimum Radius (Feet)
6	210
8	280
10	350
12	420

9. Short Lengths of VCP Pipe: When using VCP, two 1-foot lengths of sewer pipe shall be used to provide curve flexibility and prevent cracking or shearing failures as shown on the plans or as may be required by the District Representative during construction. The use of short lengths of pipe is particularly required, but not necessarily limited to these locations: (1) inlets and outlets to all manholes; and (2) ends of steel casing pipe.

10. Laterals: VCP and PVC wyes, and other types of branches shall be furnished and installed along with the VCP or PVC sewer main. Wyes sized as specified on the plans shall be installed for all sewer lateral connections and for future sewer lateral connections as shown on the plans. The longitudinal barrel of branch fittings, to be placed in line and grade with the sewer mains, shall be of the same diameter, quality, and type as specified herein for sewer installations. Earthwork and bedding for branches and shall conform to the applicable provisions set forth for vitrified clay sewer pipe. Unless otherwise specified, the branch of wye fittings shall be inclined upward at an angle not greater than 45 degrees from a horizontal line. No wye for sewer lateral branch shall be placed closer than 5 feet downstream of the centerline of any structure.

11. Backfill: Backfill shall be placed and compacted in accordance with the requirements of Section 02223, Trenching, Backfilling and Compacting, and as shown on District Standard Drawings.

D. Manholes and Manhole Bases

Precast concrete manholes and manhole bases shall be constructed in accordance with Section 03461, Precast Concrete Manholes and Bases, as shown in the plans or on District Standard Drawings.

E. Sewer Laterals with Lateral Clean-outs

1. Locations: Sewer laterals and wye branch fittings of the size indicated on the plans shall be installed at the locations shown on the plans or at the location furnished by the District Representative.

2. Wye-Branches for Future Laterals: All branch fittings that are to be left unconnected shall be plugged with a manufactured plug in accordance with the District Standard Drawings and as approved by the District Representative.

3. Fittings: Sewer laterals shall be joined to wye branch fittings at the sanitary sewer main as set forth above by eighth bends and in accordance with the District Standard Drawings. A wye branch fitting at or near the property line (right-of-way limit) or easement boundary, shall be set on each sewer lateral to allow the clean-out riser and cover to be brought up to grade for each lateral connection.

4. <u>Alignment</u>: Where possible, all sewer laterals shall run perpendicular to the sewer main to the property line. All sewer lateral trenches shall be bedded the same as the sewer main.

5. <u>Plugged Sewer Laterals</u>: All sewer laterals shall be plugged with an approved stopper or cap at the last joint of each lateral. It shall withstand the internal pressure during the test for leakage. It shall be installed in such a manner that it may be removed without damaging the pipe.

6. <u>Marking</u>: The Contractor shall mark the location of each sewer lateral near its upstream end by grinding a 2-inch tall letter "S" on the face of the curb (where a curb exists). The installation of warning tape over the trench line for lateral piping is also required.

   Where housing tracts, commercial subdivisions call for an extended time delay between District sewer construction and private on-site construction, each lateral shall be marked with a "utility marker paddle" labeled "SCO" as per District Standard Drawing G-2, at or near the property line.

7. <u>Chimney Connections</u>: Chimney connections of any kind (where sewer connections drop waste directly and vertically into the sewer main) are not allowed.

F. <u>Terminal Cleanouts</u>

1. <u>Limitations</u>: The use of terminal cleanouts (not to be confused with lateral clean-outs) shall be limited to the following:

   a. A short section (less than 250 feet) of sewer main that is to be extended.

   b. At the end of a sewer main where the distance from the downstream manhole to the cleanout does not exceed 250 feet.

G. <u>Installation Within Casing</u>

1. <u>General</u>: Vitrified clay sewer pipe shall be installed within the casing pipe to the lines and grades shown on the plans and in accordance with Section 02315, Jacked Casing.

2. <u>Pipe Support</u>: The carrier pipe shall be supported on skids, before backfilling, in such a manner as to relieve the pipe bells from any bearing loads. Pipe skids for “carrier pipe” shall be as specified in Section 02315, Jacked Casing, and as shown in the District Standard Drawings.

3. <u>Annular Casing Space</u>: The annular space between the casing and the VCP carrier pipe shall not be backfilled. Refer to Section 02315, Jacked Casing.

4. <u>Testing</u>: Before backfilling the trench and bore pits, or sealing the casing ends, the sewer carrier pipe shall pass an initial test for leakage as provided in Section 15043, Leakage and Infiltration Testing.

H. Pipe Anchorage

1. General:

   Concrete slope anchors shall be installed where shown on the plans in accordance with Section 03300 and the District Standard Drawings**.** They shall be installed wherever the profile of the ground surface above the sewer main exceeds 10 percent, and where no pavement or other surfacing is to be laid over the facility.

2. Dimensions:

   Anchors shall be a minimum of 12-inches thick and shall extend at least 12-inches into undisturbed material on each side of the trench as excavated. Refer to the District Standard Drawings.

3. Slope Protection:

   Any required surface slope protection shall be reviewed and approved in advance by the District.

4. Spacing:

   Spacing between slope anchors shall not exceed the distances shown in the District Standard Drawings.

5. Reinforcement for Concrete Anchors:

   Anchors constructed of cast-in-place reinforced concrete shall have No. 4 reinforcing bars placed at 6-inches on center each way in the center of the anchor thickness. Refer to the District Standard Drawings.

6. Sand – Cement Slurry:

   At the direction of the District Representative, a one-sack sand - cement slurry encasement may be used for additional slope and erosion protection. The encasement shall extend to within 1-foot of the ground surface and to the toe of slope in which the pipe is constructed.

I. Concrete Encasement

Unless shown otherwise, concrete for encasement shall be reinforced or unformed or rough formed, and of the class as designated on the plans. Concrete shall be in accordance with Section 03300, Concrete. Concrete used for encasing, cradling, bedding, cover for pipe, or other objects shall be as specially designed by the Engineer, or as directed by the District Representative. Encasement is by special permission from the District and in no case shall it be installed on VCP sewer pipes.

J. Cleaning

Before testing, and after each phase of development (or tract), each pipe shall be thoroughly cleaned from manhole to manhole with a sewer scrubbing ball, and all debris and trash shall be removed from each manhole.

K. <u>Mandrel Test for PVC Gravity Sewers</u>

Following placement and compaction of backfill for all utilities, and prior to the placement of permanent pavement, all sewer mains shall be cleaned and mandrelled to verify that the pipeline is free from obstructions (deflections, joint offsets, lateral pipe intrusions, etc.). A rigid mandrel, with a circular cross section having a diameter of at least 95 percent of the specified inside pipe diameter, shall be pulled through the pipe by hand. The minimum length of the circular portion of the mandrel shall be equal to the nominal diameter of the pipe. Obstructions encountered by the mandrel shall be repaired and the pipeline section retested.

1. <u>Labor</u>:

   All labor and equipment necessary to assist the District in conducting this inspection shall be furnished by the Contractor.

2. <u>Pull Line</u>:

   1/4-inch diameter nylon line shall be pulled from manhole to manhole to be left for use by the District in conducting the CCTV inspection.

3. <u>Notification</u>:

   Requests for sewer line inspection shall be made to the District Representative a minimum of two working days in advance of the requested inspection date.

L. <u>Leakage and Infiltration Test</u>

The pipe, manholes, and other appurtenances shall be tested for leakage and infiltration per Section 15043, Leakage and Infiltration Testing.

M. <u>Closed-Circuit Television Inspection</u>

1. <u>General</u>:

   In addition to the regular leakage and infiltration test, all new sewer lines shall be inspected using closed-circuit television (CCTV) equipment. The inspection shall be conducted after all utilities have been installed prior to paving. The inspection shall be conducted by District forces using District furnished camera equipment at no cost to the Contractor for the initial inspection. Re-inspection shall be conducted by the District, the cost of which shall be the Contractor's responsibility.

2. <u>Labor</u>:

   All labor and equipment necessary to assist the District in conducting this inspection shall be furnished by the Contractor.

3. <u>Notification</u>:

   Requests for sewer line inspection shall be made to the District Representative a minimum of two working days in advance of the requested inspection date.

4. Repair of Defects:

Even though the sewer line may have successfully passed the leakage and infiltration tests, any defects in the line shall be repaired to the satisfaction of the District. Following repair, mandrel testing, and CCTV inspection shall again be conducted for the repaired pipeline section and these re-inspection costs shall be the sole responsibility of the contractor.

N. Final Inspection

After paving has been completed and all manholes raised to grade (where required), a final visual inspection shall be made. The necessary labor shall be furnished to assist the District Representative in making the final inspection. Additional balling may be required if the lines are dirty, even though lines were previously balled. The Contractor shall furnish a responsible person or supervisor for the final inspection to remove manhole covers and to note any corrections required by the District Representative in order to obtain final approval. Final District inspection shall be requested through the District Representative by giving at least one day advance notice.

END OF SECTION

SECTION 02705: REINFORCED CONCRETE PIPE, GRAVITY

PART 1 - GENERAL

A. Description

This section describes materials, fabrication, installation and testing of reinforced concrete pipe (RCP).

B. Related Work Specified Elsewhere

1. Trenching, Backfilling and Compacting: 02223
2. Installation of Gravity Sewer Pipelines: 02701
3. Concrete: 03300
4. Concrete Finishing, Curing and Waterproofing: 03345
5. Precast Concrete Manholes and Bases: 03461
6. Polyvinyl Chloride Plastic Liners: 09880
7. Painting and Coating: 09900

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Tabulated layout schedule including:
   a. Order of installation and closures.
   b. Pipe invert station and elevation at each change of grade and alignment.
   c. Elements and curves and bends, both in horizontal and vertical alignment including elements of the resultant true angular deflections in cases of combined curvature.
   d. The location length, size, design designation, and number designation of each pipe section and pipe special.
   e. Locations of manholes and other structures.
   f. Locations of tunnels, casings and concrete encasements.
3. Details of pipe specials.
4. Joint details.
5. Details of reinforcement cage assemblies.
6. Details of gasket and test reports of physical properties of gasket material.

7. Certificate that cement complies with ASTM C 150; designating type.

8. Test reports of concrete test cylinders.

D. Measurement and Payment

1. Payment for work in this section shall be in accordance with the General Provisions and the following.

2. Payment shall be by the linear foot for each diameter and for each pipe strength designation measured horizontally over the pipe centerline, exclusive of the distance between the inside faces of each structure, manhole or other similar connecting structure. Unless otherwise specified herein, no additional payment shall be made for curved or radius pipe. Such pipe shall be measured and paid for in the same manner as described above for straight pipe.

PART 2 - MATERIALS

A. General

All pipe, fittings, couplings, and appurtenant items shall be new, free from defects or contamination, and wherever possible, shall be the standard product of the manufacturer. They shall be furnished in pressure or thickness classes as specified or shown. Unless otherwise indicated the size shown shall be the nominal pipe diameter.

B. Reinforced Concrete Pipe

1. Pipe

   a. Except when otherwise permitted by the District, no materials shall be used in manufacturing of the pipe other than water, type V portland cement as specified in ASTM C 150, mineral aggregates, and steel conforming to ASTM C 76.

   b. The aggregates shall be so graded, proportioned, and thoroughly mixed in a batch mixer to produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements of these specifications. Concrete mixes shall be designed on the basis of concrete attaining a compressive strength at 28 days of at least 4,500 psi. The proportion of portland cement shall not be less than six sacks per cubic yard of concrete.

   c. Pipe sections shall be made in minimum lengths of eight (8) feet, except where shorter lengths are required to meet special conditions. Maximum length shall be twenty (20) feet. The pipe wall shall have a minimum of 3/4 inches of concrete between the reinforcing steel and the inside diameter.

2. Joints

   a. Pipe ends shall be formed so that when the pipes are laid together and the joints cemented, a continuous and uniform line of pipe is produced with a smooth and regular interior surface.

   b. The type of joint to be furnished shall be a steel ring joint of the flush bell design. Each joint shall contain a neoprene ring gasket that shall be the sole element providing for watertightness of the joint. The gasket shall be of circular cross section unless otherwise approved by the District Representative. The length and cross-sectional diameter of the gasket, the annular space provided for the gasket, and all other joint details shall be such as to produce a watertight joint that will not leak when pulled 1 inch from normal closure for full circumference. The slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed 2 degrees. Where double mitered pipe joint sections are used to deflect the pipe through an angle as indicated on the plans, the section shall be completely plant manufactured and not constructed in the field. The steel joint ring shall be coated with a coal tar epoxy as specified in Section 09900, Painting and Coating.

3. Rubber Gaskets: The rubber gaskets used to seal pipe joints shall be made of neoprene of such size and cross section as to fill completely the recess provided for it. The gasket shall be the sole element depended upon to make the joint watertight. All rubber gaskets shall be extruded or molded and cured in such a manner that any cross section will be dense, homogeneous, and shall be free from pitting, blisters, porosity, and other imperfections. The gaskets shall have smooth surfaces and shall be extruded or molded to the specified diameters within a tolerance of +/- 1/64 inch. The rubber compound shall contain not less than 50 percent by volume of neoprene. The remainder of the compound shall consist of pulverized fillers free from rubber substitutes, reclaimed rubber, and deleterious substances. The compound shall meet the following physical requirements when tested in accordance with appropriate sections of "Method of Physical Tests and Chemical Analyses for Rubber Goods (Federal Specification ZZ-R-601a)":

   Tensile Strength, psi, mine. 2,000

   Elongation at rupture, percentage, mine. 425

   Shore durometer, Type A.. 40 to 50

   ASTM D 686 - Lock joint only .... 45 to 55

   Compression set, percentage of
   original deflection, max. 32

   Method B (constant deflection; 22 hours
   at 150º F) ASTM D 3895 - Lock joint only...20

Accelerated aging in air (70 hours at 212º F):

Tensile strength, percentage of original strength mine. 85

Hardness change, percentage max. 15

Water absorption, percent volume change, max. 10

Ozone 6 ppm, 25% elongation, 2 hours at 100° F max. ....No Cracking

Specific gravity .... 1.35 to 1.45

4. Vinyl Plastic Liner: Unless noted otherwise, all reinforced concrete pipe shall be manufactured with an integral vinyl plastic liner. The vinyl plastic liner shall be white in color and shall be cast into all pipe at the time of manufacture in accordance with Section 09880, "Polyvinyl Chloride Plastic Liners." The pipe shall be lined in the upper 300-degree circumferential angle, unless otherwise noted on the plans.

PART 3 - EXECUTION

A. General Manufacturing Requirements

1. Forms: The forms for the pipe shall be steel made with butt joints throughout, and the surfaces of the forms adjacent to the pipe walls shall be smooth and true. All forms shall be sufficiently tight with suitable gaskets provided at all form joints to prevent leakage of mortar. The forms shall be braced and sufficiently stiff to withstand, without detrimental deformation, all operations incidental to the placement and compaction of concrete within the form. The form and end rings shall be so constructed that the pipe, when manufactured, will have circular and cylindrical inner surfaces so that they may be stripped from the pipe without damage to the pipe or its surfaces. Forms shall be cleaned and oiled before each filling. Defective forms and end rings shall be discarded or adequately repaired.

2. Method of Manufacture

   a. The pipe shall be manufactured using the vertically cast method. The transporting and placing of concrete shall be by methods that will prevent the separation of the concrete materials and displacement of reinforcement steel in the forms. When placing the concrete in the forms, the concrete shall be vibrated continuously with internal or external mechanical vibrators to produce a dense concrete shape.

   b. A set of at least four standard test cylinders shall be taken each day from the mixed concrete being used to manufacture the pipe. Test cylinders shall be made in conformance with ASTM C 31 and shall be cured as required for the pipe.

c. All test cylinders shall be tested in conformance with ASTM C 39 by an approved testing laboratory at the expense of the manufacturer, unless the manufacturer has its own approved testing facilities at the site of the work. In such event, the test shall be made by and at the expense of the manufacturer either in the presence of the District Representative, or certified test reports may be submitted by the manufacturer.

3. Curing

a. Adequate steam plant, piping, enclosures, and other facilities for curing the pipe shall be provided. The enclosures shall be such that the temperature and humidity can be controlled to keep the pipe surfaces moist at all times and the temperature maintained continuously between 80°F and not more than 170°F.

b. After the pipe has been cast, it shall be placed under a suitable enclosure that will allow proper circulation of steam. Curing shall not commence until the concrete has hardened sufficiently, but in no case shall curing commence sooner than 1 hour nor longer than 10 hours after placement of the concrete. The temperature within the enclosure shall be increased at a rate not to exceed 30°F per hour to a temperature of at least 80°F and not more than 170°F.

After a minimum of 6 hours of continuous saturated steam, the forms may be removed. After removal of the forms, the pipe shall be suitably enclosed and again subjected to the action of saturated steam. The temperature of the concrete shall be maintained at a temperature of not less than 180°F nor more than 170°F until 28 hours of steam curing have been cumulated, at which time the pipe may be tipped and stored in a horizontal position. After completion of the 28-hour steam cure, curing shall be resumed, the method optional at the discretion of the manufacturer, until a companionate test cylinder reaches the design strength.

4. Reinforcement

a. Reinforcement shall be fabricated as a rigid cage of bars or wires. Transverse reinforcement shall be fabricated either as complete hoops, welded or lapped, or as a continuous helix. If the transverse reinforcement is formed as a cylindrical or elliptical helix, both ends of the cage shall be finished off as a complete hoop. Elliptical cages may be wound on an elliptical drum or deformed from a circular cage to the required elliptical dimensions. The location of the minor axis of elliptical reinforcement shall be clearly indicated. A letter "T" shall be painted or stamped on the inside of the pipe to indicate the minor axis so that the pipe can be laid with the minor axis vertical.

b. Splices shall be either welded or lapped and tightly wired. Either lap or butt welds may be used, but the weld must develop the full strength of the bar. When required by the District Representative, test samples of welds proposed for use shall be submitted. The lap of unwelded splices shall extend 30 diameters when bars or rods are being used for reinforcement and 40 diameters when wire is being used.

c. Suitable devices shall be used to hold the cage of reinforcement in its elliptical and circular shape and to maintain the cage in place within the forms during the placing and consolidating of the concrete. Supports between the reinforcement and the forms that are to be exposed in the finished pipe shall be made of Type 316 stainless steel.

d. Longitudinal reinforcement shall be in sufficient amount to provide a rigid cage of reinforcement. Where the pipe design is shown on the plans, the type, extent, and positioning of the longitudinal steel indicated shall be considered a minimum requirement. Whether pipe details are shown on the plans or not, enough longitudinal steel shall be provided to furnish a cage sufficiently rigid to retain its shape and position in the forms during the manufacturing process.

e. The size and spacing of longitudinal reinforcement in the RCP shall be such that it is sufficient to make the cage rigid and to support the transverse reinforcement firmly in place in the forms during placing and consolidation of the concrete, but in no case shall be less in area than 0.2% of the gross cross-sectional area of the concrete. The RCP shall be manufactured with sufficient longitudinal reinforcement to allow the finished pipe to be properly handled during installation in the construction of the pipeline. Where the pipe joint construction requires the use of a bell, the minimum specified number of bars shall be continued into the bell. Where two cages are used, the longitudinal reinforcement shall be divided approximately equally between the two cages, and only the longitudinal bars on the outer cage need to extend into the bell.

f. The reinforcing steel shall be placed in the wall of the pipe in such a manner that the end hoops of the transverse reinforcement and the ends of the longitudinal reinforcement shall not be more than 1 inch +/-1/4 inch from the extreme and concrete faces of the pipe.

5. <u>Sizes and Dimensional Tolerances</u>

a. Pipe shall be round and true and shall have smooth and dense finished surfaces. The internal diameter of any portion of each piece of pipe shall not vary more than +/1% but in no case shall exceed 3/8 inch from the nominal diameter. The wall thickness shall not be less than that shown in the design by more than 5% but in no case shall exceed 3/16 inch. A wall thickness more than that required in the design shall not cause for rejection, as long as the reinforcement is properly placed.

b. Reinforcement steel shall be accurately placed in the concrete wall of the pipe. The placement of all steel shall not vary from the position in the pipe wall shown on the drawings by more than +/-1/4 inch from the nominal shown on the drawings. In no case shall the cover over any reinforcement be less than 1 inch. Variations in laying lengths of two opposite sides of pipe shall not be more than 1/8 inch per foot or diameter with a maximum of 3/8 inch in any length of pipe except where beveled pipe is used. The underrun in length of a section of pipe shall not be more than 1/8 inch per foot with a maximum of 1/2 inch in any length of pipe.

B. Causes for Rejection:

1. Exposure of Reinforcement: Exposure of any wires or positioning spacers or chairs used to hold the reinforcement cage in position or steel reinforcement in any surface of the pipe.

2. Reinforcement out of Position: Transverse reinforcing steel found to be in excess of 1/4 inch out of specified position after the pipe is molded.

3. Shattered Concrete: A shattering or flaking of concrete at a crack.

4. Bubble Voids: Bubble voids (bugholes) on the interior and exterior surfaces of the pipe exceeding 1/4 inch in depth unless pointed with mortar or other approved material.

5. Unauthorized Work: Unauthorized application of any wash coat or cement or grout.

6. Dimensional Deficiencies

   a. A deficiency greater than 6% from the specified wall thickness of pipe larger than 30 inches in internal diameter, except that the deficiency may be 8% adjacent to the longitudinal form joint, provided that the additional deficiency does not lie closer than 20% of the internal diameter to the vertical axis of the pipe and does not extend along the circumference for a distance greater than 20% of the internal diameter of the pipe.

      The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces. Tolerances of such contact surfaces shall be submitted for approval.

   b. A variation from the specified internal diameter in excess of 1% or interior surfaces that have been reworked after placing of the concrete. The variation in internal diameter permitted herein does not apply to gasket contact surface. Tolerances at such contact surfaces shall be submitted for approval.

7. Broken Pieces from End Projections: A piece broken from the end projections of the pipe which has a circumferential length exceeding 60 degrees of the circle or extends into the body of the pipe or extends into the gasket contact surfaces for a circumferential length in excess of 6 inches (measured at the midpoint of the gasket contact surface on the bell end and at the inner shoulder of the gasket groove at the spigot end). If two or more pieces are broken from an end projection, the total length of such broken pieces on any end shall not exceed 90 degrees of the circle; and there shall be a distance of at least 9 inches of sound concrete between breaks. The total length of broken pieces that extend into the gasketed joint pipe shall not exceed a circumferential length of 6 inches. If less than 9 inches of sound concrete exists between two individual breaks, the two breaks shall be considered as one continuous break. Repair of such defects not exceeding the above limitations shall be made by Method III, paragraph 3.3C. Unsound portions of end projections shall be removed, and if the pieces removed do not exceed the above limits, the pipe may be similarly repaired.

8. Defective Molding of Concrete: Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open texture (rock pockets) greater in size than an area equal to a square with a side dimension of two and one-half times the wall thickness or deeper than two times the maximum graded aggregate size; or a local deficiency of cement resulting in loosely bonded concrete, the area of which exceeds in size the limits as provided in Item 8 above. Sand rings occurring at the ends of the pipe may be repaired for the full circumference.

9. Cracks: Any of the following cracks: A crack having a width of 0.01 inch or more throughout a continuous length of 1 foot or more.

   a. Any crack extending through the wall of the pipe and having a length in excess of the wall thickness.

   b. Any crack showing two visible lines of separation for a continuous length of 2 feet more, or an interrupted length of 3 feet or more anywhere in evidence, both inside and outside, except where such cracks occur during the external loading test.

   c. When required by the District Representative, any crack 0.01 inch wide or wider that is not a cause of rejection shall be filled with neat cement grout composed of cement mixed with water to a fluid consistency.

10. Dimensional Tolerance: Failure to meet the size and dimensional tolerances stated in Part 3, paragraph A, subparagraph 5.a. (on page 02705-6).

C. Repair of Imperfections

1. Method I - Repair by Pneumatically Applied Mortar: Pneumatically applied mortar shall be used when the repair extends to a depth greater than the embedment of the reinforcing steel. Such repairs shall be made with preshrunk mortar. Unless other methods are approved in writing by the District, this is the only method of repair allowed.

   a. Preparation of Surface to be Repaired: Surfaces to which pneumatically applied mortar are to be applied shall be prepared in the same manner as described under Method II, except that the edge of the area from which unsound or imperfect concrete is removed shall be beveled so as not to entrap rebound.

   b. Placement of Mortar: No rebound shall be included in the repair. The pipe shall be turned so that the area being repaired is at the side of the pipe in a near vertical position to permit rebound to fall clear.

      Before repairing grooved concrete spigots, the snap ring shall be replaced and retained in position until the repair has attained sufficient strength to assure no damage to the gasket groove by its removal.

Areas repaired with pneumatically applied mortar shall be built up in excess of the dimension required and then carefully trimmed to correspond with adjacent surfaces.

c. Curing: Surfaces to which pneumatically applied mortar have been applied shall be cured in the same manner as described under Method II.

2. Method II - Repair by Hand-Placed Mortar:

a. Preparation of Surfaces to be Repaired: Unsound or imperfect concrete shall be removed by chipping. Edges where concrete has been chipped out shall be sharp and squared with the surface, leaving no feathered edges. The chipped area shall be washed with water to remove all loose material and concrete dust.

Surfaces within the trimmed areas shall be kept wet for several hours, preferably overnight, before the repair replacement is made. All surfaces in areas to be repaired shall be damp, but not wet, when the material is applied.

b. Placement of the Mortar: The mortar used for the repair shall contain the same proportions of cement and sand as the mix from which the pipe was made.

This mortar shall be preshrunk by mixing it to a plastic consistency as far in advance of its use as possible. Trial mixes shall be made and aged to determine the longest period the mortar's use can be delayed while retaining sufficient plasticity to permit good workmanship.

Immediately prior to the application of the mortar, the damp surface of the area to be repaired shall be scrubbed thoroughly with a small quantity of neat cement grout, using a wire brush. Remaining loose sand particles shall be swept away immediately before application of the mortar.

In applying the mortar, it shall be compacted into the space to be filled, care being taken to eliminate air pockets and to secure bond at the edges. The surfaces shall be shaped and finished to correspond with the adjacent surfaces of the pipe.

3. Method III - Bonding Mortar Repairs with Epoxy Resin Adhesives

a. Preparation of Surfaces to be Repaired: Unsound or imperfect concrete shall be removed by chipping. If hand-placed mortar is to be used, the edges shall be left sharp and square with the surface. If pneumatically applied mortar is to be used, the edges shall be beveled.

The area to be repaired shall be kept dry. Loose material and concrete dust remaining after the chipping operation shall be removed by means of an air jet.

b. Placement of Mortar: The prepared area shall be primed with the epoxy resin compound, care being taken to ensure intimate contact with the base material. Mortar shall be applied before the epoxy resin compound sets. Mortar shall be applied by either Method I or Method II as described above.

D. D-Load Bearing Strength Test

1. Selection of Test Samples: Pipe to be D-Load tested shall be selected at random by District Representative at the point of manufacture. One pipe will be selected for each lot or fraction thereof of the pipe to be furnished for the project.

2. Lot: For the purpose of these Specifications, a lot is defined as 50 sections of pipe or fraction thereof of one size and class manufactured on consecutive working days. If an interruption in the manufacture of a lot occurs, the District Representative may permit the pipe made after the interruption to be included in the lot, provided the interruption does not last more than seven calendar days. A new lot number will be assigned if any change occurs in the size of spacing of reinforcing steel in the concrete mix or curing method.

3. Testing Equipment: Test pipe shall be furnished and adequate equipment facilities shall be provided for conducting tests without charge to the District. All testing equipment shall be calibrated at intervals not to exceed six months. All tests shall be made in the presence of the District Representative.

4. Test Method: Test pipe shall conform in all other respects to the applicable requirements specified herein. Pipe shall be tested by the three-edged bearing test as prescribed in ASTM C 76.

5. Test Load: The required strength of the pipe specimens undergoing the bearing tests shall be designated in terms of D-load. A D-load is defined as the load expressed in pounds per foot-length of pipe per foot of internal diameter. Therefore, the total load to be used in the three-edge bearing test shall be determined by multiplying the D-load by the internal diameter of the pipe, in feet, and then multiplying this product by the length of the pipe joint.

6. Test Criteria: The pipe shall withstand the required test load before a crack having a width of 0.01 inch, measured at close intervals, occurs throughout a length of 1 foot or more. The crack shall be considered 0.01 inch in width when the point of the measuring gage will, without forcing, penetrate it 1/16 inch at close intervals throughout the specified distance of 1 foot.

7. Load Application Rate: The load shall be applied at a uniform rate not to exceed 2,000 pounds per minute per foot-length of pipe for the first 80% of the required load and then at a uniform rate not to exceed 500 pounds per minute per foot-length of pipe for the remainder of the test.

8. Specimen Condition: The test specimens shall be surface dry when tested.

9. Length on Which Test Load is Computed: The length on which the test load is computed shall be determined by measuring the inside length of the barrel of the pipe from the bottom of the socket to the end of the spigot. The length of a beveled pipe shall be the average length of the inside of the barrel of the pipe, measured from the bottom of the socket to the end of the spigot.

10. Test Results

  a. If the tested specimen of a designated lot passes the test, all of the pipe of that lot shall be considered as complying with the requirements.

  b. If the tested specimen of a designated lot fails to pass the test, then five additional specimens from the same lot shall be selected for testing.

  c. If the five additional specimens pass the requirements of the test, the total number of that lot to be furnished shall be considered as complying with the requirements except that the one previous test specimen failing to meet the requirements shall be rejected.

  d. If any of the five additional specimens fails to meet the test requirements, the entire lot shall be rejected; or may be downgraded, except those test specimens that met the test requirements during the testing.

  e. Specimens of a rejected lot may be tested individually to determine whether that may comply with the requirements for acceptance.

E. Hydrostatic Tests

1. General: Hydrostatic tests shall be performed on joints for each size pipe 36 inches and larger. Testing shall be performed prior to delivery of any pipe to the worksite. One set of tests shall be conducted for each pipe diameter and each wall thickness. Tests shall be conducted on pipe selected by the District Representative from the initial pipe manufactured for each size. One additional set of tests shall be conducted for each 200 pipe sections of any one diameter and wall thickness after acceptance of the joint.

2. Test Procedure: Pipe sections shall be joined together in the yard in a horizontal position, with the axes of both sections level and along the same line. Vertical support shall be provided for each section so that no support exists directly under the joint and the reaction of the spigot on the bell is equivalent to not less than the weight of one-fourth the weight of one pipe section. Pipe sections shall be joined together to produce a gap concentrically around the pipe of 1 inch greater than the normal closure. The joint shall be subjected to a pressure of not less than 30 feet of water. Internal pressure shall be maintained for a period of four hours. At the end of that time, leakage through the rubber gasket or gaskets shall be at a rate not exceeding 1.0 gallons per hour. The test shall then be repeated with the end of one pipe lowered to produce gap at the top of the pipe of not less than 1½ inches. Gap is defined as the distance the joint is open from normal closure measured on the inside of the pipe. If the joint begin tested does not meet the leakage requirements, necessary modifications to the joint shall be made and the joint retested.

3. Additional Tests: After acceptance of the joint as an approved type, capable of being manufactured to meet the requirements stated herein, additional leakage tests shall be conducted on joints selected by the District Representative from the pipe manufactured for the job. Not less than one additional joint leakage test shall be required for each 200 pipe sections or fractions thereof of each pipe diameter. Failure of any such test shall be the basis for requiring two additional joint tests using pipe selected by the District Representative. Failure of any one

of these two retests shall be cause for suspension of the pipe manufacturing operation until remedial measures are taken to correct the joint. The remainder of the pipes with joints that do not meet the specified leakage requirements shall be subject to testing prior to acceptance. The corrected joint shall be requalified as though it were a new joint.

F. **Product Marking**

Each section of pipe shall be lettered on the interior with the following:

1. D-Load to produce a 0.01-inch crack.

2. Date of manufacture.

3. Name of manufacturer and plant.

4. For elliptical or quadrant reinforcement, the letter "T" marking the vertical axis in which the pipe is to be laid.

5. A number of designation on the inside bell ends and spigot to identify the location of installation of the pipe in reference to the laying diagram .

6. Mark all beveled pipe with the amount of bevel.

G. **Acceptance of Pipe**

Pipe shall be accepted which conforms to all previously stated requirements and tests and exhibits good workmanship and finish. Pipe that does not conform shall be rejected.

H. **Product Handling, Delivery and Storage**

1. General: Pipe shall at all times be handled with equipment designed to prevent damage to the interior or exterior coating of the pipeline. Bare cables, chains, hooks, or metal bars shall not be allowed to come in contact with the coating or lining.

2. Transportation and Storage of Pipe: Stulls or other protective methods necessary for furnishing and installing pipe meeting limitations on cracks specified herein, shall be provided and maintained throughout pipe handling, transportation, and field installation. The pipe shall not be dropped or subjected to any unnecessary jar, impact or other treatment that might crack the shell or otherwise damage the pipe. No pipe shall be loaded or hauled to the site of the work until the end of the specified curing period. Any unit or pipe that is damaged beyond repair in hauling, handling, unloading, storing, or otherwise, shall be removed from the site of the work and replaced by another unit that is reinforced to the same or greater loading requirements.

3. Gaskets: Gaskets shall be stored in containers or wrappers which will protect the gaskets from ozone and other atmospheric deterioration.

4. <u>Stringing</u>: Pipe shall be strung along the length of the Project. Pipe shall be laid on padded wood blocks or mounds of sand or rock-free dirt.

5. <u>Gaskets and Jointing Materials</u>: Gaskets, gasket lubricants, bolts, and jointing materials shall be delivered in separate, clearly marked boxes.

6. <u>Spare Jointing Materials</u>: As part of the quantity delivered, the Contractor shall include in his bid 5 percent additional gaskets and loose bolts than may be theoretically required for the amount of pipe furnished to cover field losses.

I. <u>Installing Pipe in Trenches</u>

Pipe shall be installed in accordance with the requirements of Section 02701, Installation of Gravity Sewer Pipelines, and the following:

1. <u>Trench Subgrade</u>: The bottom of trench shall be graded to form a continuous and uniform bearing and support for the pipe at every point between joints. Before laying each section of pipe, the grade shall be checked with a straight-edge and any irregularities found shall be corrected.

2. <u>Backfill</u>: After joint assembly, the bedding material shall be brought up to the limits shown on the plans. The bedding material shall be placed in even lifts on each side of the pipe. The bedding material shall be compacted into final position. Bedding material shall be 1-inch crushed rock as specified in Section 02223, Trenching, Backfilling and Compacting.

J. <u>Completion of Joints</u>

1. <u>Joining</u>

   a. Prior to placing the spigot into the bell of the pipe previously laid, the spigot groove, the rubber gasket, and the first 2 inches of the bell shall be lubricated with soft, vegetable soap compound. The gasket, after lubrication, shall be uniformly stretched or relieved when placing it in the spigot groove so that the rubber is distributed uniformly around the circumference.

   b. Before assembling the joint, place metal or wooden spacers shall be placed against the inside shoulder of the bell to provide the proper space between the abutted ends of the pipe.

   c. After the joint is assembled, a thin metal feeler gage shall be inserted between the bell and the spigot to check the position of the rubber gasket around the complete circumference of the pipe. If the gasket is not in the proper position, the pipe shall be withdrawn and the gasket checked to see that it is not cut or damaged, The joint shall be reassembled and the gasket position checked again. All pipe shall be joined in such a manner that the "T" is in the invert and the ends of the plastic liner match, are even, and in a continuous straight line. Pipe not installed in this manner shall be removed and reinstalled. Gaskets cut or damaged during joint assembly shall be replaced, at no expense to the District.

2. Grouting Joints (Exterior)

a. Where required by the joint design, a suitable cloth or plastic band shall be placed around the outside of the pipe and centered over the joint to prevent dirt from entering the joint recess. The joint band shall be bound to the pipe by steel box strapping or by an equivalent method and shall completely and snugly encase the outside joint except for an opening near the top where mortar grout is to be poured into the joint recess.

b. Joints may be grouted before or after the placement of bedding and backfilling materials if those materials are to be densified by compaction. If bedding and backfilling materials are to be hydraulically consolidated, grout shall be poured and allowed to set before consolidation of those materials. In any case, joint shall be grouted before backfill is placed over the top of the pipe.

c. With the jointing band properly secured, moisten the joint recess shall be moistened with water and filled with semifluid mortar consisting of one part portland cement to two parts sand mixed to the consistency of thick cream. The mortar grout shall completely fill the outside annular space between the ends of the pipe and around the complete circumference. After the recess has been filled, replace the jointing band over the opening left for pouring and the mortar allowed to set.

3. Pointing Joints (Interior)

All steel ring joints shall be pointed regardless of the joint gap. All joints pointed shall be pointed 360 degrees of the circumference. Pointing shall be done in such manner so that there are no bulges, ridges, other irregularities that will make welding of PVC joints difficult. Pointing shall be flush with the interior surface of the pipe. No pointing shall be performed until pipe trench has been backfilled and compacted.

END OF SECTION

SECTION 02710: VITRIFIED CLAY PIPE FOR GRAVITY SEWERS

PART 1 - GENERAL

A. Description

This section describes materials, testing, and installation of vitrified clay pipe (VCP) and fittings for sanitary sewers.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling and Compacting: 02223
2. Jacked Casing: 02315
3. Installation of Gravity Sewer Pipelines: 02701
4. Concrete: 03300
5. Precast Concrete Manholes and Bases: 03461

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Provide certificates of compliance with all standards referenced in this section to the District.
3. Provide copies of the manufacturer's required tests to the following conducted on project pipe:
    a. Crushing test.
    b. Record of retests and rejections.

D. Inverted Siphons

Inverted siphons, where not shown on the plans, will be allowed only at locations approved by the District.

E. Measurement and Payment

1. Payment for work in this section shall be in accordance with the General Provisions and the following.

2. Payment shall be by the linear foot for each diameter and for each pipe strength designation measured horizontally over the pipe centerline, exclusive of the distance between the inside faces of each structure, manhole or other similar connecting structure. Unless otherwise specified herein, no additional payment shall be made for curved or radius pipe. Such pipe shall be measured and paid for in the same manner as described above for straight pipe.

PART 2 - MATERIALS

A. Vitrified Clay Pipe

1. General: All VCP and fittings shall be extra strength, and shall comply with ASTM C700. Pipe and fittings shall be of the best quality; vitrified; homogenous in structure; thoroughly burned through their entire thickness; impervious to moisture; sound; and free from cracks, checks, blister, broken extremities, or other imperfections. Pipe ends shall be square with the longitudinal axis, and sockets shall be true, circular, and concentric with the barrel of the pipe. The thickness of the shell, the depth of the socket, and the dimension of the annular space shall be within the limits of permissible variation to dimension standards of the specifications of ASTM C700, for the size of pipe indicated on the plans.

2. Pipe Marking: All pipe or fittings shall be clearly marked with the name of the manufacturer or with a trademark and with the size and strength of the pipe as shown on the plans and as herein specified.

3. Testing: Before being used in any work under these specifications, pipe shall be subjected to and shall meet the requirements of the following hydrostatic pressure test and loading test; these tests shall be witnessed by a reputable testing laboratory approved by the District. Pipe selected for testing shall be delivered to the place and at the time designated by the testing laboratory. All costs of furnishing, transporting, and handling the pipe for testing and conducting the tests shall be borne by the Contractor.

   Where specifically approved by District, a certified statement from the pipe manufacturer, in lieu of witnessing by a testing laboratory may be furnished stating that all prescribed tests have been made and the pipe to be used on the project has met all requirements of the specifications.

   The testing laboratory shall select, at random, for testing as herein specified, no less than 1% of the number of pipe sections in each size of pipe furnished.

   The specimens selected for testing shall be sound pipe having dimensions consistent with these specifications. The lot or lots from which the tests samples are taken shall be sufficient to fill the entire order for that size of pipe used in the work under the contract and, if they pass the tests, shall be so designated and marked.

All pipe shall be subject to inspection at the factory, trench, or other point of delivery by the District Representative. The purpose of the inspection shall be to cull and reject any pipe that, independent of the physical tests herein specified, fails to conform to the requirements of these specifications or that may have been damaged during transportation or in subsequent handling.

In lieu of the standard ASTM absorption test, the ASTM C301 hydrostatic pressure test shall be substituted. The hydrostatic pressure test shall precede the loading test by not less than one hour or more than three hours and shall be applied to all the specimens received for test in each size of pipe.

The loading test shall be the 3-edge bearing test. The loading tests shall conform to the applicable provisions of ASTM C301 and shall be applied to all specimens selected for testing, except that loading to test ultimate strength will not be required.

If all of the minimum designated percentage or number of the specimens tested meet the requirements of the test, then all of the pipe in the lot, shipment, or delivery corresponding to the sizes and classes so tested shall be considered as complying with the test. If, however, 10% or more of the specimens tested fail to meet the requirements of the test or if more than one specimen fails to meet the requirements of the test when the number to be tested is less than ten, then a second selection of pipe shall be made for that test. The number of specimens to be tested in the second selection of pipe shall be five for each specimen of the first selection that failed to meet the requirements.

If 90% or more of the specimens tested, including those first tested, meet the requirements of the test, all the pipe in the lot, shipment, or delivery corresponding to the sizes and classes so tested shall be considered as complying with that test, otherwise all pipe of these sizes and classes shall be rejected.

4. <u>Causes for Rejection</u>: The following imperfections in a pipe or special fitting shall be considered injurious and cause for rejection without consideration of the test results specified above.

   a. A single crack in the barrel of the pipe will cause rejection.

   b. Surface imperfections, such as lumps, blisters, pits or flakes, on the interior surface of a pipe or fitting shall cause rejection.

   c. When the bore or socket of the pipe varies from a true circle more than 3% of its nominal diameter, it shall be rejected.

   d. The pipe or fitting shall be rejected if it is designated to be straight and it deviates from a straight line more than 1/16-inch per lineal foot. The deviation shall be measured from a straight edge at a point midway between the ends of the pipe.

e. A joint of pipe with a piece broken from either the socket or spigot end shall be rejected.

f. Pipe joints that have tramp clays, grog or other foreign matter flushed permanently to the exterior or interior surface of the pipe or fittings shall be rejected.

5. Joints: Unless otherwise specified, all VCP pipe and fitting~~s~~ joints shall be of the bell and spigot compression type, complying with ASTM C425. Joints shall be equal to "Speed Seal" manufactured by Gladding McBean division of Pacific Coast Building Projects, or polyurethane compression joints as manufactured by Mission Clay Products (MCP Industries, Inc.) for contracts between District and Contractor, approved equal. The compression joint on the spigot and bell ends of the pipe shall be factory made of plastisol, polyurethane elastomer, or other approved resilient element bonded onto the outside of the spigot and the inside of the bell to the pipe and molded and cured to a uniform hardness and compressibility to form a tight compression coupling when assembled.

   Where pipe from different manufacturers is to be jointed together, an adapter pipe with the proper matching joint on each end for the respective manufacturer shall be used. Hot poured joints or concrete encasement of plain end joints shall not be permitted.

6. Branches: Branches of the type shown on the plans shall be furnished with connections of the sizes specified and shall be securely and completely fastened to the barrel of the pipe in the process of manufacture. Tee branches shall have their axis perpendicular to the longitudinal axis of the pipe. Wye branches shall have their axis approximately 45 degrees (unless otherwise specified on the plans) to the longitudinal axis of the pipe, measured from the socket end. All branches shall terminate in sockets and the barrel of the branch shall be of sufficient length to permit making a proper joint.

7. Stoppers: The stoppers for all pipe 8-inches in diameter and smaller, in which a sealing component for a flexible compression-type joint is cast, shall be neoprene, polyethylene, or polyurethane. Stoppers in all other cases shall be discs of the same material as the pipe, equal in diameter to the outside of the pipe barrel, and made and installed as approved by the District Representative.

   Neoprene stoppers shall be manufactured from a compound containing not less than 50 percent neoprene by volume, which shall be the sole elastomer. Stoppers shall not be adversely affected when exposed to the chemical and bacteriological environments normally found in wastewater sewers. Neoprene Stoppers shall be of the type manufactured by Mission Clay Products (MCP Industries, Inc.), Gladding McBean, or for contracts between District and Contractor, approved equal.

   When installed and braced in place in branch spurs, stoppers shall withstand a hydrostatic pressure test of 10 psi with no leakage. When unbraced, stoppers shall remain in place when subject to a maximum air pressure test of 5 psi.

8. Manufacturers: Vitrified clay pipe shall be manufactured by Gladding McBean, Division of Pacific Coast Building Products, Inc., Pacific Clay Products, Mission Clay Products LLC (MCP Industries, Inc.), or for contracts between District and Contractor, approved equal.

B. Precast Concrete Manholes

Precast concrete manholes shall conform with Section 03461, Precast Concrete Manholes and Bases.

PART 3 - EXECUTION

A. Related Installation Specification

VCP pipe shall be installed in accordance with the requirements of Section 02701, Installation of Gravity Sewer Pipelines.

B. Horizontal Curve Installation

Unless noted otherwise on the Plans or Specifications, horizontal curves using Vitrified Clay Pipe shall not be less than the following radii:

Pipe Size	Length of Pipe Joint						
	10'	8'	6'	5'	4'	3'	2'
6" - 12"	---	---	---	150'	125'	85'	57'
15" - 24"	320'	256'	192'	160'	128'	96'	---
27" – 36"	480'	384'	288'	240'	192'	---	---
39" – 48"	640'	512'	384'	320'	256'	---	---

END OF SECTION

SECTION 02715: PVC PIPE AND FITTINGS FOR GRAVITY SEWERS

PART 1 - GENERAL

A. Description

This section includes materials, testing, and installation of polyvinyl chloride (PVC) gravity sewer pipe and fittings.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling and Compacting: 02223
2. Jacked Casing: 02315
3. Installation of Gravity Sewer Pipelines: 02701
4. Vitrified Clay Pipe for Gravity Sewers: 02710
5. Concrete: 03300
6. Precast Concrete Manholes and Bases: 03461
7. PVC Pressure Pipe and Fittings: 15064

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Provide materials list showing material of pipe and fittings with ASTM references and grade.
3. Provide certificates of compliance with all standards referenced in this section.

D. Application

1. Alternative to VCP: Unplasticized PVC plastic pipe may be used as an alternate to V.C.P. on residential tract sewers and residential house laterals only.
2. Limitations: Use of PVC for main line sewers on industrial, commercial, and medical installations will be permitted only where approved, in advance, by the District.
3. Pipe Material Transitions: Sewer pipe material shall remain constant between manholes. Pipe material transitions shall be made only at manholes.

E. **Sewer Force Mains**

PVC sewer force mains shall be constructed in accordance with the requirements of Section 15064, PVC Pressure Pipe and Fittings,. Pipe fittings shall be lined with or made from materials that are corrosion resistant.

F. **Inverted Siphons**

Inverted siphons will be permitted only at those locations approved by the District.

PART 2 - MATERIALS

A. **Pipe and Fittings**

1. ASTM Requirements: Pipe, fittings, couplings, and joints shall be in conformance with the size, material and performance requirements of ASTM D 3034, SDR 35, and shall have gasketed joints.

   Pipe shall be made of PVC plastic having a cell classification of 12454-B, 12454-C, or 13364-B as defined in ASTM D 1784. All pipe shall be of solid wall construction with smooth interior and exterior surfaces.

   Fittings shall be made of PVC plastic having a cell classification of 12454-B, 12454-C, or 13343-C.

2. Manufacturer's Testing Certification: During production of the pipe, the manufacturer shall perform the specified tests for each pipe marking. A certification by the manufacturer indicating compliance with specification requirements shall be delivered with the pipe. The certification shall include the test result data.

3. Pipe Marking: All pipe, fittings, and couplings shall be clearly marked at an interval not to exceed 5-feet as follows:

   a. Nominal pipe diameter.

   b. PVC cell classification.

   c. Company, plant, shift, ASTM, SDR, and date designation.

   d. Service designation or legend.

   For fittings and couplings, the SDR designation is not required. All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made. Fittings shall be marked with raised molding markings on two sides (diametrically opposite from each other) showing the manufacturer's identification information.

4. Additional Pipe Tests Following Delivery: When pipe is delivered to the jobsite, the District Representative may require additional testing to determine conformance with the requirements of pipe flattening, impact resistance, pipe stiffness, and extrusion quality.

   When testing is required, one test pipe shall be selected at random by the District Engineer from each 1,200 feet or fraction thereof of each size of pipe delivered to the jobsite, but not less than one test pipe per lot. A lot shall be defined as pipe having the same identification marking. The length of specimen for each selected pipe shall be a minimum of 8-feet.

5. Pipe Retest: Pipe which is not installed within 120 days of the latest test shall not be used without prior approval of the District Representative.

6. Fitting and Coupling End Configurations: The socket and spigot configurations for fittings and couplings shall be compatible with those used for the pipe.

7. Manufacturers: Pipe shall be as manufactured by Certainteed Corporation, J-M Manufacturing Company, Inc. and PW Eagle, Inc. (dba JM Eagle™), Vinyltech Corporation, Diamond Plastics Corporation, or for contracts between District and Contractor, approved equal.

   Fittings shall be as manufactured by GPK Products, Inc., Harco Fittings, Inc. (dba Harrington Corporation and HARCO), J-M Manufacturing Company, Inc. and PW Eagle, Inc. (dba JM Eagle™), Multi Fittings Corporation, Plastic Trends, Inc., Industrias Vasallo, Inc. (dba Vasallo Industries), or for contracts between District and Contractor approved equal.

B. Gaskets for PVC Pipe

1. General: Unless otherwise specified, gaskets shall be manufactured from a synthetic elastomer, and shall be extruded or molded and cured in such a manner as to be dense, homogeneous and of smooth surface, free of pitting, blisters, porosity, and other imperfections. The compound shall contain not less than 50 percent by volume of first-grade synthetic rubber. The remainder of the compound shall consist of pulverized fillers free of rubber substitutes, reclaimed rubber, and deleterious substances.

   The tolerance for any diameter measured at any cross section shall be ±1/32-inch (.8mm).

2. Gasket Material Requirements: When required by the District Representative, the Contractor shall furnish test samples of gaskets from each batch used in the work.

a. Gasket material shall meet the following requirements:

Property	Value	ASTM Test Method
Tensile strength (min. psi)	2,000	D 412
Elongation at break (% min.)	350	D 412
Shore durometer, Type A (Pipe manufacturer shall select value suitable for type of joint)	40 to 65*	D 2240
Compression set (constant deflection) max. % of original deflection	16	D 395 Method B
Tensile strength after oven aging (96 hours, 158°F [70°C]) % of tensile strength before aging	80	D 573
Increase in Shore durometer hardness after oven aging. Maximum increase over original Shore durometer	10	D 2240
Physical requirements after exposure to ozone concentration (150 pphm. 70 hours, 140° F [40°C], 20% strain)	No Cracks	D 1149

*This applies only to the sealing component of the gasket.

3. Splices: No more than one splice will be permitted in a gasket. A splice shall be made by applying a suitable cement to the ends and vulcanizing the splice in a full mold. The splice shall show no separation when subjected to the following tests:

   a. Elongation Test: The part of the gasket which includes the splice shall withstand 100% elongation with no visible separation of the splice. While in the stretched position, the gasket shall be rotated in the spliced area minimum of 180 degrees in each direction in order to inspect for separation.

   b. Bend Test: The portion of the unstretched gasket containing the splice shall be wrapped a minimum of 180 degrees and a maximum of 270 degrees around a rod of a diameter equal to the cross section diameter of the gasket.

PART 3 - EXECUTION

A. Related Installation Specification

PVC gravity sewer pipe shall be installed in accordance with the applicable requirements of Section 02701, Installation of Gravity Sewer Pipelines and Section 02710, Vitrified Clay Pipe for Gravity Sewers.

B. Allowable Horizontal Curve Construction

Unless noted otherwise on the Plans or Specifications, horizontal curves using PVC pipe shall not have radii less than the following:

Pipe Size (inches)	Minimum Radius (feet)
6	210
8	280
10	350
12	420

END OF SECTION

SECTION 03100: CONCRETE FORMWORK

PART 1 - GENERAL

A. Description

This section describes materials and installation of concrete forms.

B. Related Specification Sections

1. Concrete Reinforcement: 03201.
2. Concrete Joints and Waterstops: 03260.
3. Concrete: 03300.
4. Concrete Finishing, Curing, and Waterproofing: 03345.
5. Painting and Coating: 09900.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Submit manufacturer's literature for form ties, spreaders, corner form, form coating, and bond breakers.

PART 2 - MATERIALS

A. Form Construction and Design

1. General: Forms shall be designed according to the applicable portions of ACI 347, "Recommended Practice for Concrete Formwork," and all applicable regulations and codes. All concrete shall be formed unless specified otherwise.
2. Observation Points: Form windows or stage forms shall be provided to allow observation at all times before concrete is poured. Formwork and placement design shall be such as to limit free fall of concrete to 4 feet.
3. Notification: The District's Representative shall be notified a minimum of one day prior to concrete placement.

B. Classes of Forms

1. <u>Class I Forms</u>: Smooth-surface plywood 3/4 inch minimum thickness shall be used for straight surfaces and 1/2 inch minimum thickness for curved surfaces.

2. <u>Class II Forms</u>: Forms shall be made of plywood in good condition, metal, or smooth-planed boards free from large or loose knots with tongue and groove or ship lap joints. Forms shall be oiled.

3. <u>Application</u>: Class II forms shall be used for exterior concrete surfaces which are 1 foot or more below finished grade. Class I forms shall be used for all other surfaces.

C. Form Material

1. <u>General</u>: Forms shall be made of plywood, lumber, or steel of sufficient strength and surface smoothness to produce the specified finish. Joints, gaps, and apertures in forms shall be taped, gasketed, plugged and/or caulked so that the joint will remain watertight and withstand placing pressures without bulging outward or creating surface irregularities.

2. <u>Lumber</u>: Lumber used in form construction shall be standard grade Douglas fir, S4S Standard Grading and Dressing Rules No. 16, West Coast Lumber Inspection Bureau. Boards in contact with concrete shall be 6 inches or more in width.

3. <u>Plywood</u>: Plywood used in form construction shall be Grade B-B, Class 1 plyform, mill-oiled, and sanded on both sides in conformance with U.S. Product Standard PS-1.

D. Form Ties

1. <u>General</u>: Form ties shall be located on exposed surfaces in a uniform pattern or as indicated on the drawings. Form ties shall be constructed so that the tie remains embedded in the wall except for a removable portion at each end. Form ties shall have conical or spherical type inserts with a maximum diameter of 1 inch. Form ties shall be constructed so that no metal is within 1 inch of the concrete surface when the forms, inserts, and tie ends are removed. Wire ties shall not be used. Ties shall withstand all pressures and limit deflection of forms to acceptable limits.

2. <u>Flat Bar Ties</u>: Flat bar ties for panel forms shall have plastic or rubber inserts having a minimum depth of 1 inch and sufficient dimensions to permit patching of the tie hole.

3. <u>Ties with Integral Waterstops</u>: Ties for water-holding structures or dry structures with access, such as basement access shafts or pipe galleries, that are below finished grade, shall have an integral steel waterstop that is tightly and continuously welded to the tie. The waterstop shall be at least two times larger in area than the tie cross-sectional area and shall be oriented perpendicular to the tie and symmetrical about the center of the tie. Ties shall be constructed to provide a positive means of preventing rotation or disturbance of the center portion of the tie during removal of the ends.

4. Tapered Form Ties: Tapered form ties shall be tapered through-bolts at least 1 inch in diameter at smallest end, or through-bolts that utilize a removable tapered sleeve of the same minimum size.

E. Bond Breaker

Bond breaker shall be a nonstaining type which will provide a positive bond prevention, such as Williams Tilt-Up Compound, as manufactured by Williams Distributors, Inc., Seattle, Washington; Silcoseal 77, as manufactured by SCA Construction Supply Division, Superior Concrete Accessories, Franklin Park, Illinois; or for contracts between District and Contractor, approved equal.

F. Form Release Agent

Form release agent shall effectively prevent absorption of moisture and prevent bond with the concrete. Agent shall be nonstaining and nontoxic after 30 days.

For steel forms, release agent shall prevent discoloration of the concrete due to rust.

PART 3 - EXECUTION

A. Form Tolerances

1. Rejected Work: Failure of the forms to produce the specified concrete surface and surface tolerance shall be grounds for rejection of the concrete work. Rejected work shall be repaired or replaced at no additional cost to the District.

2. Allowable Tolerances: The following table indicates tolerances or allowable variations from dimensions or positions of structural concrete work:

Item	Maximum Tolerance	
Sleeves and inserts	1/4"	-1/4"
Projected ends of anchors	1/4"	-0.0"
Anchor bolt setting	1/4"	-1/4"
Finished concrete, all locations	1/4"	-1/4" in, 10 feet
Finished concrete, total length	+1"	

The planes or axes from which the above tolerances are to be measured shall be as follows:

Sleeves and inserts: Centerline of sleeve or insert.

Projected ends of anchors: Plane perpendicular to the end of the anchor as located on the drawings.

Anchor bolt setting: Centerline of anchor bolt.

Finish concrete: The concrete surface as located on the drawings.

Where equipment is to be installed, the manufacturer's tolerances shall be complied with if more stringent than the above.

B. Form Surface Preparation

1. Cleaning: Form surfaces to be in contact with the concrete shall be cleaned of all previous concrete, dirt, and other surface contaminants prior to preparation by the applicable method below.

2. Release Agent: Wood surfaces and steel surfaces in contact with the concrete shall be coated with a release agent prior to form installation.

C. Chamfers

1. General Dimensions: 3/4-inch bevels shall be formed at concrete edges except those on top of walls and elevated slabs and beams. Edges at top of walls, slabs, and beams shall be rounded to a 3/4-inch radius.

2. Exterior Corners: Exterior corners in concrete members shall be provided with 3/4-inch chamfers. Reentrant corners in concrete members shall not have fillets, unless otherwise shown on the drawings.

D. Form Placement

1. General: Forms shall be provided with adequate means for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. The forms shall be tight and braced in order to prevent movement and the loss of mortar and fines during placing and vibration of the concrete.

2. Inspection Openings: Cleanout and inspection openings shall be provided at the bottom of each lift of forms. There shall be one 12-inch-wide by 18-inch-high opening every 7 feet at the bottom of each lift of forms.

3. Allowable Embedment of Form Tie in Concrete: No part of any form tying device other than metal shall be embedded in the concrete.

4. Taper Tie Orientation: The large end of taper ties shall be located on the "wet" side of the wall.

5. Prevention of Spalling: Only form or form-tying methods which do not cause spalling of the concrete upon form stripping or tie removal shall be allowed.

6. Non-formed Concrete: Surfaces of concrete members shall be formed except where placement of the concrete against the ground is shown on the drawings The dimensions of concrete members shown on the drawings shall apply to formed surfaces, except where otherwise indicated. At least 2 inches of concrete shall be added where concrete is placed against trimmed undisturbed ground in lieu of forms. Placement of concrete against the ground shall be limited to footings and only where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing.

E. Form Reuse

Only forms which maintain a uniform surface texture on exposed concrete surfaces shall be used. Light sanding shall be applied between uses to obtain uniform texture. Unused tie rod holes with corks, shaved flush, and sandpapered on the concrete surface side. Other than filling tie rod holes, forms shall not be patched except in the case of Class II forms. Metal patching discs shall not be used on Class I forms.

F. Form Removal & Timing

1. Protection of Concrete Surfaces: Means shall be provided for removing forms without injury to the surface of the finished concrete.

2. Form Placement Duration: Forms and shoring for elevated structural slabs or beams shall remain in place until the concrete has reached a compressive strength equal to the specified 28-day compressive strength as determined by test cylinders. Supports shall not be removed and reshored. The following table indicates the minimum allowable time after the last cast concrete is placed before forms, shoring, or wall bracing shall be removed:

Sides of footings and encasements	24 hours
Walls not supporting load	48 hours
Vertical sides of beams, girders, and similar members	48 hours
Slabs, beams, and girders	10 days (forms only)
Shoring for slab, beams, and girders	Until concrete strength reaches specified 28-day strength
Wall bracing	Until top or roof slab concrete reaches 2,500 psi

3. <u>Form Placement Duration in Cold Weather</u>: Forms shall not be removed from concrete which has been placed with outside air temperature below 50° F without first determining if the concrete has properly set without regard for time. Heavy loading shall not be applied to green concrete. Immediately after forms are removed, the surface of the concrete shall be carefully examined and any irregularities in the surface shall be repaired and finished as specified.

G. **<u>Formed Openings</u>**

Openings shall be of sufficient size to permit final alignment of the items within it without deflection or offsets of any kind and to allow space for packing where the items pass through the wall to ensure watertightness around openings so formed. Openings shall be provided with continuous keyways with waterstops where required, and a slight flare to facilitate grouting and the escape of entrained air during grouting. Formed openings shall be provided with reinforcement as indicated in the typical structural details. Reinforcing shall be at least 2 inches clear from the opening.

H. **<u>Embedded Items</u>**

Anchor bolts and other embedded items shall be set accurately and held securely in position in the forms until the concrete is placed and set. All special castings, channels, or other metal parts that are to be embedded in the concrete shall be checked prior to and again after concreting. All nailing blocks, plugs, and strips necessary for the attachment of trim, finish, and similar work shall be checked prior to concreting.

I. **<u>Pipes and Wall Spools Cast in Concrete</u>**

1. <u>Fittings Cast in Formed Concrete Structures</u>: Wall spools, wall flanges, and wall anchors shall be installed before placing concrete. Wall spools or anchors shall not be welded, tied, or otherwise connected to the reinforcing steel.

2. <u>Pipe Encasement</u>: Pipe and fabricated fittings to be encased in concrete shall be supported on concrete piers or pedestals. Concrete supports shall be carried to firm foundations so that no settlement occurs during construction.

END OF SECTION

SECTION 03201: CONCRETE REINFORCEMENT

PART 1 - GENERAL

A. Description

This section describes materials, testing, and installation of reinforcing steel for concrete.

B. Related Work Specified Elsewhere

1. Concrete Formwork: 03100.
2. Concrete: 03300.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accord with the General Provisions and the following.
2. Submit mill test certificates identifying chemical and physical analyses of each load of reinforcing steel delivered. If mill test reports are unavailable and the quantity of steel for a structure exceeds 5 tons, then provide a laboratory test to prove yield strength and bending.
3. Submit bending lists and placing drawings for all reinforcing steel. Each bending list submitted shall be complete, including corner bars as required. Furnishing such lists shall not be construed that the lists will be reviewed for accuracy. The Contractor shall be wholly and completely responsible for the accuracy of the lists and for furnishing and placing reinforcing steel in accord with the details shown on the plans and as may be specified elsewhere in the contract documents.

PART 2 - MATERIALS

A. Reinforcing Steel

1. General Requirements: Reinforcing steel shall be new material conforming to ASTM A 615, Grade 60, and shall be fabricated in accord with the current edition of the Manual of Standard Practice, published by the Concrete Reinforcing Steel Institute.
   a. Reinforcing steel shall be bent while cold.
   b. Reinforcing steel which is to be welded, shall conform to ASTM A 706, Grade 60.
2. Delivery: Reinforcing steel shall be delivered to the site bundled and with identifying tags.

B. Welded Wire Fabric

Welded wire fabric shall conform to ASTM A 185.

C. Tie Wire

Tie wire shall be 16 gage minimum, black, soft annealed.

D. Bar Supports

Bar supports in beams and slabs exposed to view after form stripping shall be non-metallic and of sufficient strength to properly secure the reinforcement bars during the placement of concrete. Concrete supports shall be used for reinforcing in concrete placed on grade.

PART 3 - EXECUTION

A. Placing

1. General: Reinforcing steel shall be placed in accord with ACI and the current edition of Recommended Practice for Placing Reinforcing Bars, published by the Concrete Reinforcing Steel Institute.

2. Cleaning: Reinforcing steel, before being positioned, shall be free from loose mill and rust scale and from any coatings that may destroy or reduce the bond. Where there is delay in depositing concrete, reinforcement steel shall be cleaned by abrasive sandblasting to remove mortar, oil, dirt, excessive mill scale, scabby rust, and coatings of any character that would destroy or reduce the bonding capability.

3. Bending: Reinforcing steel shall not be straightened or reshaped in a manner that will injure the material.

    a. Bars with bends not shown on the drawings shall not be used.

    b. Bars that are partially embedded in concrete shall not be bent.

4. Reinforcing Steel Positioning: Reinforcing steel shall be positioned in accord with the drawings and secured by using annealed wire ties or clips at inter-sections and support by concrete or metal supports, spacers, or metal hangers. Metal clips or supports shall not come in contact with the forms. Tie wires shall be bent away from the forms in order to provide the specified concrete coverage. Bars in addition to those shown on the drawings, which may be found necessary or desirable for the purpose of securing reinforcement in position, may be provided, at no additional expense to the District.

5. Clearance and Cover: Reinforcing steel shall be placed a minimum of 2 inches clear of any metal pipe or fittings. Unless otherwise indicated on the Plans, reinforcement shall be placed so as to provide the thickness of protective concrete covering as indicated on the Typical Details. If not indicated on the Plans or Standard Drawings, protective covering shall be in accord with ACI 318.

B. Splices

Unless otherwise shown, splices in adjacent horizontal bars shall be staggered 48 bar diameters.

END OF SECTION

SECTION 03260: CONCRETE JOINTS AND WATERSTOPS

PART 1 - GENERAL

A. Description

This section describes materials, testing, and installation of construction and expansion joints, PVC waterstops, premolded joint filler, joint sealant, and bond breaker tape.

B. Related Work Specified Elsewhere

1. Concrete Formwork: 03100.
2. Concrete Reinforcement: 03201.
3. Concrete: 03300.
4. Concrete Finishing, Curing, and Waterproofing: 03345.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Submit manufacturer's literature, catalog data, and statement of compliance with referenced standards and specifications.
3. Submit material samples of PVC waterstops.

PART 2 - MATERIALS

A. PVC Waterstop

1. Material: Waterstops shall be extruded from a PVC compound and shall be flat-strip ribbed type as manufactured by B. F. Goodrich Company, Kirkhill Rubber Company, or for contracts between District and Contractor, approved equal. Waterstop shall comply with Corps of Engineers Specification CRD-C-572. The basic resin of the material shall be a PVC resin plastic, containing nonmigrating-type plasticizers, and shall not be appreciably affected by alkali, acids, or saltwater. All material shall be virgin material; the use of reworked PVC or approved other substitute will not be permitted.
2. Fittings: Waterstops shall be supplied and installed in accord with the dimensions shown on the drawings, and shall be made continuous by means of factory made fittings.

B. Joint Sealant for Concrete Structures

The joint sealant shall be a two-part, gray, nonstaining, nonsagging, polyurethane sealant, which cures at ambient temperature to a firm, flexible, tear-resistant rubber. The sealer shall be resilient and have excellent recovery characteristics after extended periods of compression or elongation. Sealant shall be PRC 270, Vulkem 227, Sika 2C or for contracts between District and Contractor, approved equal.

Technical Requirements

Consistency	Gun grade
Tack free time	24 hours at 75° F and 50% R.H.
Pot life	1 to 3 hours
Hardness	30 Shore A, +/-5
Elongation	750%
Tensile Strength, ASTM D 412	325 psi
Peel strength on concrete	18 psi cohesive
Temperature service range	-40° F to +175° F
Immersion in water	Continuous

C. Neoprene Rods for Precast Slab Joints

Neoprene rods shall be of the indicated diameter, 50 durometer.

D. Premolded Joint Filler

Joint filler shall be preformed, nonextruded type, constructed of closed-cell neoprene conforming to ASTM D 1752, Type I, as manufactured by W. R. Grace Company of Cambridge, Massachusetts; W. R. Meadows, Inc., Elgin, Illinois; or for contracts between District and Contractor, approved equal.

E. Neoprene Bearing Pads

Neoprene bearing pads for precast concrete slabs shall be of the indicated size, thickness, and length, 60 durometer.

F. Bond Breaker Tape

Bond breaker tape shall be an adhesive backed glazed butyl or polyethylene which will adhere to the premolded joint material or concrete surface. The tape shall be the same width as the joint. The tape shall be compatible with the sealant.

PART 3 - EXECUTION

A. PVC Waterstops

1. Installation: Waterstops shall be installed in construction and expansion joints in hydraulic structures or where shown on the drawings. Forms for construction joints shall be constructed in such a manner as to prevent damage to waterstops. Waterstops shall be held securely in position in the construction joints by wire ties, continuous bars, and rings as indicated. Waterstops shall be properly heat spliced at ends and intersections to ensure continuity.

2. Field Splices: Field splices shall be made with a thermostatically controlled heating iron in conformance with the manufacturer's recommendations. At least 10 minutes shall be allowed before pulling or straining the new splice in any way. The finished splices shall provide a cross section that is dense and free of porosity with tensile strength of not less than 80% of the unspliced materials.

B. Construction Joints

1. General: Construction joints shall be provided where shown on the drawings. In case of emergency, additional construction joints shall be placed. An interval of 45 minutes between two consecutive batches of concrete shall constitute cause for an emergency construction joint. At the District's sole discretion, the slab or concrete placement may be rejected and be removed entirely. The costs related to such removal and replacement shall be born by the contractor. All emergency construction joints are subject to final approval by the District.

2. Construction Joint Keyways: Construction joints shall be keyed, if indicated on the drawings. Keyways shall be formed by beveled strips or boards placed at right angles to the direction of shear. Except where otherwise shown on the drawings or specified, keyways shall be at least 1-1/2 inches in depth over at least 25% of the area of the section.

3. Reinforcing Dowels: When an emergency joint is necessary, the joint shall be keyed and reinforcing dowels shall be furnished and placed across the joint. These dowels shall be embedded 60 bar diameters into each side of the joint. Size and number of dowels shall match reinforcing in the member. Furnishing and placing such reinforcing steel shall be done at no additional costs to the District.

4. Joint Preparation for Adjacent Pour: After the pour has been completed to the construction joint and the concrete has hardened, the entire surface of the joint shall be thoroughly cleaned of surface laitance, loose or defective concrete, and foreign material, and clean aggregate shall be exposed by sandblasting the surface of construction joints before placing the new concrete. Horizontal construction joints shall be covered with mortar. Mortar shall be spread uniformly and worked thoroughly into all irregularities of the surface. The mortar shall be flowable and shall consist of sand, water, and a minimum of 12 sacks of cement per cubic yard. A positive measuring device, such as a bucket, or other device shall be provided that will contain only enough mortar for depositing in one place in the wall or column to ensure that portion of the form does not receive too much mortar. Mortar shall not be deposited from pump hoses or large concrete buckets unless inspection windows close to the joint are available to allow visual measurement of mortar thickness and means for mortar removal is available for removal of any excess. The water-cement ratio of the mortar in place shall not exceed that of the concrete to be placed upon it. The consistency of the mortar shall be suitable for placing and working.

C. Installation of Premolded Joint Filler

Premolded joint filler shall be installed in joints accurately as shown. Joint filler shall be attached to concrete with a bonding agent recommended by the joint sealant and joint filler manufacturer for compatibility.

D. Installation of Joint Sealants

1. Joint Cavity Preparation: Immediately before installing the joint sealant, the joint cavity shall be cleaned by sandblasting or power wire brushing. Bond breaker tape shall be installed per manufacturer's instructions.

2. Sealant Application: After the joints have been prepared as described above, the joint sealant shall be applied. Primer, if required, and joint sealant shall be applied only with the equipment and methods recommended by the joint sealant manufacturer. Application criteria for the sealant materials, such as temperature and moisture requirements and primer cure time, shall be in accordance with the recommendations of the sealant manufacturer.

3. Finishing: Masking tape shall be applied along the edges of the exposed surface of the exposed joints. Joints shall be troweled smooth with a tuck pointing tool wiped with a solvent as recommended by the sealant manufacturer.

4. Cleanup: After the sealant has been applied, masking tape and any sealant spillage shall be removed.

E. Installation of Neoprene Rods in Precast Slab Joints

Neoprene rods shall be forced down to the bottom of the shaped joint prior to placing drypack in the joint.

F. Installation of Neoprene Bearing Pads

Neoprene bearing pads shall be placed in the indicated position on the concrete walls and glued to the wall with suitable adhesive.

END OF SECTION

SECTION 03300: CONCRETE

PART 1 - GENERAL

A. Description

This section describes materials, mixing, and placing of concrete and grout.

B. Related Work Specified Elsewhere

1. Concrete Formwork: 03100.
2. Concrete Reinforcement: 03201.
3. Concrete Joints and Waterstops: 03260.
4. Concrete Finishing, Curing, and Waterproofing: 03345.
5. Standard Specifications for Public Works Construction.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accord with the General Provisions, ACI 318, and the following.
2. Mix design with proof of design by laboratory 7-day and 28-day compressive tests, or test reports of 7-day and 28-day compressive tests of the mix where the same mix was used on two previous projects, shall be submitted in writing for review by the District at least 15 days before placing of any concrete.
3. Certificate that cement used in the concrete complies with ASTM C 150 and these specifications shall be submitted.
4. Aggregates: Certificate of compliance with ASTM C 33 shall be provided. Weathering region limits of coarse aggregates: severe, moderate, or negligible shall be stated. Basis of determining that potential reactivity is negligible shall be stated.
5. Ready Mix Concrete: Delivery tickets or weighmasters certificate per ASTM C 94, including weights of cement and each size aggregate, volume of water in the aggregate, and volume of water added at the plant shall be provided. The volume of water added on the job shall be written on the ticket or certificate.
6. Concrete admixtures: Manufacturer's certificate of compliance with these specifications shall be provided.
7. Epoxy Bonding Compound: Manufacturer's specific instructions for use shall be provided.
8. Nonshrink Grout: Manufacturer's certificate of compliance with these specifications and specific instructions for use shall be provided.

PART 2 - MATERIALS

A. Cement

Cement shall conform to ASTM C 150, Type II or Type V. The content of tricalcium aluminate shall not to exceed 6% and the content of alkalies shall not exceed 0.6%.

B. Aggregates

Aggregates shall comply with ASTM C 33 and shall be free from any substances that will react with the cement alkalies.

C. Water and Ice

Water and ice that is clean and free from objectionable quantities of organic matter, alkali, salts, and any other impurities which might reduce the strength, durability, and quality of the concrete shall be used in the concrete mix.

D. Color Additive

For exterior electrical duct concrete encasements, a color additive shall be used for identification purposes: Color additive shall be: brick red "Colorfull," as manufactured by Owl Manufacturing Company, Arcadia, California; coral red "Chromix C-22," as manufactured by L. M. Scofield Company, Los Angeles, California; or for Contracts between District and Contractors, approved equal. The color additive shall be added while the concrete is being mixed using the quantity per cubic yard of concrete recommended by the manufacturer for the class of concrete indicated.

E. Concrete Admixtures

1. Air-Entraining Admixture: Concrete may contain an air-entraining admixture which shall conform to ASTM C 260, except it shall be nontoxic after 30 days and shall contain no chlorides. Admixture shall be Master Builders MB-VR, Sika AER (Sikamix 104), or for contracts between District and Contractor, approved equal.

2. Water-Reducing Admixture: Concrete may contain a water-reducing admixture which shall conform to ASTM C 494, Type A or Type D, except it shall contain no chlorides, shall be nontoxic after 30 days, and shall be compatible with the air-entraining admixture. The amount of admixture added to the concrete shall be in accord with the manufacturer's recommendations. Admixture shall be Master Builders Pozzolith polymer-type normal setting, Plastocrete (Sikamix 160) Normal Set, Sika Chemical Corporation, or for contracts between District and Contractor, approved equal.

3. Admixture Restrictions: Accelerating water-reducing admixtures or any other type of admixture that contains chlorides or other corrosive elements shall not be used in any concrete.

4. High-Early Strength Concrete: Admixtures for high-early strength concrete shall be non-chloride admixtures which meet the requirements of ASTM C 494. Acceptable products are Pozzutec 20 and Pozzolith NC 534, by Master Builders, Inc. or District approved equal. Concrete shall reach 2,500 psi compressive strength within eight (8) hours of being placed.

F. **Non-shrink Grout**

Non-shrink grout shall conform to the Corps of Engineers Specification for Nonshrink Grout, CRD-C588-78, and to these specifications. Use a non gas-liberating type, cement base, premixed product requiring only the addition of water for the required consistency. Grout shall be UPCON High Flow, Master Flow 713, or for contracts between District and Contractor, approved equal. All components shall be inorganic.

G. **Ordinary Type Grout (Dry Pack)**

Ordinary type grout shall consist of one part portland cement to two parts sand (100% passing a No. 8 sieve). Sufficient water shall be added to produce damp formable consistency.

H. **Epoxy Bonding Compound**

Manufacturer's certifications as to suitability of product to meet job requirements with regard to surface, pot life, set time, vertical or horizontal application, and forming restrictions shall be provided. Bonding compound shall be Concresive 1001 LPL, Adhesive Engineering Company, San Carlos, California; Sikadur Hi-Mod (Sikastix 370), Sika Chemical Corporation, Lyndhurst, New Jersey; or for contracts between District and Contractor, approved equal.

I. **Concrete Mix Design**

1. General: Concrete mix design shall conform to ASTM C 94 and ACI 318, except as modified by these specifications.

2. Fly Ash: Fly ash shall not be used in the mix as a partial substitute for cement.

3. Air Content: Air content as determined by ASTM C 231 shall be 4% ±1%.

4. Water-Cement Ratio: Maximum water-cement ratio for Class A concrete shall not exceed 0.44 by weight.

5. Classes: Classes of concrete shall be used as described in the following table:

Class	**Type of Work**	**28-Day Compressive Strength (psi.)**	**Minimum Cement Content (lbs per C.Y.)**
A	Structures (all) plans Curbings, Sidewalks Unspecified by plans	3,250	560 = 6 sack
B	Where shown on plans or IRWD std. drawings.	2,500	470 = 5 sack
C	Fill for structure foundations, cradles, supports across pipe trenches, anchors, and miscellaneous unreinforced concrete	2,000	376 = 4 sack

6. Slump: Slump shall be measured in accord with ASTM C 143. Slump shall be as follows:

Slab on grade or heavy sections wider (in plan view) than 3 feet .... 3 inches maximum

Footings, walls, suspended slabs, beams, and columns .... 4 inches maximum

Concrete shall be proportioned and produced to have a maximum slump as shown. A tolerance of up to 1 inch above the indicated maximum shall be allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

7. Aggregate Size: Aggregate size shall be ¾-inch maximum for slabs and sections 8 inches thick and less. Aggregate size shall be 1½ inches maximum for all larger slabs and sections. Combined aggregate grading shall be as shown in the following table:

Maximum Aggregate Size
Percentage Passing by Weight

Sieve Sizes	1½"	¾"
2"	100	---
1½"	90 - 100	---
1"	50 - 86	100
¾"	45 - 75	90 - 100
⅜"	38 - 55	60 - 80
No. 4	30 - 45	40 - 60
No. 8	23 - 38	30 - 45
No. 16	17 - 33	20 - 35
No. 30	10 - 22	13 - 23
No. 50	4 - 10	5 - 15
No. 100	1 - 3	0 - 5
No. 200	0 - 2	0 - 2

8. Pumped Concrete Design Mix: Mix design for pumped concrete shall produce a plastic and workable mix. The percentage of sand in the mix shall be based on the void volume of the coarse aggregate.

J. Workability

1. General: Concrete shall be of such consistency and composition that it can be worked readily into the forms and around the reinforcement without excessive spading and without permitting the materials to segregate or free water to collect on the surface. The proportions shall be adjusted to secure a plastic, cohesive mixture, and one which is within the specified slump range.

2. Aggregate: To avoid unnecessary changes in consistency, aggregate shall be obtained from a source with uniform quality, moisture content, and grading. Materials shall be handled in such a manner that variations in moisture content will not interfere with production of concrete of the specified degree of uniformity and slump.

PART 3 - EXECUTION

A. Site-Mixed Concrete

1. General: Site-mixed concrete shall conform to ACI 304 as modified by these specifications.

2. Batching and Mixing Equipment: A batch-type mixer shall be used that is capable of combining the aggregates, cement, and water within the specified time into a thoroughly mixed and uniform mass and discharging the mixture without segregation. Supporting equipment shall be used that can accurately proportion the cement, the coarse and fine aggregates, the admixtures, and the water which enters the mixing drum. Cement and aggregate shall be proportioned by weight. Each entire batch shall be discharged before recharging. The volume of the mixed materials per batch shall not be allowed to exceed the manufacturer's rated capacity of the mixer.

3. Mixing Time: Mixing time shall be as follows:

   a. For mixer of a capacity of 1 cubic yard or less, one and one-half minutes after batching is completed.

   b. For mixers of capacities larger than 1 cubic yard, one and one-half minutes plus one-half minute for each additional ½-cubic-yard capacity or fraction thereof in excess of 1 cubic yard.

   c. The mixer shall revolve at a uniform rate as specified by the manufacturer for the mixing equipment.

B. Ready-Mixed Concrete

1. General: Ready-mixed concrete shall conform to ASTM C 94 as modified by these specifications.

2. Haul Time Requirements: The haul time of ready-mixed concrete shall be limited so that the specified slump is attained without the onsite addition of water, which may cause the mix design water-cement ratio to be exceeded. In no case shall the time between the time when the concrete is batched and it is placed exceed 90 minutes. When haul time is excessive, truck-transported, dry-batched concrete shall be used and mixed on the jobsite. Partially hardened concrete shall not be retempered.

C. Placing Concrete

1. General: Concrete placement shall conform to ACI 304 as modified by these specifications.

2. Placement Sequence: The sequence of concrete placement shall be coordinated in advance of actual placement to assure that construction joints will occur only as designed. The District's Representative shall be furnished a copy of the sequence of placement in advance of actual placement. Alternate sections of concrete walls and slabs shall be placed monolithically. Concrete for walls and slabs shall not be placed until seven days after placement of concrete for adjacent walls and slabs.

3. <u>Notification</u>: The District's Representative shall be notified of readiness, not just intention, to place concrete in any portion of the work. This notification shall be such time in advance of the operation as the District's Representative deems necessary for him to observe the preparations at the location of the proposed concrete placing. All forms, steel, screeds, anchors, ties, inserts and other items to be embedded shall be in place before notification of readiness is given to the District's Representative.

4. <u>Equipment Readiness</u>: Sufficient primary and backup equipment shall be scheduled for continuous concrete placement, and anticipate what actions will be taken during interruption. Extra concrete vibrators shall be provided. Concrete vibrators shall be tested the day before placing concrete.

5. <u>Removal of Water from Areas to Receive Concrete</u>: Concrete shall not be placed until all water entering the space to be filled with concrete has been properly cut off or has been diverted by pipes or other means and carried out of the forms, clear of the work. Concrete shall not be placed underwater, nor shall still water be allowed to rise on any concrete until the concrete has attained its initial set. Water shall no be permitted to flow over the newly deposited concrete in such manner and of such velocity that will damage the surface finish.

6. <u>Moisture Barriers</u>: Where a moisture barrier is installed, the moisture barrier shall not be punctured by stakes or any other concrete accessories.

7. <u>Concrete Pours and Freefall</u>: Concrete shall be deposited at or near its final position to avoid segregation caused by rehandling or flowing. Concrete shall not be deposited in large quantities in one place to be worked along the forms with a vibrator. Concrete shall not be dropped freely into place from a height greater than 4 feet. Tremies shall be used where the drop could exceed these limits.

8. <u>Consolidation of Concrete</u>: Mechanical vibrators shall be used while placing concrete to eliminate rock pockets and voids, to consolidate each layer with that previously placed, to completely embed reinforcing bars and fixtures, and to bring just enough fine material to exposed surfaces to produce a smooth, dense, and even texture. Vibrators shall be of the high-frequency internal type, and the number in use shall be able to consolidate the incoming concrete to a proper degree within 15 minutes after it is deposited in the forms. <u>In all cases, at least two vibrators shall be available at the site.</u> External vibrators shall be used for consolidating concrete only when the concrete is otherwise inaccessible for adequate internal consolidating.

9. <u>Protection of Concrete</u>: Concrete shall not be placed during rainstorms. Concrete placed immediately before rain shall be protected to prevent rainwater from coming in contact with it. Sufficient protective covering shall be kept on hand at all times for this purpose.

D. <u>Concrete Tests (For Contracts between the District and Contractor)</u>

1. <u>General</u>: Strength tests shall be performed on the concrete by the District's Representative as follows:

   a. Mold and cure five concrete test cylinders from each 50 cubic yards, or fraction thereof, of each class of concrete placed in any one day. Mold and cure the cylinders in accord with ASTM C 31.

b. Test cylinders in accord with ASTM C 39. Test one cylinder at 7 days for information. Test one cylinder at 14 days for information. Test two cylinders at 28 days for acceptance. Hold one cylinder for verification. The test results shall be the average of the strengths of the two cylinders tested at 28 days. If one cylinder in a test manifests evidence of improper sampling, molding, or testing, other than low strength, discard it and use the fifth cylinder for the test result.

c. Determine slump of the concrete using ASTM C 143 for each strength test sample and as required to establish consistency.

d. Determine air content of the concrete using ASTM C 231 for each strength test sample and as required to establish consistency.

2. Notification and Handling of Samples: To facilitate testing and inspection:

a. The District shall be advised in advance of concrete placing operations to allow for completion of quality tests.

b. Labor necessary to assist the District's Representative in obtaining and handling samples at the project shall be furnished by the Contractor.

c. Facilities for safe storage and proper curing of concrete test specimens on the project site, as required by ASTM C 31 shall be provided and maintained by the Contractor for the sole use of the District.

3. Requirements for Attainment of Compressive Strength: Concrete shall attain the 28-day strength specified. The average value of concrete strength tests shall be equal to or greater than the specified 28-day strength. Not more than 10% of the tests shall be less than the specified 28-day strength. No test shall be less than 90% of the specified 28-day strength.

4. Failure to Attain Specified Strength: If the 28-day tests fail to meet the specified minimum compressive strength, the concrete will be assumed to be defective and one set of three cores from each area may be taken as selected by the District's Representative and in accord with ASTM C 42. If the average compressive strength, of the set of three concrete cores fails to equal 90% of the specified minimum compressive strength or if any single core is less than 75% of the minimum compressive strength, the concrete will be considered defective and shall be removed and replaced, all at no cost to the District. Costs of coring, testing of cores, and all required repairing pertaining thereto shall be the responsibility of the Contractor.

E. Pumping Concrete

1. Equipment Capacity Requirements: Pump size shall be determined by the rate of concrete placement, length of delivery pipe or hose, aggregate size, mix proportions, vertical lift, and slump of concrete.

Minimum inside diameter of pipe or hose shall be based on the maximum aggregate size as follows:

¾-inch-max aggregate:	2 inches min ID
1½-inch-max aggregate:	4 inches min ID

2. Disallowance of Aluminum Pipe: Aluminum pipes shall not be used for delivery of concrete to the forms.

3. Priming: Before pumping is started, the delivery pipe or hose shall be primed by pumping mortar through the line using 5 gallons of mortar for each 50 feet of delivery line. Mortar shall be pumped to waste and not deposited in the forms.

F. Hot Weather Requirements

1. General: During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation in accord with ACI 305 and the following. There shall be no additional reimbursement for costs incurred for placing concrete in hot weather.

2. Cooling Methods: When the weather is such that the temperature of the concrete as placed would exceed 90°F, ice or other effective means of cooling the concrete during mixing and transportation shall be used so that the temperature of the concrete as placed will not exceed 90°F.

3. Prevention Against Early Setting of Concrete: Precautions shall be taken when placing concrete during hot, dry weather to eliminate early setting of concrete. This includes protection of reinforcing from direct sunlight to prevent heating of reinforcing, placing concrete during cooler hours of the day, and the proper and timely application of specified curing methods.

G. Cold Weather Requirements

1. General: Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near-freezing weather in accord with ACI 306 and the following. There shall be no additional reimbursement for costs incurred for placing concrete during cold weather.

2. Heated Mixing Water: When the temperature of the surrounding atmosphere is 40°F or is likely to fall below this temperature, the mixing water shall be heated to, but not exceed, 140°F. The heated water shall not be allowed to come in contact with the cement before the cement is added to the batch.

3. Temperature Requirements: When placed in the forms during cold weather, the concrete temperature shall be maintained at not less than 55°F. All materials shall be free from ice, snow, and frozen lumps before entering the mixer.

4. Curing Requirements: The air and the forms in contact with the concrete shall be maintained at temperatures above 40°F for the first five days after placing, and above 35°F for the remainder of the curing period. Thermometers shall be provided by the Contractor to indicate the ambient temperature and the temperature 2 inches inside the concrete surface.

H. Bonding to Existing Concrete

Existing concrete to which new concrete is to be bonded shall have the contact surfaces coated with epoxy bonding compound. The method of preparation and application of the bonding compound shall conform to the manufacturer's printed instructions and recommendations for specific application for this project.

I. Grouting Machinery Foundations

During placement of machinery, concrete shall be blocked out or finished off a sufficient distance below the bottom of the machinery base to provide for the thickness of grout shown on the drawings. After the machinery has been set in position and wedged to the proper elevation by steel wedges, the space between the bottom of the machinery base and the original pour of concrete shall be filled with a pourable nonshrink grout.

END OF SECTION

SECTION 03345: CONCRETE FINISHING, CURING, AND WATERPROOFING

PART 1 - GENERAL

A. Description

This section describes materials and methods of concrete finishes, curing, repair of defects, surface protection, and waterproofing.

B. Related Work Specified Elsewhere:

1. Concrete Formwork: 03100.

2. Concrete Reinforcement: 03201.

3. Concrete Joints and Waterstops: 03260.

4. Concrete: 03300.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.

2. Curing Compound: Submit manufacturer's statement of compliance with these specifications and recommended coverage to meet or exceed the specified tests. Submit manufacturer's application instructions.

PART 2 - MATERIALS

A. Curing Compound

1. General: Curing compound shall conform to ASTM C 309, Type 2, Class B, and shall be compatible with required finishes and coatings.

2. Manufacturers: Curing compound shall be: Masterseal, manufactured by Master Builders, Cleveland, Ohio; Evco Floor Coat, manufactured by Euclid Chemical Co., Cleveland, Ohio; or for contracts between District and Contractor, approved equal.

C. Mortar for Repair of Concrete

Mortar used for repair of concrete shall be made of the same materials as used for concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than one part cement to two and one-half parts sand by damp loose volume. The quantity of mixing water shall be no more than necessary for handling and placing.

D. Roof Membrane for Underground Reservoirs

1. General Requirements: The reinforced membrane shall be a compounded Hypalon rubber elastomer-coated fabric conforming to the following requirements:

Property	Std/Test Method	Minimum Specification
Thickness:		
Total, overall	ASTM D 751	41 mils
Minimum over scrim	Optical Method	11 mils
Tensile Properties each direction):	ASTM D 751 Grab Method	
Breaking strength		
Fabric		90 lbs.
Membrane rupture		120 lbs.
Elongation at break		
Fabric		15 %
Membrane rupture		150 %
Tear Propagation	ASTM D 751 Tongue Tear (8" X 8" sample)	16 lbs.
Hydrostatic Resistance	ASTM D 751 Method A Procedure 1	140 psi
Puncture Resistance	FTMS D 101B Method 2031	180 lbs.
Bonded Seam Strength	ASTM D 751 Modified (12 in./min)	96 lbs.
Ply Adhesion	ASTM D 413 Machine Method Type A (12 in./min)	10 lbs./in-width (or film tearing bond)
Ozone Resistance	ASTM D 1149 1/8" bent loop, 100 pphm, 104°F, seven days	No cracks at 7X magnification
Low Temperature	ASTM D 2136 1/8" mandrel, four hours at -40°F	Pass

2. Cover Material and Supporting Fabric: The thermoplastic elastomer cover material shall be manufactured totally by calendering, with each ply of rubber laminated to the next ply through the openings in the scrim weave to produce a pinhole-free construction. The open-weave polyester supporting fabric (scrim) shall have a 16 X 8, 2:1 leno weave 140 warp/250 fill denier with an 8 X 8-250d apparent construction. The two plies of supporting fabric shall be totally encapsulated within three plies of rubber, giving a five-ply construction of nominal 45-mil thickness. Exposed fabric or indication of delamination will not be permitted.

3. Cover Material Elastomer: The thermoplastic elastomer cover material shall be manufactured from a synthetic rubber compound designed to contain Hypalon Type 45 synthetic rubber as the sole elastomer and formulated in accordance with the recommendations of E. I. DuPont Company of Wilmington, Delaware.

4. Sheet Size: Basic calendered sheet size shall be 54-inch-minimum width and fabricated at the membrane manufacturer's plant into one sheet to fit membrane size identified on the drawings.

5. Color: The material shall be furnished with the exposed side black. The color shall be "built in" to the material.

E. Protective Cover For Roof Membranes

Protective cover shall be 1/2-inch-thick fiberboard treated to resist decay from earth materials and groundwater. Provide largest size sections that are available.

F. Crystalline Waterproofing

Waterproofing shall be "XYPEX" crystalline waterproofing, or for contracts between District and Contractor, approved equal.

PART 3 - EXECUTION

A. Concrete Finishes

Concrete surfaces shall be completed in accordance with the following schedule:

Finish Designation	Applicable Surface
F-1	Exterior walls exposed to water or groundwater, and interior of tank walls.
F-2	Walls, structures, or building walls exposed to view. Underside of formed floors or slabs.
S-1	Slabs and floors not water bearing.

Finish Designation	Applicable Surface
E-1	Exposed edges of slabs, floors, and wall tops.

Finish F-1: Defective concrete shall be repaired, fins removed, depressions 1/4 inch or deeper filled, and form-tie holes filled.

Finish F-2: In addition to repairs of Finish F-1, depressions and air holes shall be opened by whip-blasting and filled with mortar. Surfaces shall be dampened and a slurry consisting of one part cement and one and one-half part sand by damp loose volume shall be spread over the surface with clean burlap pads or sponge rubber floats. Any surplus shall be removed by scraping and then rubbing with clean burlap.

Finish S-1: Shall be a smooth steel trowel finish.

Finish E-1: Exposed edges of slabs, floors, and tops of walls, shall be finished with a 3/4-inch-radius edger, where chamfer is not indicated.

B. Finishing of Formed Surfaces

1. Curing Requirement: Surfaces shall be water cured until finishing and repairing are completed.

2. Repair of Surface Defects: Immediately after forms are removed, fins and irregularities shall be removed by grinding or rubbing. Depressions deeper than specified shall be filled with mortar, and form-tie holes filled.

3. Form-tie Holes: Form-tie holes shall be reamed with toothed reamers until surface of hole is rough and clean. Surface shall be coated with epoxy bonding compound and filled with mortar. Tapered form-tie holes shall be finished as follows:

   a. Form-tie holes shall be sandblasted and blown clean prior to filling.

   b. A rubber plug, with one end open, shall be driven to the center of the hole. Plug size shall be larger in diameter than the diameter of the hole at the center of the wall.

   c. The entire annular surface of the hole shall be coated with epoxy prior to filling with mortar. Epoxy shall be applied in accordance with manufacturer's instructions.

   d. Each side of hole shall be filled with mortar. Mortar shall be applied to the "wet" side of the wall first. Mortar shall be solidly consolidated into the hole.

   e. The District Representative shall be notified in advance of the form-tie hole filling schedule.

C. Repair of Surface Defects

1. Repair Limits: Honeycombed and other defective concrete shall be removed down to sound concrete. Edges shall be perpendicular to surface. Surfaces to receive repair shall be sandblasted.

2. Bonding Compound: Sandblasted surface shall be coated with epoxy bonding compound.

3. Mortar Placement: Mortar shall be placed in layers having a compacted thickness of 3/8 inch. The surface of each layer shall be scratched to promote bonding with next layer. Finish repair shall match adjacent concrete and cure as specified.

4. Repair of Large Defective Areas: Defective areas of more than 1 foot square and deeper than the reinforcing steel shall be repaired as above, with the exception that the area shall be filled with pneumatically applied concrete.

D. Curing

1. Allowable Curing Methods: Concrete surfaces shall be cured by water curing or by use of sprayed curing compound at the Contractor's option. Where wooden forms are used, the forms shall be wet immediately before concreting and keep moist by sprinkling until removed. All exposed surfaces of formed concrete shall be kept moist until curing compound is applied.

2. Curing Compound Method

   a. Concrete shall be cured for not less than 14 days after placement.

   b. The surface shall be sprayed with two coats of liquid curing compound. Curing compound shall be applied in accordance with the manufacturer's instructions to cover the surface with a uniform film which will seal thoroughly. A second coat shall be applied at 90 degrees to the direction of spray for the first coat.

   c. Curing compound shall be applied immediately after completion of the finish on unformed surfaces, and within two hours after removal of forms on formed surfaces. Formed surfaces shall be repaired within the said two-hour period; provided, however, that any such repairs which cannot be made within the said two-hour period shall be delayed until after the curing compound has been applied. When repairs are to be made to an area on which curing compound has been applied, the area shall first be sandblasted to remove the curing compound, then repaired.

   d. Wherever curing compound may have been applied to surfaces against which concrete subsequently is to be placed and to which it is to adhere, the curing compound shall be removed entirely by sandblasting prior to the placing of new concrete.

   e. Care shall be taken to avoid damaging the seal during the curing period. Damaged or broken seals shall be repaired immediately by the application of additional curing compound.

E. Roof Membrane

1. Factory Seams: All factory seams for either fabrication or repairs shall provide a minimum overlap of the reinforcing fabric of 1 inch and shall extend to the edge of the sheet so that no loose edge is present on the top side of the sheet. A loose edge on the underside of the sheet is permissible as long as the 1-inch-minimum overlap of the reinforcing fabric is maintained and a minimum of 1-inch bonded seam is maintained within the overlap.

2. Field Seams: Field seam, if required, shall provide a minimum overlap of the reinforcing fabric of 2 inches and shall extend to the edge of the sheet so that no loose edge is present on the top side of the sheet. A loose edge on the underside of the sheet is permissible as long as the 2-inch-minimum bonded overlap of the reinforcing fabric is maintained. A nominal 6-inch overlap of liner panels shall be allowed to keep dirt out of the field seams.

3. Surface Preparation: Concrete surface that are to receive Hypalon adhesive shall be thoroughly cleaned. Adhesive shall be applied in accordance with manufacturer's recommendations.

F. Protective Cover for Roof Membranes

Boards shall be butted tightly and shall cover the entire membrane surface, and overlap beyond the end of the membrane as indicated. Suitable adhesive shall be applied to the prepared concrete surface at the ends of the boards.

G. Crystalline Waterproofing

1. General: Preparation of and application to concrete surface shall be in accordance with manufacturer's recommendations.

2. Application Rate: Waterproofing shall consist of one coat of XYPEX "Concentrate" applied at the rate of 1-1/2 pounds per square yard of concrete surface, followed by one coat of XYPEX "Modified" applied at the rate of 1-1/2 pounds per square yard of concrete surface.

3. Areas to be Waterproofed: Waterproofing shall be applied to all walls from the top of the footing to top of walls (except wall areas receiving membrane and protective cover).

END OF SECTION

SECTION 03461: PRECAST REINFORCED CONCRETE MANHOLES & BASES

PART 1 - GENERAL

A. Description

This section includes materials, testing, and installation of precast concrete manholes, manhole bases, manhole frames and covers.

B. Related Work Specified Elsewhere

1. Structure Earthwork: 02200.
2. Trenching, Backfilling, and Compacting: 02223.
3. Concrete: 03300.
4. Polyvinyl Chloride Plastic Liners: 09880.
5. Leakage and Infiltration Testing: 15043.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accord with the General Provisions.
2. Submit manufacturer's catalog and test data on precast concrete manholes, frames, and covers along with installation recommendations for inlet and outlet seals and watertight caulking. Show dimensions and materials of construction by ASTM reference and grade. Show manhole cover lettering and pattern.

PART 2 - MATERIALS

A. Precast Concrete Manholes

1. General: Precast reinforced concrete manholes shall comply with ASTM C 478, with a minimum wall thickness of 6-inches.
2. Design Load: Manhole components shall be designed for H-20 highway loads and site soil conditions.
3. Concrete: Precast reinforced concrete manhole risers and tops shall be constructed of Class A concrete with Type II or Type V cement per Section 03300, Concrete.
4. Manhole Section Configuration: Manholes shall be fabricated only from eccentric taper sections and standard cylinder units of the proper internal diameter.
5. Manhole Section Dimensions: Unless noted otherwise, minimum diameter and wall thickness of manholes and manhole sections shall be as follows:

Depth of Cover, feet	Manhole Diameter, in	Manhole Section Wall Thickness, inches
0 - 15	48	6
15½ – 22	60	6
Greater than 22½	72	7

Depth of cover shall be measured from proposed finish surface elevation to the elevation of the top of the manhole base.

6. Steps: Manhole sections shall be cast without steps.

7. Drop Manholes: Drop manholes shall be constructed only at the locations shown on the drawings or where permission has been obtained from the District. Where approved for use in sewer lines of diameter 10-inches and smaller, drop manholes shall conform to Standard Drawing S-2. Drop manhole sections shall be lined with PVC liner per Section 09880, Polyvinyl Chloride Plastic Liners.

8. Manufacturers: Precast reinforced concrete manholes shall be manufactured by Associated Concrete Products, Ameron, Southwest Concrete Products, Inland Concrete Products, Precon Products, Olson Precast Company or for contracts between District and Contractor, approved equal.

9. Warning Signs: Warning signs shall be stenciled onto the vertical wall of the uppermost cone section of every manhole, as shown on Standard Drawing S-1.

B. Manhole Frames and Covers

1. General Requirements: Manhole frames and covers shall be made of ductile iron conforming to ASTM A 536, Class 400, or cast iron conforming to ASTM A 48, Class 30. Casting shall be smooth, clean, and free from blisters, blowholes, and shrinkage. Frames and covers shall be of the traffic type, designed for H-20 loading.

2. Fit and Matchmarking: Each manhole cover shall be ground or otherwise finished so that it will fit in its frame without rocking. Frames and covers shall be matchmarked in sets before shipping to the site.

3. Cover Inscription: Covers shall have the words "IRWD" and "SEWER" cast thereon as shown in Standard Drawing No. S-1 or on the plans. No other lettering on the top side shall be permitted.

   Cast letters shall be 3-inches and the relief depth shall be at least 3/16-inch. Top surface of the letters and diamond tread pattern shall be flush with the outer ring edge and the frame top surfaces.

4. Inspection and Coating: Before leaving the foundry, castings shall be cleaned and subjected to a hammer inspection. Castings shall then be dipped twice in a preparation of asphalt or coal tar and oil applied at a temperature of not less than 290°F, not more than 310°F, and in such a manner as to form a firm and tenacious coating.

5. Manufacturers: Manhole frames and covers shall be manufactured by Neenah Foundry, Alhambra Foundry, South Bay Foundry, Pont-A-Mousson, or for contracts between District and Contractor, approved equal.

C. Imported Sand

Imported sand shall comply with Section 02223, Trenching, Backfilling, and Compacting.

D. Crushed Rock

Crushed rock shall comply with Section 02223, Trenching, Backfilling, and Compacting. Crushed rock shall be the same material as the pipe bedding. If rock is not used for the pipe bedding, 3/4-inch crushed rock shall be used for the manhole. Crushed rock base material shall extend 1 foot beyond the outside edge of the concrete manhole base.

E. Manhole Bases

Concrete used in pouring the manhole base shall be Class A concrete, Type II or Type V cement per Section 03300, Concrete.

F. Cement-Mortar Grout

Grout for grade-ring joints between precast sections shall be composed of one part portland cement to two parts of clean well-graded sand of such size that all pass a No. 8 sieve. Cement, aggregate, and water for mortar shall conform to the applicable provisions of Section 03300, Concrete.

G. Epoxy Grout

Epoxy grout shall be used in repairing manhole and manhole base surfaces. Epoxy grout shall be made with epoxy and sand. The sand shall be clean, bagged, graded, and kiln dried silica sand. The prepared grout shall wet the contact surface and provide proper adhesion, or a coat of epoxy shall be applied prior to placing the epoxy grout. The epoxy bonding compound shall be as specified in Section 03300, Concrete.

H. Plastic Joint Sealing Compound

Preformed, cold-applied, ready-to-use, plastic joint sealing compound for water-tight joints shall be Quick-Seal as supplied by Associated Concrete Products, Santa Ana, California, or for contracts between District and Contractor, approved equal and shall be used on all manhole joints unless otherwise directed by the District representative.

PART 3 - EXECUTION

A. Work Within Existing Manholes

Any proposed work inside an existing manhole that is part of a wastewater system in service, shall not be undertaken until all the tests and safety provisions of Article 4, Section 1532 "Confined Spaces" State of California Construction Safety Orders have been made.

B. Excavation

Excavation for the precast concrete manhole shall be in accord with Section 02223, Trenching, Backfilling, and Compacting.

C. Manhole Base

1. General: Manhole bases shall be poured in place against undisturbed soil with Class A concrete having 3/4-inch-maximum size aggregate and a slump of not greater than 2-inches. The manhole base shall be poured as one monolithic pour. Specifications for ready-mixed concrete are set forth in Section 03300. If soil conditions are not adequate as determined by the District's Representative, a specified depth of over-excavation shall be required and the re-fill material shall be placed per Section 02223 prior to the placement of concrete.

2. Manhole Stub Placement: The manhole stubs and sewer main shall be set before the concrete is placed and shall be rechecked for alignment and grade before the concrete has set. The various sized inlets and outlets to the manhole shall be constructed per the IRWD Standard Drawings. Refer to Standard Drawing S-1.

3. Matching Pipe Crown Elevations: Invert elevations of connecting sewers many vary depending upon sizes. The crown elevation of all pipes shall be the same as the crown elevation of the largest pipe unless otherwise indicated on the plans.

4. Channel Configuration: The invert of the manhole base shall be formed so as to provide smooth channels conforming in size and shape to the lower portions of the inlet and outlet pipes. The channel shall vary uniformly in size and shape from inlet to outlet, and a shelf shall be constructed higher than the pipe as indicated on the drawings. The manhole base shall extend 12-inches below the bottom of the lowest pipe.

5. Transitions: All transitions shall be smooth and of the proper radius to give an uninterrupted transition of flow.

6. Finishing: The concrete base shall be shaped with a wood float and shall receive a hard steel trowel finish before the concrete sets.

7. Curing Time Before Further Construction: Unless approved otherwise by the District, in advance, the bases shall set a minimum of 24 hours before the manhole construction is continued.

D. Installing Manholes

1. General: Manholes shall be constructed as shown on Standard Drawings S-1. Manholes for larger diameter sewers shall be constructed as shown on the plans.

2. Joints for Grade-Rings: Precast concrete manhole units shall be set in a bed of grout to make a watertight joint at least 1/2 inch thick with the concrete base or with the preceding unit. Manhole sections shall be set perfectly plumb. Joints shall be pointed and trowelled and smoothed inside and outside of the manhole shaft joint. The excess grout shall be wiped off and removed.

3. Finish Elevation of Manhole Covers: Precast sections shall be assembled so that the cover conforms to the elevation determined by the manhole location as follows, but limited to a maximum of 18-inches of grade ring unless otherwise instructed by the District Representative.

    a. Paved Area: Top of cover shall be flush with the paving surface.

b. Un-paved Areas: Top of cover shall be flush with the existing surface where it is in the "traveled way" or shoulder and the concrete pad shall be 2 inches above the adjacent unpaved surface.

4. Manhole Frame and Cover: The manhole frame shall be secured to the grade ring with grout and cement mortar. After the frames are securely set, the frames and the covers shall be cleaned and scraped free of foreign materials, and shall be ground or otherwise finished as needed so the cover fits in its frame without rocking.

5. Watertightness: It is the intent of these specifications that manholes and appurtenances be watertight and free from infiltration. Enough cold-applied, preformed, plastic joint sealing compound shall be applied such that the compressed material protrudes from the interior and exterior of each manhole joint. The excess material on the interior shall be trimmed flush.

   Where called for on the plans or supplemental or project technical specifications, manholes that are to be given a protective lining or coating shall be free of any seeping or surface moisture. The adequacy of manholes and appurtenances as to watertightness shall be determined by the District Representative and shall be tested in accord with Section 10543, Leakage and Infiltration Testing.

6. Stubs: Sewer pipe shall be furnished and installed in manholes at the locations shown and in conformance with the detail drawings and plans. All stubs shall be plugged with stoppers as shown on the plans for various sizes of pipe.

7. Sealing Before Completion: In order to prevent accidental use of the new sewer before completion and acceptance, the inlet to existing tie-in manholes shall be sealed with broken brick and mortar. Installation of these plugs shall be approved by the District Representative. Plugs shall be removed at the time of final inspection or as directed by District Representative.

8. Bulkheads: Brick and mortar bulkheads shall be installed at the downstream end of all unused stub channels to prevent the creation of a septic condition resulting from ponding of sewage and debris in the unused channels, and until such time as the manhole stub is connected and normal sewage flow can occur.

9. New Connections to Existing Manholes: New connections to existing manholes wherein stubs have not been provided shall be made by core drilling through the base, as directed by the District Representative.

10. Backfill: Backfill around the precast concrete manhole shall be imported sand, and shall be placed and compacted in accord with Section 02223, Trenching, Backfilling, and Compacting.

11. Concrete Collar: Class B concrete collar shall be cast around manhole frames that are flush with the surface. The collar shall be placed after final grading or paving together with final cleanup.

12. Pavement Replacement: Replacement of bituminous or concrete pavement shall be in accord with the requirements of the governmental agency having jurisdiction.

E. Manhole and Manhole Base Repairs

Manhole sections and bases that exhibit defects in the concrete surface may be rejected for the reasons set forth in Section 2705, PVC Lined Reinforced Concrete Pipe, Part 3-B, Causes for Rejection. Defective concrete surfaces of manhole sections and bases not rejected shall be repaired by chipping away unsound or imperfect concrete. Edges shall be left sharp and square with the surface. Loose material and dust remaining after chipping shall be removed by means of an air jet. Epoxy grout shall be applied to the surface to be repaired in accord with the manufacturer's instructions. The grout shall wet the contact surface and provide proper adhesion, or a coat of epoxy shall be applied prior to placing the epoxy grout.

F. Manhole Liners / Coatings

Where called for in the plans or supplemental specifications, manhole liners and/or manhole coatings shall be provided. The requirement for manhole liners and coatings shall be as specified in Section 09880, Polyvinyl Chloride Plastic Liner.

END OF SECTION

SECTION 03462: PRECAST CONCRETE VAULTS AND METER BOXES

PART 1 - GENERAL

A. Description

This section describes the materials, manufacture, and installation of precast concrete vaults and meter boxes.

B. Related Work Specified Elsewhere

1. Structure Earthwork: 02220
2. Trenching, Backfilling and Compacting: 02223
3. Concrete Joints and Waterstops: 03260
4. Concrete: 03300
5. Structural Steel and Miscellaneous Metalwork: 05120

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.

2. Submit manufacturer's catalog data on precast concrete vaults and meter boxes. Show dimensions and materials of construction by ASTM reference and grade.

PART 2 - MATERIALS

A. Precast Concrete Vault

1. Manufacturers: Precast concrete vaults and covers shall be manufactured in a plant especially designed for that purpose and shall conform to the size, shape and dimensions indicated on the detailed plans. Vaults and covers shall be Jensen Precast, Eisel Enterprises, Inc., Inland Concrete Enterprises, Inc., J & R Concrete Products, Inc., Christy Concrete, Olson Precast, or for contracts between District and Contractor, approved equal.

2. Design Loads: Design loads shall consist of dead load, live load, impact, and in addition, loads due to water table and any other loads which may be imposed upon the structure. Live loads shall be based on H-20 loading per AASHTO standard specifications for highway bridges. Design wheel load shall be 16 kips. The live load shall be that which produces the maximum shear and bending moments in the structure.

3. Concrete: Concrete for vaults and meter boxes units shall be Class A conforming to Section 03300, Concrete.

4. Sectional Vaults: Sectional precast concrete vaults may be used where specified on the drawings or approved by the District Representative.

C. Precast Meter Boxes and Covers

1. Materials: Meter boxes and covers shall be reinforced polymer/plastic mortar.

2. Meter Box Covers: Meter box covers with reading lid shall be manufactured of reinforced polymer/plastic mortar in two separate rectangular pieces.

3. Traffic Covers: Meter box covers within roadways or driveways shall be cast-iron or steel designed to withstand H-20 highway loading, with reading lid and may only be used where specified on the plan or approved by the District representative.

4~~5~~. Manufacturers: Meter boxes shall be manufactured of reinforced polymer/plastic mortar by J&R, Inc., Armorcast Products Company, Quazite Corporation, or for contracts between District and Contractor, approved equal.

	Meter Size(s) 5/8 to 1 (inches)	Meter Size(s) 1-1/2 & 2 (inches)
Meter Box Size Nominal inside dimesions	13 wide x 24 long x 12 deep	17 wide x 30 long x 12 deep

D. Vault Frames and Covers

Unless noted otherwise, vault access hatches and frames shall be fabricated in accordance with the requirements of Section 05120, Structural Steel and Miscellaneous Metalwork.

E. Joint Sealing Compound

The joint sealing compound shall be permanently adhesive flexible plastic material complying in every detail to Federal Specification SS-S-00210 (GSA-FSS). Joint sealing compound shall be Quickseal by Associated Concrete Products, or for contracts between District and Contractor, approved equal.

PART 3 - EXECUTION

A. Earthwork

1. General: Excavation and backfill for precast concrete vaults and meter boxes shall be in accordance with Section 02220, Structure Earthwork, and the requirements herein. Excavation limits shall be large enough to accommodate the structure and permit grouting of openings and backfilling operations.

2. Sub-base: The bottom of the structure shall be placed on compacted, crushed rock sub-base, graded level and to the proper elevation as shown in the Standard Drawings or on the plans, and shall conform to the specifications in Section 02220, Structure Earthwork.

B. Vault Installation

1. Vault Wall Openings: Openings or "knockouts" in precast concrete vaults shall be located as shown on the drawings and shall be sized sufficiently to permit passage of the largest dimension of pipe and/or coupling flange. Upon completion of installation, all voids or openings in the vault walls around pipes

   a. 3-inches outside diameter and smaller: shall be filled with Class A concrete or mortar, using an epoxy for bonding concrete surfaces, as specified in Section 03300, Concrete.

   b. Larger than 3-inches outside diameter: shall have the annular openings sealed with a rubber linked mechanical sealing mechanism such as Link-Seal or Inner-Linx in accord with the District Standard Drawings.

      (1.) The vault wall opening shall be round and lined with a wall sleeve and integral water stop ring. The rubber linked mechanical sealing mechanism shall be used to seal the annular space between the outside of the pipe penetrating the vault wall and the inside of the wall sleeve. Wall sleeves may be coated steel or pre-molded high density polyethylene.

2. Backfill: After the structure and all appurtenances are in place and approved, backfill shall be placed to the original groundline or to the limits designated on the plans.

3. Watertightness: All joints between precast concrete vault sections shall be made watertight. The sealing compound shall be installed according to the manufacturer's recommendations to provide a watertight joint.

4. Installed Elevation: Vaults shall be built up so that the cover is 0.1 foot above the surrounding surface, unless otherwise specified on the drawings or directed by the District Representative in the field. The Contractor is responsible for placing the cover at the proper elevation and slope where paving is to be installed, and shall make all necessary adjustments so that the cover meets these requirements.

C. Meter Box Installation

1. Line and Grade: Meter boxes shall be set true to line and to the grade of the top of the curb, sidewalk. For landscaped, or other unpaved surfaces, the meter box shall be set with the top 0.1 foot above the adjacent surrounding area, or as directed by the District Representative in the field. The Contractor is responsible for placing the cover at the proper elevation and slope, and shall make all necessary adjustments so that the cover meets these requirements.

2. Sequence of Installation: Meter boxes shall not be set until fine grading or landscape grading in the vicinity has been completed.

END OF SECTION

SECTION 05120: STRUCTURAL STEEL AND MISCELLANEOUS METALWORK

PART 1 - GENERAL

A. Description

This section describes materials and installation of structural steel, connecting bolts, stainless-steel fasteners, ladders, access hatches, and gratings.

B. Related Work Specified Elsewhere

1. Concrete: 03300.
2. Painting and Coating: 09900.
3. Standard Specifications for Public Works Construction.
4. Placeholder for fiberglass grating reference spec (not yet written)

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accord with the General Provisions and the following.
2. Submit drawings of fabricated items, such as pipe supports, bolts, ladders, concrete anchors, grating, and access hatches. Show dimensions and reference materials of construction by ASTM designation and grade.

PART 2 - MATERIALS

A. Structural Steel

Material for all-purpose bolted or welded construction shall conform to ASTM A 36 or approved equal.

B. Aluminum

Structural shapes shall conform to ASTM B 308, Alloy 6061-T6. Plates and sheets shall conform to ASTM B 209. Tubing shall conform to ASTM B 241.

C. Nuts, Bolts and Washers

Except where otherwise specified, washers shall be Type 316, ASTM A 167. Bolts shall be ASTM A 193, Grade B8M. Nuts shall be ASTM A 194, Grade 8M.

D. Galvanizing

Zinc coating for all plates, bolts, anchor bolts, and threaded parts shall be hot-dipped coated in accord with ASTM A 153. Structural steel and pipe shall be zinc coated in accord with ASTM A 123.

E. Stainless Steel

Except where otherwise specified, stainless steel plate, members, and washers shall be Type 316, ASTM A 167. Bolts shall be ASTM A 193, Grade B8M. Nuts shall be ASTM A 194, Grade 8M.

F. Welding Electrodes

Welding electrodes for structural steel shall conform to AWS A5.5. Use electrodes in the E-70 series. Welding electrode for aluminum shall be 4043 filler metal and Type 347 electrode for stainless steel.

G. Ladders

1. General: Ladders shall be fabricated as shown on the drawings and shall comply with OSHA Safety Standards. Ladders shall be of welded steel construction and hot-dip galvanized after fabrication or stainless steel where indicated on the drawings.

2. Safety Devices: When indicated on the plans, a safety climb device (ladder fall prevention device) shall be provided, consisting of a SAF-T-NOTCH rail, standard attaching parts, SAF-T-LOK sleeve, SAF-T-CLIMB removable extension, and two complete safety belt assemblies. The device shall comply with OSHA requirements and shall be SAF-T-CLIMB as manufactured by Air Space Devices Norton Co., Paramount, California, or for contracts between District and Contractor, approved equal. All safety climb device assemblies and parts shall be fabricated of Type 316 stainless steel.

3. Side-rail Extensions: All ladders shall have side-rail extensions fabricated onto the ladder in accord with the IRWD Standard Drawing G-4.

H. Concrete Anchors

Drilled anchors shall be Type 316, stainless steel wedge anchors, unless otherwise indicated, as manufactured by Phillips Drill Company, or for contracts between District and Contractor, approved equal. Where steel anchors are indicated, they shall be one-piece design with expander ring consisting of steel zinc coated and chrome plated as manufactured by McCullough Industries, Inc., Kwik Bolt, or for contracts between District and Contractor, approved equal.

I. Access Hatches

Hatches may be of aluminum or stainless steel construction, as called for and specified on the project plans. In general aluminum hatches maybe be used in applications of parkway loading (ie., low-volume traffic with H-5 loading) where a severe corrosion environment is not present, (ie., non-wastewater applications). In every case, hinges, hardware and all threaded pieces and connectors shall be Type 316 stainless steel.

Aluminum access hatches shall be of the size and type indicated on the drawings. Hardware shall be 316 stainless steel and shall include but not be limited to hinges, hold-open arms, springs, and spring covers. Hatches shall be equipped with extruded aluminum channel trough frames with 1-1/2 inch drain coupling, flush aluminum drop handles which do not protrude above the cover, a recessed padlock box and stainless steel staple sized for a No. 5 padlock, and shall be as manufactured by U. S. Foundry, INRYCO, or BILCO, or for contracts between District and Contractor, approved equal.

J. Metallic Grating

Unless noted otherwise, metallic grating shall be aluminum. Main bars shall be of the size and thickness indicated on the drawings.

PART 3 - EXECUTION

A. Fabrication and Erection

1. General: Miscellaneous metal items shall be fabricated to straight lines and true curves. Drilling and punching shall not leave burrs or deformations. Permanent connections shall be welded continuously along the entire area of contact. Exposed work shall have a smooth finish with welds ground smooth. Joints shall have a close fit with corner joints coped or mitered and shall be in true alignment. Unless specifically indicated, there shall be no bends, twists, or open joints in any finished member nor any projecting edges or corners at intersections. Fastenings shall be concealed wherever possible. Built-up parts shall be free of warp. Exposed ends and edges of metal shall be slightly rounded. All boltholes shall be 1/16-inch in diameter larger than bolt size. Cast-in-place bolt locations shall be measured in the field before drilling companion holes in structural steel beam or assembly.

2. Surfaces in Contact with Concrete: Surfaces of metalwork to be in contact with concrete shall be cleaned of rust, dirt, grease, and other foreign substances before placing concrete.

3. Embedded Metalwork: Embedded metalwork shall be set accurately in position when concrete is placed and supported rigidly to prevent displacement or undue vibration during or after the placement of concrete. Unless otherwise specified, where metalwork is to be installed in recesses in formed concrete, said recesses shall be made, metalwork installed, and recesses filled with dry-pack mortar in conformance with Section 03300.

B. Ladders

Ladder rungs shall have a minimum diameter of 1-inch. The distance between rungs, cleats, and steps shall not exceed 12-inches and shall be uniform throughout the length of the ladder. The minimum clear length of rungs or cleats shall be 17-inches. Ladders shall be mounted to provide clearance in back of ladder so that the distance from the centerline of rungs, cleats, or steps to the nearest permanent object in back of the ladder shall be not less than 7-inches. Refer to IRWD Standard Drawing G-4.

C. Common Machine Bolts and Nuts

1. General: Bolts shall be inserted accurately into the boltholes without damaging the thread. Boltheads shall be protected from damage during driving. Boltheads and nuts shall rest squarely against the metal. Where bolts are to be used on beveled surfaces having slopes greater than 1 in 20 with a plane normal to the bolt axis, beveled washers shall be provided to give full bearing to the head or nut.

2. Bolt Insertion: Bolts shall be of the length that will extend entirely through but not more than 1/4-inch beyond the nuts. Boltheads and nuts shall be drawn tight against the work.

D. Anchor Bolts and Anchors

1. General: Bolts and anchors shall be preset by the use of templates. Concrete anchors shall not be used where cast-in-place anchor bolts are called for.

2. Protection of Anchor Bolts: After anchor bolts have been embedded, bolt threads shall be protected by applying anti-seize compound and by placing the nuts on the treaded bolt end until the time of installation of the equipment or metalwork.

E. Control of Flame Cutting

The use of a gas-cutting torch in the field for correcting fabrication errors on any member in structural framing shall not be permitted. A flame-cutting torch shall be used only on minor members, when the member is not under stress.

F. Repair of Galvanized Surfaces

Damaged galvanized metal surfaces shall be repaired or replaced at no additional cost to the District. Repair of galvanized surfaces shall be accomplished by use of DRYGALV as manufactured by the American Solder and Flux Company; Cold Galvanizing Repair Compound as manufactured by Rust-Oleum, applied in accord with the manufacturer's instructions; or for contracts between District and Contractor, approved equal.

G. Storage of Materials

All material, either plain or fabricated, shall be stored above ground on platforms, skids, or other supports. Material shall be kept free from dirt, grease, and other foreign matter and protected from corrosion.

H. Welding

1. Steel: Welding of steel shall be performed by the Shielded Metal Arc Welding (SMAW) process. Welding procedures shall comply with AWS D1.1.

2. Aluminum: Welding of aluminum shall be performed by the Gas Metal Arc (MIG) or Gas Tungsten Arc (TIG) process, per the AWS Welding Handbook.

I. Grating

1. Measurement: Grated areas shall be field measured for proper size.

2. Banding: Grating shall be completely banded.

3. Grating Angles: Seat angles for grating shall be set so that the top of the vertical leg is flush with the concrete floor. Seat angles and anchors shall be stainless steel.

J. Corrosion Protection

Aluminum surfaces that are in contact with concrete shall be coated in accord with Section 09900, Painting and Coating. Coating shall be allowed to dry before placing in or against concrete.

END OF SECTION

SECTION 09880: POLYVINYL CHLORIDE PLASTIC LINERS

PART 1 - GENERAL

A. Description

This section describes materials, installation, and testing of polyvinyl chloride (PVC) liners, where called for, in reinforced concrete pipe, precast concrete manholes, and cast-in-place concrete structures.

1. The District has experienced substantial deterioration in manholes due to hydrogen sulfide gas release from wastewater flows. To mitigate the problem, the following criteria are established to set requirements for manholes with protective linings; one such alternate lining being polyvinyl chloride T-Lock Liner.

   a. If any sewer line connecting to a manhole has a slope of 7 percent (7%) or greater, then the manhole shall be lined.

   b. Wherever there is a change in slope, from steep to flat, of 5 percent (5%) or greater, the manhole at the grade change and the next manhole upstream shall be lined.

   c. All "Drop-type manhole", where specifically allowed, shall be lined. Refer to Standard Drawing no. S-2.

   d. All manholes at the terminus of sewer force mains shall be lined.

   e. Approved PVC T-Lock liners are Ameron T-Lock liner, Koroseal Lok-Rib by B.F. Goodrich or for contracts between the District and Contractor, approved equal.

B. Related Work Specified Elsewhere

1. PVC-lined Reinforced Concrete Pipe: 02705

2. Concrete Manholes and Manholes Bases: 03461.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.

2. Submit installation details showing how manholes will be lined. Show returns, corners, joints, and coverage. Show location and type of field welds.

3. Submit manufacturer's test data, catalog data, and descriptive literature of the plastic liner, adhesives, solvents, and activators.

4. Submit manufacturer's installation instructions.

PART 2 - MATERIALS

A. Manufacturers

Plastic liner shall be Ameron Amer-Plate T-lock liner as manufactured by Ameron, Koroseal Lok-Rib as manufactured by B. F. Goodrich, or for contracts between District and Contractor, approved equal.

B. Liner Composition

1. Material: The materials used in all sheets of plastic liner and in joint, corner and welding strips for the liner shall be high molecular weight PVC resin and other necessary ingredients compounded to make permanently flexible sheets and strips for lining precast concrete manholes. PVC resin shall constitute not less than 99%, by weight, of the resin used in the formulation.

   Copolymer resins shall not be used. Changes in formulation may be permitted only after prior approval by the District and only if the manufacturer can demonstrate that the plastic liner meets or exceeds all requirements in this specification for chemical resistance and physical properties.

2. Color: Liner shall be white in color.

3. Joint Strips: The material used in joint strips and in plain sheets of plastic liner shall be identical to that used in sheets having locking extensions.

4. Impermeability: Plastic liner shall be impermeable to sewage gasses and liquids and shall be nonconductive to bacterial or fungus growth. Liner shall be factory checked electrically to ensure freedom from any porosity.

5. Physical Properties: The lining shall be flexible, shall have good impact resistance, and shall have an elongation sufficient to bridge up to a 1/8-inch settling crack without damage to the lining.

C. Physical Properties and Chemical Resistance Testing

1. Samples for Testing: The District's Representative, at any time during manufacture or at any time prior to completion of the work, may direct sampling and testing of materials. Holes left by coupon removal shall be repaired by the Contractor. The samples thus taken shall be subjected to the tests described below:

   a. Specimens shall be prepared and tested for tensile strength and elongation in accordance with ASTM D 412, Dye B. Indentation hardness shall be determined in accordance with ASTM D 2240 using a Type D durometer. Specimens shall be cut from sheets, joint strips and flat welding strips.

   b. Weight change specimens shall be 1-inch by 3-inch sample of the sheet thickness.

2. Description of Test: Test specimens shall be conditioned to a constant weight at 110°F before and after submersion in the following solutions for a period of 112 days at 77°F +/- 5°F. At 28-day intervals, tensile specimens and weight change specimens shall be removed from each of the chemical solutions and tested.

Chemical Solution	Concentration Percentage
Sulphuric Acid	20*
Sodium Hydroxide	5
Ammonium Hydroxide	5*
Sodium Hypochlorite	1*
Nitric Acid	1*
Ferric Chloride	1
Soap	0.1
Detergent (Linear Alkyl Benzyl Sulfonate or LAS)	0.1
Bacteriological	BOD not less than 700 mg/l

*Volumetric percentages of concentrated C.P. grade reagents.

Plastic liner sheets, joint, corner, and welding strips shall have the following physical properties when tested at 77°F +/- 5°F:

Property	Initial	After 112 Days Exposure in Above Listed Chemical Solutions
Tensile Strength	2,200 psi min.	2,100 psi min.
Elongation at Break	200% min.	200% min.
Shore Durometer, Type D	Inst. 50-60 10-sec. 35-50	+/-5 +/-5 (with respect to initial test result)
Weight Change	+/-1.5%	

If any specimen fails to meet the 112-day requirements before completion of the 112-day exposure, the material shall be rejected.

3. Pull Test of Liner Embedded in Concrete: Liner locking extensions embedded in concrete shall withstand a test pull of at least 100 pounds per linear inch, applied perpendicularly to the concrete surface for a period of one minute, without rupture of the locking extensions or withdrawal from embedment. This test shall be made at a temperature between 70°F to 80°F, inclusive.

4. Freedom from Physical Defects: Plastic liner sheets, including locking extensions and all joint, corner, and welding strips, shall be free of cracks, cleavages, or other defects adversely affecting the protective characteristics of the material.

5. Period During which Tests may be Conducted: Specimens taken from sheets and strips at any time prior to final acceptance of the work, when tested as specified, shall meet the requirements set forth above.

D. Dimensions

1. Thickness of Material: Liner bonded to concrete by means of integral locking extensions embedded in the concrete shall have a minimum thickness of 0.065-inch. Liner which is to be bonded to concrete or steel surfaces by means of adhesive shall have a minimum thickness of 0.094-inch. Welding strips shall have a minimum thickness of 0.095-inch and maximum thickness of 0.156-inch. Joint strips shall have a minimum thickness of 0.075-inch.

2. Sheet and Strip Size: Sheets of liner shall be as large as practicable to fit the intended use. Large sheets shall be formed in the shop by lapping basic size sheets a minimum of 0.50-inch and fusing the sheets together to produce a continuous welded joint. Specimens taken from shop-welded joints shall show no cracks or separation and shall be tested for tensile strength. Each specimen shall withstand a minimum load of 132 pounds per linear inch of weld or the product of 2,000 psi times the minimum thickness in inches of the material adjoining the weld, which ever is greater. The thickness shall be taken within a 2-inch gage length.

3. Cause for Rejection: Sheets having tears, cracks or separation in the laps shall be rejected.

4. Joint Strips: Joint strips shall be 4-inches +/-0.25-inch in width and shall have each edge beveled prior to application.

5. Welding Strips: Welding strips shall be 1-inch +/-0.125-inch in width. Welding and outside corner strips shall have edges beveled at the time of manufacture.

E. Locking Extensions

1. General: Liners cast into concrete shall have integral locking extensions embedded in the concrete. Liner may be bonded to concrete surfaces with an adhesive only if specifically shown on the drawings.

2. Material: Locking extensions shall be of the same material as the liner and shall be integral with the sheets of liner.

3. Dimensions: Locking extensions shall have an approved cross section with a minimum height of 0.375-inch and a minimum web thickness of 0.085-inch. They shall be approximately 2-1/2-inches apart and shall be such that, when the extensions are embedded in concrete, the liner will be held permanently in place.

4. Orientation: Locking extensions shall be parallel and shall be continuous except where omitted for joint flaps, transverse weep channels, and strap channels. Weep channels which involve the omission of locking extensions may be made during the manufacture of liner.

F. Weep Channels

1. General: At 8-foot maximum intervals along liner longitudinally, a gap not less than 2-inches (3-1/2-inches in the case of extruded sheets) nor more than 4-inches wide shall be left in all locking extensions for liners of cast-in-place structures to provide an unobstructed transverse weep channel. Any area behind liner that is not properly served by regular weep channels shall have additional weep channels 2-inches wide provided by cutting away locking extensions. Provisions shall be made to permit water behind the liner of concrete manhole shafts to drain into the weep channels of the lined structure. Weep channels shall be cut into the extruded sheet so that a maximum of 1/32-inch of the base locking extension is left on the sheet.

2. Weep Channels for Liners in Cast-in-Place Structures: At transverse joints in cast-in-place structures, a gap of not less than 2-inches nor greater than 4-inches shall be left in all locking extensions to provide a transverse weep channel. If locking extensions are removed to provide a weep channel at joints, the base of the extension left on a sheet shall not exceed 1/32-inch.

3. Weep Channels in Liner where Lined-Surfaces Join Unlined Surfaces: A transverse weep channel shall be provided approximately 12-inches from each liner return where surfaces lined with plastic liner join surfaces that are not so lined.

4. Cleaning Weep Channel Outlets: As part of the work of installing the liner, all outlets of transverse weep channels shall be cleared of obstructions that would interfere with their proper function.

G. Flaps

When transverse flaps are required, they shall be fabricated so that a maximum of 1/32-inch of base of the locking extensions is left on the sheet.

H. Adhesives and Cleaners

1. Adhesives: Adhesives which will deleteriously affect the liner or strip in any way shall not be applied to the liner or to any of the liner strips. Flammable adhesives and solvents shall not be used for any purpose in connection with plastic liner with locking extensions.

2. Cleaning Agents: Cleaning agents for use with plastic liner with locking extensions shall be a water soluble or dispersible nonflammable product not detrimental to the plastic liner.

I. Factory Testing

The liner shall be shop tested for holes with a spark tester set to provide from 15,000 to 20,000 volts. Prior to shipment from the manufacturer's plant, sheets having holes shall be shop-repaired and retested. Repairs shall be made by welders qualified as specified below. The District's Representative may test samples at the point of manufacture during production of sheet and strip material.

PART 3 - EXECUTION

A. Qualification of Installers

1. Applicators: The application of plastic liner to forms and other surfaces shall be considered as highly specialized work, and personnel performing this type of work shall be trained in methods of installation.

2. Welders: Each welder shall pre-qualify by successfully passing a welding test before doing any welding. Pre-qualification may be required at any time deemed necessary by the District's Representative. All test welds shall be made in the presence of the District's Representative and shall consist of the following:

a. Two pieces of liner, at least 15-inches long and 9-inches wide, shall be lapped 1-1/2-inches and held in a vertical position.

b. A welding strip shall be positioned over the edge of the lap and welded to both pieces of liner. Each end of the welding strip shall extend at least 2-inches beyond the liner to provide tabs.

c. The weld specimen shall be submitted to the District's Representative and will be tested as follows:

(1) Each welding strip tab, tested separately, shall be subjected to a 10-pound pull normal to the face of the liner with the liner secured firmly in place. There shall be no separation between the welding strip and liner when the welding tables are submitted to the test pulls.

(2) Three test specimens shall be cut from the welded sample and tested in tension across the welds. If none of these specimens fail when tested as specified in Part 2, Subsection D.2, the weld will be considered as satisfactory in tension.

(3) If one of the specimens fails to pass the tension test, a retest will be permitted. The retest shall consist of testing three additional specimens cut from the original weld sample. If all three of the retest specimens pass the test, the weld will be considered satisfactory.

d. A disqualified welder may submit a new welding sample after receiving sufficient off-the-job training to warrant reexamination.

B. <u>Installation of Plastic Liner</u>

1. <u>General</u>: The plastic liner shall be applied in accordance with the manufacturer's instructions, the drawings, and the following:

2. <u>Attachment to Concrete Structures</u>: As cast into the concrete of structures, the lining shall be attached permanently and physically to the concrete by embedment of the locking extension mechanism. An adhesive bond shall not be used unless otherwise specified at a specific location. The lining shall be attached to metal surfaces by applying the lining manufacturer's adhesive to the metal surface and then installing the liner. The lining shall withstand a 15-psi back hydrostatic pressure applied to the under surface of the lining without losing anchorage or without rupture or leakage.

3. <u>Freedom from Defects</u>: Liners shall be located and installed in accordance with the drawings and in such a manner as to be continuous and free from holes, defects, or other faults that may limit the liner's effectiveness as a corrosion-control barrier. Joint welding and sealing shall be equally as effective as the liner.

4. <u>Orientation</u>: Liners shall be installed in cast-in-place structures or pipe so that the locking extensions are parallel to the axis of the structure, and installed in other structures with locking extensions horizontal unless otherwise indicated on the drawings.

5. <u>Fit</u>: Liner sheets shall be closely fit to inner forms. Sheets shall be cut to fit curved and warped surfaces using a minimum number of separate pieces.

6. Joints: At transverse joints between regular size sheets of liner used in cast-in-place structures and at pipe joints, the space between ends of locking extensions, measured longitudinally, shall not exceed 4-inches. Where sheets are cut and joined for the purpose of fitting irregular surfaces, this space shall not exceed 2-inches.

7. Penetrations through Liner: Where form ties or form stabilizing rods pass through liner, the liner shall be maintained in close contact with the forms during concrete placement.

8. Liner Returns: Liner returns shall be installed where shown on the drawings and wherever surfaces lined with plastic liner join surfaces which are not so lined, such as brick, clay pipe, cast-iron pipe, manhole frames and metal or plastic gate guides. Unless otherwise indicated, returns shall be made as follows:

    a. Each liner return shall be a separate strip of liner at least 3-inches wide joined to main liner by means of corner strips.

    b. Corner strips shall be welded continuously to the return and to the main liner and applied wherever possible from the back of the lining.

    c. Locking extensions shall be provided on returns to lock the returns to the concrete of plastic-lined, cast-in-place structures.

9. Fastening Liner to Adjacent Construction: Each liner shall be sealed to adjacent construction with which it is in contact with adhesive or as shown on the drawings.

C. Liner Field Joining

1. General: Field joints in the liner shall not be made until the structure has been backfilled and 30 days has elapsed. Where groundwater is encountered, joints shall not be made until pumping of the groundwater has been discontinued for at least 30 days and no visible leakage is evident at the joint. Liner at joints shall be free of mortar and other foreign material and shall be clean and dry before joints are made.

2. Hot Joint Compound: Hot joint compound shall not be brought into contact with liner.

3. Coating Restriction: No coating of any kind shall be applied over any liner joint, corner, or welding strip except where non-skid coating is applied to liner surfaces.

4. Field Joints in Cast-in-Place Structures: Field joints in liner on cast-in-place structures shall be one of the following types:

    a. Type C-1: A Type C-1 joint shall be made using a 4-inch joint strip, centered over the transverse joint and secured along each edge to adjacent liner by means of a welding strip. The width of the space between adjacent sheets of liner in a Type C-1 joint shall not exceed 1/2-inch. This type of joint is the only type permitted at transverse contraction joints in concrete. Its only other use is for joints between pipes and cast-in-place structures.

b. Type C-2: A Type C-2 joint shall be made by overlapping sheets not less than 1-1/2-inches and securing the overlap to the adjacent liner by means of a welding strip. The upstream sheet shall overlap the downstream sheet. The length of that part of the overlapping sheet not having locking extensions shall not exceed 4-inches. A welding strip shall be applied to the back of the joint. This type of joint may be used at any transverse liner joint other than those collateral with joints in concrete and shall be used for liner joints made at longitudinal joints in concrete.

c. Type C-3: A Type C-3 joint shall be made by butting sheets of liner together and applying a welding strip over the back of the joint before concrete is poured and applying a welding strip over the front of the joint after concrete is poured. A Type C-3 joint shall not be used at a transverse joint which extends to a lower terminal edge of liner or at any joint where the gap between adjoining sheets of liner exceeds 1/8-inch.

6. Field Joints in Pipe Installations: Field joints in liner at pipe joints shall be one of the following types:

a. Type P-1. A Type P-1 joint shall consist of a 4-inch joint strip, centered over the mortared pipe joint and secured along each edge to adjacent liner by means of a welding strip. The gap between ends of lock extensions shall not exceed 4-inches.

b. Type P-2. A Type P-2 joint shall be made with an integral part of the liner extending 4-inches, ±1/4-inch, beyond the spigot end of the pipe, overlapping the liner downstream from the pipe joint by at least 1/2-inch and secured to the downstream liner by means of a welding strip. The 4-inch liner flap extending beyond the spigot end of pipe shall be devoid of locking extensions and shall be protected from damage during pipe handling and jointing operations. Excessive tension and distortion in the flap caused by bending it back sharply at the end of the pipe will not be permitted. Transverse flaps on extruded sheet shall be as specified herein.

Any flap which has been bent and held back during pipe laying and jointing operations shall be allowed to return to its original shape and flatness well in advance of making the liner joint.

For beveled pipe, the liner extension at the spigot end of the pipe shall be trimmed to extend 4-inches beyond and parallel to the beveled end. Length between ends of locking extensions shall not exceed 4-inches.

Field joints in liner at pipe joints shall not be made until the mortar in the pipe has been allowed to cure for at least 48 hours.

All joints between lined pipe and lined cast-in-place structures shall be either Type C-1 or Type C-2 as specified herein.

6. Welding Strips: Welding strips shall be fusion welded to joint strips and liner by qualified welders. The welding operation of any joint shall be continuous until that joint has been completed.

7. Joint Reinforcement: A 12-inch long welding strip shall be applied as reinforcement across each transverse joint and weep channel in liner which extends to the lower terminal edge of liner on each side of a pipe or structure. These reinforcement strips shall be centered over the joint being reinforced and located as close to the lower edge of liner as practicable. After the transverse welding strips have been tested and the test tabs removed, the welding strips shall be welded into place.

8. Special Terminations: Special terminations shall be provided at sluice and slide gate frames, manholes, pipe sleeves, and at other such locations in structures to receive plastic liner. Bonding agents shall be used to seal edges where plastic-liner joins metal items which are cast in the concrete. Surfaces to be bonded shall be thoroughly cleaned. Mixing and application of bonding agents shall be in accordance with the manufacturer's instructions.

D. Liner Protection and Repair

1. General: Care shall be taken to prevent damage to liner from equipment and materials used in, or taken through, the work. Damage to the installed liner shall be repaired in accordance with the following:

2. Repair Methods: Nail and tie holes and cut, torn, and abraded areas in the liner shall be patched. Patches made entirely with welding strip shall be fused to the liner over the entire patch. The use of this method is limited to patches which can be made with a single welding strip. Do not use parallel, overlapping, or adjoining welding strip. Parallel, overlapping, or adjoining welding strips shall not be used. Larger patches may consist of smooth liner over the damaged area with edges covered with welding strips fused to the patch and to the liner adjoining the damaged area. The size of a single patch of the latter type shall be limited only as to its width, which shall not exceed 4-inches.

E. Concrete Operations

1. Concrete Vibration: Concrete placed against liner shall be vibrated in a manner so as to avoid damage to the liner and to produce a dense, homogeneous concrete securely anchoring the locking extensions in the concrete. External vibrators may be used in addition to internal vibrators, particularly along the lower edge of plastic liner.

2. Stiffeners: If stiffeners are used along locking extensions of liner installed in forms for pipe, the stiffeners shall be completely withdrawn during the placement of concrete in the forms. The concrete shall be revibrated to consolidate the concrete in the void spaces caused by the withdrawal of the stiffeners.

3. Form Removal: The liner shall be protected from damage during form removal. Sharp instruments shall not be used to pry forms from lined surfaces. When forms are removed, any nails that remain in the liner shall be removed without tearing the liner, and the resulting holes shall be clearly marked. Form tie holes shall be marked before ties are broken off. Areas of serious abrasion of the liner shall be marked. Marked areas and holes shall be repaired in accordance with Part D of this Section.

4. Banding Strap Removal: Banding straps used in securing liner to forms for pipe and cast-in-place structures within the limits of the unlined invert shall be removed. Voids left in the invert at the edge of the liner shall be filled with cement mortar.

F. Non-Skid Surfaces

Surfaces of liner shown on the plans to be non-skid shall be treated as follows:

1. Surface Cleaning and Adhesive Application: After corner and welding strips have been installed, the surface of the liner shall be cleaned, dried, and sprayed with an adhesive coating recommended by the manufacturer of the liner.

2. Sand Application: The surface shall be liberally sprinkled with clean, dry, well-graded sand which will pass a No. 30 sieve but be retained on a No. 70 sieve.

3. Cleanup: After the sanded surface has thoroughly dried, all excess sand shall be brushed away and a seal coat applied to bond the sand to the liner. The seal coat shall be compatible with the plastic liner. The coated sand surface shall be allowed to dry thoroughly before walking thereon is permitted.

G. Field Testing

1. Spark Testing: Upon completion of the installation, the surface of the liner shall be cleaned to permit visual inspection and spark testing by the CONTRACTOR. Spark testing shall be performed in the presence of the District's Representative, using a spark-type detector supplied by the Contractor, and complying with the requirements of factory testing herein. Areas of liner plate failing to meet the field test shall be repaired and retested. To assist the District with the inspection ~~and~~ of spark testing of the liner, ventilation, ladders for access, barricades, or other traffic control devices shall be provided by the CONTRACTOR, and entrances and exits shall be opened and closed.

2. Pull Testing: Each transverse welding strip which extends to a lower edge of the liner shall be tested. The welding strips shall extend below the liner providing a tab. A 10-pound pull shall be applied normal to the face of the structure by means of a spring balance. Liner adjoining the welding strip shall be held against the concrete during application of the force. The 10-pound pull shall be maintained if a weld failure develops or until no further separation occurs. Defective welds shall be retested after repairs have been made. Tabs shall be trimmed away neatly after the welding strip has passed inspection. Equipment shall be provided to test liner in the manner recommended by the manufacturer and as described above. Personnel qualified to perform the testing shall be provided by the Contractor. Testing shall be performed in the presence of the District's Representative.

H. Clean-Up

Before acceptance of the installed liner by the District, the liner shall be cleaned to the satisfaction of the District's representative.

END OF SECTION

SECTION 09900: PAINTING AND COATING

PART 1 - GENERAL

A. Description

This section describes materials and application of painting and coating systems for submerged metal surfaces, exposed metal surfaces, buried metal surfaces, metal surfaces in contact with concrete, submerged concrete, exposed PVC and FRP pipe, and valve interiors.

Coating thicknesses specified herein are given as "dry-film thickness" in mils. Mil thicknesses specified are minimums.

B. Related Work Specified Elsewhere

1. Structural Steel and Miscellaneous Metalwork: 05120
2. Carbon Steel Pipe & Fittings: 15053
3. Ductile-Iron Pipe and Fittings: 15056
4. Combination Air Release and Vacuum Relief Valves: 15089
5. Manual Valves: 15100
6. Fire Hydrants: 15139
7. Flexible Pipe Couplings and Expansion Joints: 15162
8. Cathodic Protection and Joint Bonding: 16640

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.
2. Submit manufacturer's data sheets showing the following information:
    a. Recommended surface preparation.
    b. Minimum recommended dry-film thicknesses per coat for prime and finish coats.
    c. Percent solids by volume.
    d. Recommended thinners.
    e. Statement that the selected prime coat is recommended by the manufacturer for use with the selected finish coats.
    f. Application instructions including recommended application, equipment, humidity, and temperature limitations.

3. Submit certification that all coatings conform to South Coast Air Quality Management District Rules and Regulations for products and application.

D. Pre-Submittal Meeting

For contracts between the District and Contractor, a pre-submittal meeting shall be conducted two weeks prior to the submittal of coating shop drawings, at the discretion of the District Representative. The meeting shall be attended by the painting and coating (sub) contractor.

E. Air Quality Requirements

Materials shall comply with South Coast Air Quality Management District's Rule 1107 for shop coating and Rule 1113 for field coating.

F. Painting Systems

All paints shall be delivered to the jobsite in the original, unopened containers. All materials of a specified painting system, including primer, and finish coats, shall be produced by the same manufacturer. Thinners, cleaners, driers, and other additives shall be as recommended by the paint manufacturer for the particular coating system.

PART 2 - MATERIALS

A. Color System for Coatings and Coating System Summary

Unless noted otherwise, colors for surfaces that are to be coated shall be defined as follows:

Color	Pantone ID Number (closest match in sunlight)	Amershield Designation
Brown	PMS 1405	PMS 1405
Dark Blue	2766 C	Newport Coast # 33
Factory Finish	N/A	No Color Coating
Light Blue	2925 C	1159 Light Blue
Medium Bronze	N/A	Medium Bronze
Olive Light	451 C	PMS 451 C
Purple	512 C	PMS 512 C
Safety Green	348 U	1135 Safety Green
Safety Orange	021 C	OR-2 Safety Orange
Safety Red	485 C 2X	RO-1 Bright Red
Safety Yellow	U2X	Safety Yellow

The following table provides a summary of the coating systems and the various surfaces to be coated:

Application	Utility	System No.											
		A-1	B-1	B-2	B-3	B-4	C-1	C-2	D-1	E-1	F-1	G-1	G-2
Public Fire Hydrants	Potable & Recycled	X											
Submerged Metal	Potable			X									
Submerged Metal	Recycled		X										
Submerged Metal	Raw Water		X										
Submerged Metal	Raw Sewage				X								
Submerged Concrete	Raw Sewage					X							
Exposed Metal	All						X	X					
Buried Metal	All								X				
Metal in Contact with Concrete	All									X			
Exposed PVC/FRP	All										X		
Valves	All											X	X

B. <u>Specialty Items</u>

Surfaces shall be coated as described below:

1. <u>Valve Can & Test Box Lids:</u> Valve can and test box lids shall be coated per System No. C-2.

2. <u>Buried Items</u>: Buried flanges, nuts and bolts, valves, flexible pipe couplings, exposed rebar from thrust blocks, and valve boxes shall be coated per System No. D-1 unless otherwise specified in the particular specifications for these items.

3. <u>Above Ground Structural Steel and Structural Steel in Vaults</u>: Above ground structural steel or structural steel located in vaults and steel structures shall be coated as described in the exposed metal coating system sections.

4. <u>Pipe Supports</u>: All non-galvanized and non-stainless steel pipe supports in vaults shall be coated the same as the adjacent piping. If pipe is PVC, pipe supports shall be coated per System No. C-1.

5. Exposed Indoor Galvanized Electrical Conduit: Exposed indoor galvanized electrical conduit shall only be coated when specified in the project technical specifications. When specified, coating System No. C-3 shall be used.

6. Mechanical Equipment: Mechanical equipment, such as motors, shall be coated as described in the exposed metal coating system sections.

7. Pumps: The interior and exterior of the pump discharge head, suction bell, or elbow and bowls, or volute shall be coated per System No. G-1 for pumps in wells, sewage lift stations, domestic water pump stations, and recycled water pump stations. Impellers for pumps at sewage lift stations shall be coated per System G-1.

   The pump column shall be coated as follows.
   a. Flanged Column – System No. G-1, interior and exterior
   b. Threaded Column – No coating is required

C. Public Fire Hydrant Coating Systems

1. System No. A-1--Public Fire Hydrants

   a. Type: Water-based low Volatile Organic Compound (VOC) acrylic coating. Thinners, cleaners, driers, and other additives shall be as recommended by the paint manufacturer. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 5 mils.

   b. Surface preparation: Remove oil, grease and chalking. Abrade existing paint and visible rust areas. Do not sandblast or prepare more surface area than can be coated in one day. Surface preparation shall conform to the Society for Protective Coatings (SSPC) specifications as follows:

      SP-1 Solvent Tool Cleaning
      SP-2 Hand Tool Cleaning
      SP-3 Power Tool Cleaning

   c. Color: Safety Yellow

   d. Prime Coat: Apply to a dry-film thickness of 2 to 3 mils. Primer shall be synthetic. Approved manufacturers for previously painted surfaces include:

      i. Carboline Carbocrylic 120;
      ii. Sherwin Williams Zero VOC Acrylic;
      iii. Tnemec Series 1028 Enduratone;
      iv. International/Devoe Devflex 4216 HP; or
      v. For contracts between District and Contractor, approved equal.

      Approved manufacturers for bare metal surfaces include:

      i. Carboline Carbocrylic 120;
      ii. Sherwin Williams Pro Industrial Pro-Cryl Universal Primer;
      iii. Tnemec Series 94-H20 Hydro-zinc;

iv. International/Devoe Devflex 4216 HP; or
v. For contracts between District and Contractor, approved equal.

e. Finish Coat: Apply to a dry-film thickness of 3 to 4 mils. Approved manufacturers for finish coats include:

i. Carboline Carbocrylic 3359 MC;
ii. Sherwin Williams Zero VOC Acrylic;
iii. Tnemec Series 1028 Enduratone;
iv. International/Devoe Devflex 4216 HP; or
v. For contracts between District and Contractor, approved equal.

D. Submerged Metal Coating Systems

1. System No. B-1--Submerged Metal, Recycled, and Raw Water

a. Type: Two part low VOC epoxy-polyamide. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 20 mils.

b. Service Conditions: Shall be used on metal structures, pipes, or equipment including, but not limited to tanks, clarifier mechanisms, scum troughs, slide gates and other miscellaneous metal exposed to recycled water or raw water.

c. Surface Preparation: SSPC SP-10

d. Prime Coat: Apply to a dry-film thickness of 8 mils. Approved manufacturers for prime coat include:

i. PPG Ameron Amerlock VOC;
ii. Carboline Carboguard 890 VOC;
iii. Tnemec Series L69 Hi-build Epoxoline II;
iv. International/Devoe 233H; or
v. For contracts between District and Contractor, approved equal.

e. Finish Coats: Apply two coats, each with a 6 mil dry-film thickness to achieve the total dry-film thickness. The coating material shall be the same material as the prime coat.

2. System No. B-2--Submerged Metal, Potable Water

a. Type: Two part low VOC epoxy-polyamide, or two-part amido-amine epoxy. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 15 mils. Coating shall be NSF 61 approved.

b. Service Conditions: Shall be used on surfaces including, but not limited to, structural steel, tank interiors and piping exposed to potable water.

c. Surface Preparation: SSPC SP-10

d. Prime Coat: Apply to a dry-film thickness of 5 mils. Approved manufacturers for prime coats include:

i. Tnemec Series L140F Pota Pox;
ii. Sherwin Williams Macropoxy 646-100PW;
iii. PPG Ameron Amerlock VOC;
iv. International/Devoe 233H; or
v. For contracts between District and Contractor, approved equal.

e. Finish Coats: Apply two coats, each with a 5 mil dry-film thickness, to achieve the total dry-film thickness. The coating material shall be the same material as the prime coat.

3. <u>System No. B-3--Submerged Metal, Raw Sewage</u>

a. Type: 100% solids epoxy for metal surfaces. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 40 mils.

b. Service Conditions: Shall be used on metal structures or pipes exposed to raw sewage.

c. Surface Preparation: Surface preparation shall be SSPC SP-10 for steel surfaces. Surface preparation shall be NAPF 500-03-05 Clean No. 2 for ductile iron or cast iron surfaces.

d. Prime Coat: Apply to a dry-film thickness of 5 mils. Approved manufacturers include:

i. Tnemec Series 435 Perma-Glaze;
ii. International Enviroline 224;
iii. Sherwin Williams Fast Clad ER;
iv. Carboline Plasite 4550; or
v. For contracts between District and Contractor, approved equal.

e. Finish Coat: Apply one coat with a 35 mil dry-film thickness, to achieve the total dry-film thickness. The coating material shall be the same material as the prime coat.

4. <u>System No. B-4--Submerged Concrete, Raw Sewage</u>

a. Type: 100% solids polyurethane and epoxy for concrete surfaces. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 100 mils for polyurethane and 70 mils for epoxy.

b. Service Conditions: Shall be used on concrete structures or pipes exposed to raw sewage including, but not limited to, junction structures, wet wells, and sumps. Sewer manholes shall be coated using this system unless otherwise specified in the project technical specifications.

c. Surface Preparation: SSPC SP-13. If the coating terminates mid-wall, the Contractor shall sawcut a termination strip 1/4-inch deep and 1/4-inch wide. Newly placed concrete shall cure for a minimum of 28 days before preparing the surface for coating.

d. Surface Filler: Prior to coating with an epoxy system, the surface shall be coated with 1/16 inch of filler to fill all surface voids. Approved manufacturers include:

i. Tnemec Series 218 Mortar-Clad;
ii. Sherwin Williams CorCote SC Grout;
iii. International Ceilcote 400 Mp Mortar; or
iv. For contracts between District and Contractor, approved equal.

e. Prime Coat: Apply to a dry-film thickness of 2 mils. If the Carboline Polibrid 705 Polyurethane System is used for the finish coat, then a prime coat is not required. Approved manufacturers include:

i. Zebron epoxy primer;
ii. Sancon 100 epoxy primer;
iii. Enviroline 58 UHS (to be used only with International Enviroline 222 finish coat); or
iv. For contracts between District and Contractor, approved equal.

f. Finish Coat: Apply one coat to achieve the total dry-film thickness. Approved manufacturers include:

i. Zebron Polyurethane System;
ii. Sancon 100 Polyurethane;
iii. Carboline Polibrid 705 Polyurethane System;
iv. Tnemec Series 436 Perma Shield FR;
v. Sherwin Williams CorCote FRE;
vi. International Enviroline 222; or
vii. For contracts between District and Contractor, approved equal.

E. Exposed Metal Coating Systems

1. System No. C-1--Exposed Metal, Severely Corrosive Environment

a. Type: Low VOC Inorganic zinc prime coat with low VOC epoxy-polyamide finish coat. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 12 mils.

b. Service Conditions: Shall be used on metal surfaces including, but not limited to, structures, piping, fittings, pumps, and appurtenances subjected to continuous water condensation, occasional immersion, or splashing. Below grade vaults shall be considered as severely corrosive environments.

c. Surface Preparation: Surface preparation shall be SSPC SP-10 for steel surfaces. Surface preparation shall be NAPF 500-03-05 Clean No. 2 for ductile iron or cast iron surfaces.

d. Prime Coat: Apply to a dry-film thickness of 3 mils. For ductile iron surfaces, the ductile iron shall have an asphaltic free surface with a factory applied prime coat the same as the finish coat. For all other surfaces, a two-component inorganic zinc rich primer shall be used with a minimum zinc content of 14 pounds per gallon. Approved zinc primer manufacturers include:

   i. Ameron Amercoat 68HS VOC;
   ii. Tnemec Series 94-H20 Hydro-zinc;
   iii. International/Devoe Cathacoat 302V;
   iv. Sherwin Williams Zinc Clad XI;
   v. Carboline Carbozinc 11; or
   vi. For contracts between District and Contractor, approved equal.

e. Finish Coats: Apply two coats, each with a 4 to 5 mil dry-film thickness, to achieve the total dry-film thickness. Approved manufacturers include:

   i. Ameron Amerlock VOC;
   ii. Tnemec Series L69 Hi-build Epoxoline II;
   iii. International/Devoe Devran 224HS VOC;
   iv. Sherwin Williams Macropoxy 646-100;
   v. Carboline Carboguard 890 VOC; or
   vi. For contracts between District and Contractor, approved equal.

2. <u>System No. C-2--Exposed Metal, Atmospheric Weathering Environment</u>

   a. Type: Low VOC Aliphatic Polyurethane with low VOC epoxy-polyamide or amido-amine epoxy primer. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 8 mils.

   b. Service Conditions: Shall be used on metal surfaces including, but not limited to, structures, piping, fittings, pumps, and appurtenances subjected to atmospheric elements and weathering.

   c. Surface Preparation: Surface preparation shall be SSPC SP-6 for steel surfaces. Surface preparation shall be NAPF 500-03-05 Clean No. 2 for ductile iron or cast iron surfaces. Surface preparation shall be SSPC SP-1 for galvanized surfaces and shall be brush blasted or acid etched surface prior to application of prime coat.

   d. Prime Coat: Apply one or two coats to a dry-film thickness of 5 mils. For ductile iron surfaces, the ductile iron shall have an asphaltic free surface with a factory applied prime coat the same as the finish coat. Approved manufacturers include:

      i. Ameron Amerlock VOC;
      ii. Tnemec Series 135 Chembuild with low VOC thinner or L69 Epoxyline;
      iii. International/Devoe BarRust 231;
      iv. Sherwin Williams Macropoxy 646-100;
      v. Carboline Carboguard 890 VOC; or
      vi. For contracts between District and Contractor, approved equal.

e. Finish Coat: Apply one coat to a dry-film thickness of 3 mils to achieve the total dry-film thickness. Approved manufacturers include:

i. Ameron Amershield VOC;
ii. Tnemec Series 1080 Endura-shield;
iii. International/Devoe Devthane 379;
iv. Sherwin Williams Hi-Solids Polyurethane 100;
v. Carboline Carbothane 134 MC; or
vi. For contracts between District and Contractor, approved equal.

F. **Buried Metal Coating Systems**

1. System No. D-1--Buried Metal

a. Type: Low VOC epoxy coating. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 24 mils.

b. Service Conditions: Shall be used to coat buried metal including, but not limited to, valves, flanges, bolts and nuts, fittings, flexible pipe couplings, and structural steel.

c. Surface Preparation: SSPC SP-10

d. Prime Coat: Apply to a dry-film thickness of 8 mils. Approved manufacturers include:

i. Ameron Amerloc VOC;
ii. Tnemec Series L69F;
iii. International/Devoe Bar-Rust 231;
iv. Carboline Carbothane 890 VOC; or
v. For contracts between District and Contractor, approved equal.

e. Finish Coats: Apply two coats, each with an 8 mil dry-film thickness, to achieve the total dry-film thickness. The coating material shall be the same material as the prime coat.

G. **Coating System for Metal in Contact with Concrete**

1. System No. E-1--Aluminum and Galvanized Surface in Concrete

a. Type: Low VOC epoxy coating. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 15 mils.

b. Service Conditions: Shall be used to coat areas including, but not limited to, gates, stairs, or structural members in contact with concrete.

c. Surface Preparation: Apply synthetic resin wash primer (phosphoric acid or vinyl butyral acid) to surface. Surface preparation shall comply with SSPC SP-1.

d. Prime Coat: Apply to a dry-film thickness of 5 mils. Approved manufacturers include:

   i. Ameron Amerlock VOC;
   ii. Tnemec Series L69F;
   iii. International/Devoe Bar-Rust 231;
   iv. Carboline Carbothane 890 VOC; or
   v. For contracts between District and Contractor, approved equal.

e. Finish Coats: Apply two coats, each with a 5 mil dry-film thickness, to achieve the total dry-film thickness. The coating shall be the same material as the prime coat.

H. PVC and FRP Pipe Coating System

1. System No. F-1-- PVC and FRP Pipe, Atmospheric Weathering Environment

   a. Type: Low VOC Aliphatic Polyurethane with low VOC epoxy-polyamide primer. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 6 mils.

   b. Service Conditions: Shall be used to coat PVC or FRP piping exposed to atmospheric elements and weathering.

   c. Surface Preparation: Surfaces shall be cleaned and dried prior to application of coating.

   d. Prime Coat: Apply one coat to a dry-film thickness of 3 mils. Approved manufacturers include:

      i. Ameron Amerlock VOC;
      ii. Tnemec Series 135 Chembuild with low VOC thinner or L69 Epoxyline;
      iii. International/Devoe BarRust 231;
      iv. Sherwin Williams Macropoxy 646-100;
      v. Carboline Carboguard 890 VOC; or
      vi. For contracts between District and Contractor, approved equal.

   e. Finish Coat: Apply one coat to a dry-film thickness of 3 mils to achieve the total dry-film thickness. Approved manufacturers include:

      i. Ameron Amershield VOC;
      ii. Tnemec Series 1080 Endura-shield;
      iii. International/Devoe Devthane 379;
      iv. Sherwin Williams Hi-Solids Polyurethane 100;
      v. Carboline Carbothane 134 MC; or
      vi. For contracts between District and Contractor, approved equal.

I. Valve Coating System

1. System No. G-1--Surface of Ferrous-Metal Valves

   a. Type: Thermosetting powdered epoxy coating.

b. Service Conditions: Shall be used to coat interior surfaces of ferrous metal valves, excluding seating areas and bronze and stainless steel pieces.

c. Surface Preparation: Protuberances which may produce pinholes in the coating shall be removed. Sharp edges shall be rounded. Surface contaminants which may prevent bonding of the coating shall be removed. Surface preparation shall comply with SSPC SP-5.

d. Coating: Apply to a total dry-film thickness of 12 mils in accordance with manufacturer's recommendation. Approved manufacturers include:

i. 3M Scotchkote 134; or
ii. For contracts between District and Contractor, approved equal.

2. System No. G-2 Surfaces of Ferrous-Metal Valves (Alternative)

a. General: This is an alternative to System No. G-1 when specified in the technical specifications.

b. Type: Two part low VOC epoxy-polyamide coating. A total dry-film consisting of the combined thickness of both a prime coat and finish coat is described herein. The total dry-film thickness of this system shall be 15 mils.

c. Service Conditions: Shall be used to coat interior surfaces of ferrous metal valves, excluding seating areas and bronze and stainless steel pieces.

d. Surface Preparation: Protuberances which may produce pinholes in the coating shall be removed. Sharp edges shall be rounded. Surface contaminants which may prevent bonding of the coating shall be removed. Surface preparation shall comply with SSPC SP-10.

e. Prime Coat: Apply to a dry-film thickness of 5 mils in accordance with manufacturer's recommendation. Approved manufacturers include:

i. Tnemec Series L140F Pota Pox;
ii. Sherwin Williams Macropoxy 646-100PW;
iii. Ameron Amerlock VOC;
iv. International/Devoe 233H; or
v. For contracts between District and Contractor, approved equal.

f. Finish Coats: Apply two coats, each with a 5 mil dry-film thickness, to achieve the total dry-film thickness. The coating material shall be the same material as the prime coat.

PART 3- EXECUTION

A. General

1. Quality assurance procedures and practices shall be utilized to monitor all phases of surface preparation, application, and inspection throughout the duration of the project. Procedures or practices not specifically defined herein may be utilized

provided they meet recognized and acceptable professional standards and are approved by the District.

2. Work accomplished in the absence of prescribed inspection may be required to be removed and replaced under the proper inspection, and the entire cost of removal and replacement, including the cost of all materials which may be furnished by the District and used in the work thus removed, shall be borne by the Contractor, regardless of whether the work removed is found to be defective or not. Work covered up without the authority of the District, shall, upon order of the District, be uncovered to the extent required, and the Contractor shall similarly bear the entire cost of accomplishing all the work and furnishing all the materials necessary for the removal of the covering and its subsequent replacement, as directed and approved by the District.

3. The District will make, or have made, such tests as it deems necessary to assure the work is being accomplished in accordance with the requirements of the Contract Documents. Unless otherwise specified, the cost of such testing will be borne by the District. In the event such tests reveal non-compliance with the requirements of the Contract Documents, the Contractor shall bear the cost of such corrective measures deemed necessary by the District, as well as the cost of subsequent retesting and re-inspection. Tests shall not constitute an acceptance of any portion of the work, nor relieve the Contractor from compliance with the terms of the Contract Documents.

4. Application: No coating shall be applied under the following conditions:

    a. When the surrounding air temperature or the temperature of the surface to be coated or painted is below 55 ºF for epoxy coatings, below 45 ºF for epoxy low temperature cure coatings, or above 125 ºF for all materials;

    b. To wet or damp surfaces or in rain, snow, fog or mist;

    c. When the air temperature is less than 5 ºF above the dewpoint;

    d. When it is expected the air temperature will drop below 55 ºF for epoxy coating; or 45 ºF. for epoxy low temperature cure coatings or less than 5 ºF above the dewpoint within two hours after application of coatings or paints;

        i. Dewpoint shall be measured by use of an instrument such as a Sling Psychrometer manual or electronic in conjunction with U.S. Department of Commerce Weather Bureau Psychrometric Tables or equivalent. If dehumidification is used, equipment must run continuously during all phases of the contract, except disinfection phase. If above conditions are prevalent, coating application shall be delayed or postponed until conditions are favorable. The day's application shall be completed in time to permit the film sufficient drying time prior to damage by atmospheric conditions.

5. Overspray and Dust Control: The Contractor shall conduct all operations so as to confine abrasive blasting debris and coating and paint overspray to within the bounds of the site. The Contractor shall take all precautions necessary to prevent adverse off-site consequences of application operations. Any complaints received by the District relating to any such potential off-site problems will be immediately

delivered to the Contractor. The Contractor shall immediately halt blast cleaning or application work and shall take whatever corrective action is required to mitigate any such problems. All costs associated with protection of off-site properties and/or correction of damage to property as a result of blast cleaning or application operations shall be borne directly by the Contractor at no additional expense to the District.

6. Inspection Devices: Contractor shall furnish, until final acceptance of coatings and paints, inspection devices in good working condition for detection of holidays and measurement of dry-film and wet-film thickness. Contractor shall also furnish U.S. Department of Commerce, National Bureau of Standards certified thickness calibration plates to test accuracy of thickness gauges. Dry film thickness gauges and holiday detectors shall be available at all times until final acceptance of application. Inspection devices shall be operated by, or in the presence of the District with location and frequency basis determined by the District. The District is not precluded from furnishing their own inspection devices and rendering decisions based solely upon their tests.

7. All surface preparation, coating and paint application shall conform to applicable standards of the Society for Protective Coating, the District and the manufacturer's printed instructions. Material applied prior to approval of the surface, by the District, shall be removed and reapplied to the satisfaction of the District at the expense of the Contractor.

8. All work shall be accomplished by skilled craftsmen qualified to accomplish the required work in a manner comparable with the best standards of practice. Resumes of personnel to be used on the project shall be made available upon request. Continuity of personnel shall be maintained and transfers of key personnel shall be coordinated with the District.

9. The Contractor shall provide a supervisor to be at the work site during cleaning and application operations. The supervisor shall have the authority to sign change orders, coordinate work and make other decisions pertaining to the fulfillment of the Contract Documents.

10. The Contractor's equipment shall be designed for application of materials specified and shall be maintained in first class working condition. Compressors shall have suitable traps and filters to remove water and oils from the air. Blotter test shall be accomplished at each start-up period and as deemed necessary by the District. Contractor's equipment shall be subject to approval of the District. This approval does not relieve the Contractor's responsibility for the safe operation of the equipment or its performance.

    a. Cleanliness of compressed air supply shall be verified daily, and as deemed necessary by Engineer, by directing a stream of air, without abrasive, from the blast nozzle onto a white blotter or cloth for twenty seconds. If oil or water appears on the blotter or cloth, all traps and separators shall be blown down until two subsequent twenty-second tests show no further oil or water.

11. Because of presence of moisture and possible contaminants in the atmosphere, care shall be taken to ensure previously coated or painted surfaces are protected or re-cleaned prior to application of subsequent coat(s). Methods of protection and re-cleaning shall be approved by the District.

a. The project is subject to intermittent shutdown if, in the opinion of the District, cleaning and application operations are creating a localized condition detrimental to ongoing facility activities, personnel or adjacent property.

b. In the event of emergency shutdown by the District, Contractor shall immediately correct deficiencies. All additional costs created by shutdown shall be borne by Contractor.

B. Surface Preparation

1. General: Sandblast or prepare only as much surface area as can be coated in one day. All sharp edges, burrs, and weld spatter shall be removed. Epoxy-coated pipe that has been factory coated shall not be sandblasted.

2. SSPC Specifications: Wherever the words "solvent cleaning", "hand tool cleaning", "wire brushing", "blast cleaning", or similar words are used in these specifications or in paint manufacturer's specifications, they shall be understood to refer to the applicable SSPC (Society for Protective Coatings, Surfaces Preparation Specifications, ANSI A159.1) specifications listed below:

SP-1	Solvent Cleaning
SP-2	Hand Tool Cleaning
SP-3	Power Tool Cleaning
SP-5	White Metal Blast Cleaning
SP-6	Commercial Blast Cleaning
SP-7	Brush-Off Blast Cleaning
SP-8	Pickling
SP-10	Near White Blast Cleaning

3. The Contractor shall provide suitable enclosure, exhaust system, and bag house for sandblasting operations to prevent violations of applicable air quality requirements.

4. Surface preparation shall be based upon comparison with: "Pictorial Surface Preparation Standards for Painting Steel Surfaces", SSPC-Vis 1, ASTM Designation D2200, NACE Standard TM-01-70. Anchor profile for prepared surfaces shall be measured by using a non-destructive instrument such as a K-T Surface Profile Comparator or Testex Press-O-Film System. Temperature and dewpoint requirements shall apply to all surface preparation operations.

5. Dust, dirt, oil, grease or any foreign matter which will affect the adhesion or durability of the finish must be removed by washing with clean rags dipped in an approved commercial cleaning solution, rinsed with clean water and wiped dry with clean rags. Abrasive blasting nozzles shall be equipped with "deadman" emergency shut-off nozzles. Blast nozzle pressure shall be a minimum of 95 psi and shall be verified by using an approved nozzle pressure gage at each start-up period or as directed by the District. Number of nozzles used during all blast cleaning operations must be sufficient to ensure timely completion of project, subject to designation and approval by the District.

6. All blast hose connections shall be tethered and secured to prevent separation during blast cleaning operations, and shall be taped with duct tape prior to pressurizing. All taped connections shall be visually inspected for leaks within five minutes after start of blast cleaning operations and at the end of blast cleaning operations. Leaking connections shall be immediately repaired to prevent further damage.

7. Particle size of abrasives used in blast cleaning shall be that which will produce a 2 mil surface profile or in accordance with recommendations of the manufacturer of the specified coating system to be applied, subject to approval of the District.

8. Abrasive used in blast cleaning operations shall be new, washed, graded and free of contaminants which would interfere with adhesion of coatings and shall not be reused unless specifically approved by the District. Abrasives shall be certified for unconfined dry blasting pursuant to the California Administrative Code, Section 92520 of Subchapter 6, Title 17, and shall appear on the current listing of approved abrasives. Invoices or load sheets confirming above shall be submitted to the District upon request.

9. During blast cleaning operations, caution shall be exercised to ensure existing coatings and paint are not exposed to abrasion from blast cleaning.

10. Blast cleaning from rolling scaffolds shall only be accomplished within confines of interior perimeter of scaffold. Reaching beyond limits of perimeter will be allowed only if blast nozzle is maintained in a position which will produce a profile acceptable to the District.

11. The Contractor shall keep the area of his work in a clean condition and shall not permit blasting materials to accumulate as to constitute a nuisance or hazard to the prosecution of the work or the operation of the existing facilities. Spent abrasives and other debris shall be removed at the Contractor's expense as directed by the District.

12. Blast cleaned and coated/painted surfaces shall be cleaned prior to application of specified coatings/paints via a combination of blowing with clean dry air, brushing/brooming and/or vacuuming as directed by the District. Air hose for blowing shall be at least 1/2-inch in diameter and shall be equipped with a shut-off device. Tests on surfaces of abrasively blast cleaned steel shall be accomplished to detect oil and other contaminants which might be deposited on surfaces. This will include chemical tests or ultraviolet (black light) tests, as required.

C. <u>Application</u>

1. Multiple-component coatings shall be prepared using all the contents of each component container as packaged by the paint manufacturer. Partial batches shall not be used. Multiple-component coatings that have been mixed beyond their pot life shall not be used. Small quantity kits for touch-up painting and for painting other small areas shall be provided. Only the components specified and furnished by the paint manufacturer shall be mixed. For reasons of color or otherwise, additional components shall not be intermixed even within the same generic type of coating.

2. Application of the first coat shall follow immediately after surface preparation and cleaning within an eight hour working day. Any cleaned areas not receiving first coat within an eight hour period shall be re-cleaned prior to application of first coat.

3. Coating and paint application shall conform to the requirements of the Society for Protective Coating Paint Application Specification SSPC-PA1, latest revision, for "Shop, Field and Maintenance Painting," the District, the manufacturer of the coating and paint materials printed literature and as specified herein.

4. All coating components shall be mixed in exact proportions specified by the manufacturer. Care shall be exercised to ensure all material is removed from containers during mixing and metering operations.

5. All coatings shall be thoroughly mixed, utilizing an approved slow-speed power mixer until all components are thoroughly combined and are of a smooth consistency.

6. Thinning shall only be permitted as recommended by the manufacturer and approved by the District and shall not exceed limits set by applicable regulatory agencies.

   a. If the Contractor applies any materials which have been modified or thinned to such a degree as to cause them to exceed established VOC levels, the Contractor shall be responsible for any fines, costs, remedies, or legal action and costs that may result.

7. Each application of coating or paint shall be applied evenly, free of brush marks, sags, runs and no evidence of poor workmanship. Care should be exercised to avoid lapping on glass or hardware. Coatings and paints shall be sharply cut to lines. Finished surfaces shall be free from defects or blemishes.

8. Protective coverings or drop cloths shall be used to protect floors, fixtures, equipment, prepared surface and applied coatings or paints. Care shall be exercised to prevent coating or paint from being spattered onto surfaces which are not to be coated or painted. Surfaces from which such material cannot be removed satisfactorily shall be refinished as required to produce a finish satisfactory to the District.

9. All welds and irregular surfaces specified by the District shall receive a brush coat of the specified product prior to application of each complete coat. Coating shall be brushed in multiple directions to ensure penetration and coverage, as directed by the District. Care shall be exercised to ensure dry film thickness of coatings and paints do not exceed the maximum thickness allowed by the manufacturer of the specific product being applied.

10. At conclusion of each day's blast cleaning and coating operations, a 6-inch wide strip of blast cleaned substrate shall remain uncoated to facilitate locating point of origin for successive day's blast cleaning operations.

11. Epoxy coated surfaces or other multi-component materials exposed to excessive sunlight or an excessive time element beyond manufacturer's recommended recoat cycle, shall be scarified by Brush-Off Blast Cleaning (SSPC SP-7) or methods

approved by Engineer, prior to application of additional coating or paint. Scarified coating or paint shall have sufficient depth to assure a mechanical bond of subsequent coat.

12. When two or more coats are specified, where possible, each coat shall contain sufficient approved color additive to act as an indicator of coverage or the coats must be of contrasting color.

13. Care shall be exercised during spray operations to hold the spray nozzle perpendicular and sufficiently close to surfaces being coated, to avoid excessive evaporation of volatile constituents and loss of material into the air or the bridging of cracks and crevices. Reaching beyond limits of scaffold perimeter shall not be permitted. All overspray identified by the District shall be removed by hand or pole sanding prior to application of subsequent coat.

D. Surfaces Not To Be Painted

Unless noted otherwise, the following surfaces shall not be painted and shall be fully protected when adjacent areas are painted.

1. Mortar-coated pipe and fittings
2. Stainless Steel surfaces
3. Aluminum guardrails and handrails
4. Galvanized pipe supports and ladders
5. Nameplates and grease fittings
6. Aluminum grating
7. Brass and copper pipe

E. Protection of Surfaces Not To Be Painted

Hardware, lighting fixtures, switch plates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not intended to be painted shall be removed, masked, or otherwise protected. Drop cloths shall be provided to prevent paint materials from falling on or marring adjacent surfaces. Working parts of mechanical and electrical equipment shall be protected from damage during surface preparation and painting process. Openings in motors shall be safely masked to prevent paint and other materials from entering the motors. All masking materials shall be completely removed and surfaces cleaned at completion of painting operations.

F. Color Schedule

1. Definitions:

   At Grade: Facilities that are flush with streets, sidewalks, parking lots, green belts or graded areas. This also includes pipelines and other facilities that are protruding through and are located above finished grade, out of doors and not enclosed by a shelter, cover, vault or housing.

Enclosed: Pipeline and other facilities that are located above or below grade and are enclosed within a shelter, covers, or vaults.

N/A: Not Applicable.

I.D. Mark: System identification marker as described herein. The I.D. Mark shall identify the system of which the facility is a part.

2. Color Guidelines: Unless noted otherwise, surfaces that are to be coated and that require a color designation for any of the following uses, shall be coated to match the colors listed below. Final color selection shall be determined by District Representative.

3. Potable Water System:

Facility	Enclosed	At Grade
Airvac Assemblies	Dark Blue	Olive Light w/I.D. Mark
Airvac Covers (metallic only)	N/A	Olive Light w/I.D. Mark
Detector Check Valves	Olive Light	Olive Light
Electric Motors	Olive Light	Olive Light w/I.D. Mark
Electrical Enclosures	Factory Finish	Olive Light or Factory Finish
Piping	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pressure Vessels	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pump & Pump Bases	Olive Light	Olive Light
Valves (all types)	Olive Light	Olive Light
Valve Can Lids: Normally Open Normally Open (for fire hydrants) Normally Closed (at zone breaks)	 N/A N/A N/A	 Safety Yellow Dark Blue Safety Red

4. Recycled Water System:

Facility	Enclosed	At Grade
Airvac Assemblies	Purple	Olive Light w/I.D. Mark
Airvac Covers (metallic only)	N/A	Olive Light w/I.D. Mark
Electric Motors	Olive Light	Olive Light
Electrical Enclosures	Factory Finish	Olive Light or Factory Finish
Piping	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pressure Vessels	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pump & Pump Bases	Olive Light	Olive Light
Valves (all types)	Olive Light	Olive Light
Valve Can Lids: Normally Open Normally Closed (at zone breaks)	 N/A N/A	 Purple Safety Red

5. Sewer Collection System (Force Mains):

Facility	Enclosed	At Grade
Airvac Assemblies	Safety Green	Olive Light w/I.D. Mark
Airvac Covers (metallic only)	N/A	Olive Light w/I.D. Mark
Electric Motors	Olive Light	Olive Light
Electrical Enclosures	Factory Finish	Olive Light or Factory Finish
Piping	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pump & Pump Bases	Olive Light	Olive Light
Valves (all types)	Olive Light	Olive Light
Valve Can Lids	N/A	Safety Green

6. Raw Water System:

Facility	Enclosed	At Grade
Airvac Assemblies	Light Blue	Olive Light w/I.D. Mark
Airvac Covers (metallic only)	N/A	Olive Light w/I.D. Mark
Electric Motors	Olive Light	Olive Light
Electrical Enclosures	Factory Finish	Olive Light or Factory Finish
Piping	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pressure Vessels	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pump & Pump Bases	Olive Light	Olive Light
Valves (all types)	Olive Light	Olive Light
Valve Can Lids	N/A	Light blue

7. Non-Reclaimable Waste System:

Facility	Enclosed	At Grade
Airvac Assemblies	Brown	Olive Light w/I.D. Mark
Airvac Covers (metallic only)	N/A	Olive Light w/I.D. Mark
Electric Motors	Olive Light	Olive Light
Electrical Enclosures	Factory Finish	Olive Light or Factory Finish
Piping	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pressure Vessels	Olive Light w/I.D. Mark	Olive Light w/I.D. Mark
Pump & Pump Bases	Olive Light	Olive Light
Valves (all types)	Olive Light	Olive Light
Valve Can Lids	N/A	Brown

8. Test station box lids for cathodic protection shall be painted safety orange. Refer to Section 16640, Cathodic Protection and Joint Bonding for test box specifications.

9. Identification (I.D.) Mark:

Certain facilities listed above to be coated shall have an identification system applied by the Contractor at the District's direction.

Vault hatches (coated or uncoated) shall be identified with the IRWD initials and the system the facility serves (recycled water, raw water, potable water, sewer). The identification mark shall be able to stand up to traffic and not pose a tripping hazard.

Other facilities listed above that are to be coated and/or provided with an I.D. mark shall receive a District supplied identification decal that consists of the District's logo, phone number, system identification color, and the system the facility serves.

G. Field Touch Up of Shop-Applied Prime Coats

1. Organic Zinc Primer: Surfaces that are shop primed with inorganic zinc primers shall receive surface preparation and a field touchup of organic zinc primer to cover all scratches or abraded areas. Organic zinc primer system shall have a minimum volume solids of 70%. Finish coats shall be in accordance with System No. C-1 or for contracts between District and Contractor, approved equal. Organic zinc primer shall be manufactured by the prime coat and finish coat manufacturer.

2. Other Surfaces: Other surfaces that are shop primed shall receive surface preparation and a field touchup of the same primer used in the original prime coat.

H. Dry-Film Thickness Testing

1. Coating Thickness Testing: Coating thickness specified herein are "dry-film thickness" in mils. Mil thicknesses specified are minimums. Coating thickness specified for steel surfaces shall be measured with a magnetic-type dry-film thickness gage. Dry-film thickness gage shall be provided as manufactured by Positector, Quanix, Mikrotest, or Elcometer.

   Each coat shall be checked for the correct dry-film thickness. Measurement shall not be made until a minimum of eight hours after application of the coating. Non-magnetic surfaces shall be checked for coating thickness by micrometer measurement of cut and removed coupons. Contractor shall repair coating at all locations where coupons are removed.

2. Holiday Testing: The finish coat (except zinc primer and galvanizing) shall be tested for holidays and discontinuities using only the specified high voltage instrument, with a wire brush electrode, at a minimum of 100 volts per mil in accordance with AWWA Standard C203, latest revision. Detector shall be provided as manufactured by Tinker and Rasor, Models AP and AP-W holiday detectors.

3. Repair: If a surface has an improper finish color, insufficient film thickness, or holidays, the surface shall be cleaned and top-coated with the specified paint material to obtain the specified color and coverage. Visible areas of chipped, peeled, or abraded paint shall be hand or power-sanded, feathering the edges. The areas shall then be primed and finish coated in accordance with the specifications. Work shall be free of runs, bridges, shiners, laps, or other imperfections.

END OF SECTION

SECTION 15040: INTERIOR JOINT INSPECTION FOR 4" – 30" CEMENT-MORTAR LINED PIPE

PART 1 - GENERAL

A. Description

This section describes the inspection required for the acceptance and verification of cement-mortar lined steel pipe for diameters 4-inch through 30-inch and for other sections of pipe deemed not readily accessible for inspection personnel to enter the pipe.

B. Related Work Specified Elsewhere

1. Chlorination of Water Mains for Disinfection: 15041.
2. Hydrostatic Testing of Pressure Pipelines: 15042.
3. Installation of Pressure Pipelines: 15051.
4. Cement Mortar Lined and Coated Steel Pipe: 15076.
5. Cathodic Protection and Joint Bonding: 16640.

C. Interior Joint Inspection

1. After the pipeline had been backfilled and compacted, a closed circuit television (CCTV) inspection will be required prior to pipeline testing and disinfection to document the condition of the joints within the pipeline, and to verify the condition of the lining after installation for all CML pipe with diameters of 4-inches up to and including 30-inches in diameter.

2. All video inspections shall be recorded on a four-head VCR in VHS format, standard play mode, CD or DVD. All original video tapes, CD's, DVD's, log sheets, notes and reports shall be submitted to and become the property of the District.

3. Any work found in non-compliance with the Contract Documents and rejected shall be repaired and re-televised at the Contractor's expense.

4. If the quality of the videotape, CD or DVD is deemed unacceptable by the District's representative, the pipeline shall be re-televised at no additional cost to the District.

5. Payment for the video inspection shall be included in the unit price for the pipeline and no additional compensation shall be allowed therefor.

PART 2 - MATERIALS

A. Ventilation for Confined Space Safety

The Contractor shall provide access points and ventilation for the video inspection of the interior of the pipeline. Ventilation shall be sufficient to permit entry for personnel if it is deemed necessary.

PART 3 - EXECUTION

A. <u>General</u>

1. <u>CCTV Equipment</u>:

   a. CCTV equipment shall include television cameras, a television monitor, cables, power sources and other equipment necessary to perform a video camera inspection.

   b. The camera shall have a rotating video camera lens system.

   c. Focal distance shall be adjustable through a range from 6-inches to infinity.

   d. The remote reading footage counter shall be accurate to less than 1-percent error over the length of the particular section of pipeline being inspected.

   e. The camera and television monitor shall produce a minimum 14 lines per 350-lines-per inch resolution.

   f. Video camera shall be mounted on a transporter or skid system.

   g. Lighting for the camera shall minimize reflective glare. Lighting and picture quality shall be suitable to provide a clean, in focus picture of the entire periphery of the pipeline.

   h. A padded seat that will accommodate at least one Inspector and one Engineer shall be located behind the TV operator in-line with the video monitor. This seat may be used by the Inspector and Engineer to monitor the video inspection.

   i. CCTV inspection shall be performed utilizing a camera and cable that is exclusively used for potable water applications.

2. <u>Communications Equipment</u>:

   a. Telephones, radios or other suitable means of communication shall be set up to ensure that adequate communication exists between members of the crew.

B. <u>Inspection</u>

1. <u>CCTV Inspection</u>:

   a. The Contractor shall submit records for review and approval of the CCTV inspection equipment with cut sheets to the District.

   b. Information verifying the usage (potable only) and type of the equipment prior to video inspection shall be provided as a project submittal.

C. <u>**Field Inspection**</u>

1. <u>CCTV Field Inspection</u>: CCTV Field inspection shall be performed such that:

   a. The camera shall be moved through the pipeline in one direction, no skipping or changing of directions will be allowed.

   b. The camera shall move at a uniform rate, stopping when necessary, but in no case shall the television camera be pulled at a speed greater than 30 feet per minute.

   c. The camera shall stop at each joint and the camera lens rotated to inspect each joint. All CML&C steel pipe joints shall have "mark numbers" on interior joints as well as exterior joints.

      (1.) The operator shall focus on the joint and pan 360 degrees around the finished joint to verify that there are:

         (a.) no gaps or voids in the lining:

         (b.) smooth transitions of the cement mortar lining.

D. <u>**Inspection Documentation**</u>

1. <u>Inspection Documentation</u>:

   a. Documentation shall consist of a color, VHS-format videotape/CD/DVD, log sheets and a written report detailing the condition found at the joints.

   b. Distances shall correspond to the pipeline stationing shown on the plans.

   c. The report shall note the time and date of video inspection, street name, pipeline station, direction of view, pipeline length, pipe section length, pipe size, pipe material, laterals, videotape number, counter number and a detailed logging of defects encountered.

END OF SECTION

SECTION 15041: CHLORINATION OF WATER MAINS WELLS & RESERVOIRS

PART 1 - GENERAL

A. Description

This section describes the disinfection of potable water mains, wells and well-head facilities, reservoirs, services, appurtenances, and connections by chlorination, in accord with ANSI/AWWA B300, B301, C651, and C652 and as specified herein.

B. Related Work Specified Elsewhere

Hydrostatic Testing of Pressure Pipelines: 15042.

C. Job Conditions

1. Discharge of chlorinated water into watercourses or surface waters is regulated by the National Pollutant Discharge Elimination System (NPDES). A copy of the District's permit is included in the appendix.

2. The rate of flow and locations of discharges shall be scheduled in advance to permit review and coordination with District and cognizant regulatory authorities.

   a. Orange County EMA--Flood Control.

   b. City of Irvine.

3. Potable water shall be used for chlorination. See Special Provisions section for availability of water.

4. Requests for use of water from District waterlines shall be submitted 48 hours in advance.

5. Chlorination shall be performed prior to hydrostatic testing for pipelines having a diameter of 12-inches and larger. See Part 3, Paragraph A-9 for concurrent hydrostatic testing and chlorination of smaller diameter pipelines.

PART 2 - MATERIALS

A. Liquid Chlorine Solution

Liquid chlorine solution shall be in accord with the requirements of ANSI/AWWA B301, and shall be injected with a solution feed chlorinator and a water booster pump or a sufficiently pressurized source of water to provide an adequate flow to inject and disperse the chlorine solution.

B. Calcium Hypochlorite (Dry)

Calcium Hypochlorite shall be in accord with the requirements of ANSI/AWWA B300, and shall be dissolved in water to a known concentration in a container and pumped into the pipeline at a measured rate.

C. Sodium Hypochlorite (Solution)

Sodium Hypochlorite shall be in accord with the requirements of ANSI/AWWA B300, and be diluted in water to desired concentration and pumped into the pipeline at a measured rate.

D. Calcium Hypochlorite Tablets and Adhesive

1. Chlorine Content: The tablets shall have an average weight of 5 grams each and shall contain not less than 70% of available chlorine.

2. Adhesive: Adhesive shall be a type that will not impart taste, odor, or detrimental compounds to the water supply.

3. Storage: Proper care shall be taken to store hypo-chlorite tablets in tightly closed containers where they will not be accessible to children or unauthorized persons.

E. Chlorine Residual Test Kit

For measuring chlorine concentration, a medium range, drop count, titration kit or an orthotolidine indicator comparator with wide range color discs shall be used. The kit shall be capable of determining chlorine concentration in the range 1.0 to 25 mg/L. Test kits shall be Hach Chemical, Hellige, or for contracts between District and Contractor, approved equal. An adequate number of kits shall be maintained by the Contractor in good working order and available for immediate test of residuals at points of sampling.

PART 3 - EXECUTION

A. Pipelines

1. General: Before being placed into service, all pipelines and appurtenances shall be chlorinated. Pipelines with a diameter of 10-inches or less shall be disinfected by either direct chlorine solution injection or by use of calcium hypochlorite tablets. Pipelines with a diameter of 12-inches and larger shall be disinfected by direct chlorine solution injection. Steel pipelines shall be disinfected by continuous feed chlorine solution injection. Bacteriological testing after disinfection shall be performed by the District.

2. Chlorination Contractor: Chlorination shall be performed by a certified chlorination and testing Contractor. Chlorination shall be in accord with the instructions of the chlorinator manufacturer.

3. Groundwater: In the event groundwater is encountered and it is impossible to prevent its entrance into the mains, or the mains are not free from dirt, they shall be thoroughly flushed prior to disinfection. Disinfection shall be by continuous feed chlorine solution injection.

4. Services: Every service connection served by a main being disinfected shall be tightly shutoff at the curb stop before water is applied to the main. Care shall be taken to expel all air from the main and services during the filling operation.

5. Pipeline Flushing:

   a. Before chlorinating pipeline, flush pipes with water to remove dirt and debris. Maintain a flushing velocity of at least 3 feet per second. Flush pipes for a minimum of the time period calculated from the formula: $T = \frac{2}{3}L$ in which:

      T = flushing time in seconds
      L = pipe length in feet

6. Continuous Feed: Chlorine Solution Injection Method

   a. Chlorine solution shall be applied by means of a vacuum-operated chlorinator and a booster pump or a sufficiently pressurized source of water to provide an adequate flow to operate the eductor system and properly disperse the chlorine solution. Direct-feed chlorinators, which operate from gas pressure in the chlorine cylinder, without a vacuum regulator, shall not be used for application of a chlorine solution.

   b. Chlorine solution shall be applied at the beginning of the section to be chlorinated and shall be injected through a corporation stop, a hydrant, or other approved connection to ensure treatment of the entire system being disinfected. All required corporation stops and other plumbing materials necessary for chlorination or flushing of the main shall be installed by the Contractor.

   c. Potable water shall be introduced into the pipeline at a constant measured rate. Chlorine solution shall be injected into the potable feed water at a measured rate. The two rates shall be proportioned so that the chlorine concentration in the pipeline is maintained at a minimum concentration of 50 mg/L to 100 mg/L, with a chlorine residual of 25 mg/L after 24 hours in the pipe. The concentration at points downstream shall be checked periodically during the filling to ascertain that sufficient chlorine is being added.

7. Disinfection by Calcium Hypochlorite Tablets: The use of calcium hypochlorite tablets will be permitted in pipe sizes 4- through 10-inches. The tablets shall be attached by means of an approved adhesive to the inside top of the lengths of pipe as they are being laid. The amount of adhesive shall be limited to the smallest practicable amount applied to one side of the tablet only.

   The following table shows the number of tablets to be used per length of pipe of various sizes to provide the required chlorine residual:

Inside Diameter of Pipe (Inches)	No. of 5g. Hypochlorite Tablets Per Length of Pipe, in feet		
	10	18 & 20	40
4	1	1	1
6	1	1	2
8	1	2	4
10	2	3	5

8. Disinfection of Valves and Appurtenances: During the period that the chlorine solution is in the section of pipeline, valves shall be opened and closed to obtain a chlorine residual at hydrants and other pipeline appurtenances. Care shall be taken to ensure that no chlorinated water enters any active pipeline.

9. Concurrent Testing (for Pipelines with Diameter of 10-inches or Less): Disinfecting mains and appurtenances, and hydrostatic testing may run concurrently for the required 24-hour test period. In the event there is leakage and repairs are necessary, disinfection of the pipeline shall be repeated by injection of chlorine solution into the line as provided in this section.

10. Confirmation of Residual: After the chlorine solution applied by the continuous feed method has been retained in the pipeline for 24 hours, samples shall be taken at air valves and other points of access to confirm that a chlorine residual of 25 mg/L minimum exists along the pipeline.

11 Water Quality Samples and Testing: The contractor shall provide adequate and convenient means for the District Representative to collect an appropriate number of water samples for each segment of pipeline tested. A bacteriologic and physical quality test will be performed by the District to demonstrate the absence of coliform organisms in each separate section of the pipeline after chlorination and refilling.

12 Repetition of Procedure: If the initial chlorination fails to produce required residuals and bacteriologic results, chlorination and testing shall be repeated until satisfactory results are obtained.

13 Pipeline Flushing: After confirming the chlorine residual, excess chlorine solution shall be flushed from the pipeline until the chlorine concentration in the water leaving the pipe is within 0.5 mg/L of the replacement water. See Part 3, Execution, Sub-part D., Disposal of Chlorinated Water for other requirements.

14 Test Facility Removal**:** After satisfactory disinfection, all temporary disinfection and test facilities shall be removed and restored to the satisfaction of the District Representative.

B. Wells, Well-Heads and Pump Stations

1. General: The well and well head piping shall be disinfected as a complete unit. Adequate bracing shall be provided to resist thrust.

2. Depth of Disinfection: The well shall be disinfected to its full depth. A double capped, perforated pipe container filled with granular chlorine compound shall be moved up and down the entire water-filled casing and screen section until all the chlorine compound has dissolved.

3. Pump Column Disinfection: The pump column shall be washed with a chlorine solution, containing at least 12 percent chlorine, as the pump column is lowered into the well or pump can.

4. Mixing: After the well pump has been placed into position, it shall be turned on and off several times so as to thoroughly mix the disinfectant with the water in the well. The flow control valve shall be set at a pumping rate of 2 cfs. The pump shall be run until the water discharged has the odor of chlorine. This procedure shall be repeated several times at one-hour intervals.

5. Disinfection Time: After mixing, the well shall be allowed to stand without pumping for 24 hours.

6. Flushing: Well water shall be pumped to waste until the presence of chlorine is no longer detectable, as determined by testing for available chlorine residual using a test kit. Allow the well to stand without pumping for 24 hours. See Part 3, Execution, Sub-part D, Disposal of Chlorinated Water for other requirements.

7. Bacteriological Tests: On two consecutive days, bacteriological samples shall be taken and submitted to the District's laboratory for examination. Samples shall be tested by the District's laboratory for coliform bacteria and heterotrophic plate count. All coliform test results must be negative and heterotrophic plate counts must be less than 500 colonies/mL prior to placing the well into service.

8. Repetition of Procedure**:** If the laboratory analysis shows the water is not free of bacterial contamination, the disinfection procedure shall be repeated. Depending on the level of contamination, it may be necessary to use a higher concentration chlorine solution. The water shall then be re-tested. Two consecutive samples must pass the bacteriological tests before the well can be placed in service.

C. Reservoirs

1. General: The Contractor shall make all necessary provisions for conveying water from the District designated supply source to the points of use.

2. Facilities to be Disinfected: All hydraulic structures and appurtenant pressure piping shall be tested; those for potable water shall also be disinfected. In the case of a reservoir, testing and disinfecting operations shall be combined. Disinfection shall be accomplished by chlorination. All chlorinating and testing operations shall be done in the presence of the District Representative.

3. Scheduling: Disinfection operations shall be scheduled by the Contractor as late as possible during the contract time period so as to assure the maximum degree of sterility of the facilities at the time the work is accepted by the District.

4. Bacteriological Testing: Bacteriological testing shall be performed by the District's laboratory. Results of the bacteriological testing shall be satisfactory to the State Department of Health or other appropriate regulatory agency. Passing tests on two consecutive days for heterotrophic plate count (<500 cfu/mL) and absence from coliform bacteria must be achieved prior to placing the reservoir into service.

5. Release of Disinfection Water: Release of water from structures, after testing and disinfecting have been completed, shall be acceptable to the District.

6. Preliminary Cleaning and Flushing: Prior to both testing and disinfecting, all hydraulic structures shall be cleaned by thoroughly hosing down all surfaces with a high pressure hose and nozzle of sufficient size to deliver a minimum flow of 50 gpm. All water, dirt, and foreign material accumulated in this cleaning operation shall be discharged from the structure or otherwise removed.

7. <u>Disinfection of Hydraulic Structures and Appurtenant Pipelines</u>: All hydraulic structures which store or convey potable water shall be disinfected by chlorination. Chlorination of hydraulic structures shall be performed in accord with the requirements of ANSI/AWWA C-652.

   a. Chlorination: A strong chlorine solution (about 200 mg/L) shall be sprayed on all interior surfaces of the structure. Following this, the structure shall be partially filled with water to a depth of approximately one foot. During the partial filling operation, a chlorine-water mixture shall be injected by means of a solution feed chlorinating device in such a way as to give a uniform chlorine concentration during the entire filling operation. The point of application shall be such that the chlorine solution will mix readily with the in-flowing water.

      The dosage applied to the water shall be sufficient to provide a chlorine residual of at least 50 mg/L upon completion of the partial filling operation. Precaution shall be taken to prevent the strong chlorine solution from flowing back into the lines supplying the water. After the partial filling has been completed, sufficient water shall be drained from the lower ends of appurtenant piping to ensure filling the lines with the heavily chlorinated water.

   b. Retention Period: Chlorinated water shall be retained in the partially filled structure and appurtenant piping long enough to destroy all non-spore-forming bacteria, and in any event, for at least 24 hours. After the chlorine-treated water has been retained for the required time, the free chlorine residual in the structure and appurtenant piping shall be at least 25 mg/L. All valves shall be operated while the lines are filled with the heavily chlorinated water.

   c. Final Filling of Structure: After the free chlorine residual has been checked, and has been found to satisfy the above requirement, the water level in the structure shall be raised to its final elevation by addition of potable water. Before final filling is commenced, the concentration of heavily-chlorinated water remaining in the structure and piping shall, unless otherwise acceptable to the District's representative, be sufficient to produce a free chlorine residual of between 1 and 2 mg/L when the water level is raised to its final elevation. After the structures have been filled, the strength of the chlorinated water shall be determined. If the free chlorine residual is less than one mg/L, an additional dosage shall be applied to the water in the structure. If the free chlorine residual is greater than 2 mg/L, the structure shall be partially emptied and additional potable water added. In no case shall water be released prior to the expiration of the required retention period. See Part 3, Execution, Sup-part D, Disposal of Chlorinated Water for other requirements.

8. <u>Connections to Existing System</u>: Where connections are to be made to an existing potable water system, the interior surfaces of all pipe and fittings used in making the connections shall be swabbed or sprayed with a one percent hypochlorite solution before they are installed. Thorough flushing shall be started as soon as the connection is completed and shall be continued until all discolored water is eliminated.

D. Disposal of Chlorinated Water

1. Disposal to DISTRICT's Wastewater Collection System: Unless noted otherwise in the Contract Documents, or directed otherwise by the District Representative, chlorinated water may be disposed of into the DISTRICT's wastewater collection system.

2. Dechlorination Prior to Disposal: If discharge to collection system is not permitted, chlorinated water shall be dechlorinated during flushing, prior to disposal. Dechlorination shall be performed by a certified chlorination and testing company. Dechlorinated water shall have a total chlorine residual concentration of less than 0.1 mg/L.

END OF SECTION

SECTION 15042: HYDROSTATIC TESTING OF PRESSURE PIPELINES

PART 1 - GENERAL

A. Description

This section describes pressure and leakage testing of all pressure pipelines, in accordance with ANSI/AWWA C600 and as specified herein.

B. Related Work Specified Elsewhere

Chlorination of Water Mains for Disinfection: 15041.

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and the following.

2. Test bulkhead locations and design calculations, pipe attachment details, and methods to prevent excessive pipe wall stresses.

D. Job Conditions

1. For potable water pipelines, obtain and use only potable water for hydrostatic testing. See Special Provision Section for availability of water.

2. Submit request for use of District water to the District 48 hours in advance.

3. Hydrostatic testing shall be successfully completed before new pipelines are connected to existing District pipes and mains.

E. Testing Company

All testing shall be performed by independent testing companies with a Class A license, and/or who are certified and District-approved to perform the required pressure testing and disinfection. Testing companies will be required to provide the District Representative with certified testing results. The testing company shall provide gauges and meters which have been calibrated and certified at least quarterly.

PART 2 - MATERIALS

A. Test Bulkheads

Test bulkheads shall be designed and tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. Materials shall comply with Part UCS of said code. Bulkhead design pressure shall be at least 2.0 times the specified test pressure for the section of pipe containing the bulkhead. Stress shall be limited to 70% of yield strength of the bulkhead material at the bulkhead design pressure. Air-release and water drainage connections shall be included.

B. Manual Air-Release Valves

Temporary manual air-release valves shall be provided where necessary for pipeline test. The number and location of release valves shall be subject to the review and approval of the District Representative. The pipe outlet shall be constructed in the same manner as for a permanent air valve. After use, the connection shall be sealed with a blind flange, pipe cap, or plug in a manner and with the fittings satisfactory to the District Representative. All connections and exposed fittings which are installed shall be coated equivalently to the adjacent pipe and in accord with the District specifications.

C. Water

The same water used for chlorination of the pipeline may be used to fill the line for testing. Make up water for testing potable water pipelines shall be potable water.

PART 3 - EXECUTION

A. General

All labor, materials, tools, and equipment for testing shall be furnished by the Contractor. The test shall conducted with valves in the test section open. Ends of each test section, open ends of pipes, valves, and fittings shall be suitably closed. Valves in the test section shall be operated during the test period.

B. Testing and Disinfection Sequence

See Section 15041, Chlorination for Disinfection of Water Mains.

C. Isolation of Test Pipe Section from Existing Pipelines

Test bulkheads, valves, connections to existing pipelines, and other appurtenances shall be located and installed in a manner to provide air gap separation between existing potable water pipelines and pipeline being tested.

D. Length of Test Section

The maximum length of test section for pipe of 12 inches or smaller in diameter shall be 3,500 feet; for pipe larger than 12 inches, 1 mile. Test bulkheads shall be provided where the distance between valves exceeds these limits.

E. Requirements Prior to Testing

1. Backfill: The pipe trench shall be backfilled with a minimum of 2½ feet of material.

2. Concrete Anchor and Thrust Blocks: All concrete anchor blocks shall be allowed to cure a sufficient time to develop the designed minimum strength before testing.

3. Mortar Lining: Steel pipelines shall not be tested before the mortar lining and coating on all of the pipe lengths in the line have attained an age of 14 days. Cement-mortar lined pipe shall not be filled with water until a minimum period of eight hours has elapsed after the last joint in any section has been made.

4. Flushing: All pipelines shall be flushed prior to hydrostatic testing and disinfection. Flushing should be performed via the District Flush-out assemblies constructed in accord with the District Standard Drawings. Refer to W-12, W-13 and W-14. Velocities should be sufficient to achieve a minimum of 2 fps velocity in the pipeline. Refer to the table herein below in Section F., 1. *Filling / Flushing Rate*.

F. Field Test Procedure

1. Filling / Flushing Rate: The pipeline shall be filled at a rate such that the average velocity of flow is no greater than 2 fps. At no time shall the maximum velocity of flow exceed 2 fps. The following table gives filling rates to provide 2 fps velocity for various pipe diameters.

FILLING/FLUSHING RATES FOR 2 FPS VELOCITY

Nominal Pipe Size (Inches)	Filling Rates to achieve velocity of 2 fps (gpm)
4	80
6	180
8	320
10	490
12	700
16	1,250
18	1,580
20	1,960
24	2,820
30	4,400
36	6,340
42	8,640
48	11,280
54	15,350
60	17,620
66	21,320

Note: This table is also useful for determining the minimum flows required to achieve adequate flushing. Refer to Section E., 4. *Flushing*, herein above.

2. Air Removal: All air should be purged from the pipeline before checking for leaks or performing pressure tests on the system. To accomplish this, if air valves or hydrants or other outlets are not available at high points, taps shall be made to expel the air, and these taps shall be tightly plugged after testing.

3. Pressurization: After the pipeline has been filled and allowed to sit a minimum of 48 hours (72 hours for mortar-lined pipelines), the pressure in the pipeline shall then be pumped up to the specified test pressure. If a large quantity of water is required to increase the pressure during testing, entrapped air, leakage at joints, or a broken pipe may be suspected. TESTS SHOULD BE DISCONTINUED until the source of trouble is identified and corrected.

4. Field Test Pressure: Unless otherwise specified, the pipeline shall be subjected to a field hydrostatic pressure at 50 psi in excess of the class rating of the pipe being tested.

G. Allowable Leakage

1. When the test pressure has been reached, pumping shall be discontinued until the pressure in the line has dropped 5 psi, at which time the pressure shall again be pumped up to the specified test pressure. This procedure shall be repeated until four hours have elapsed from the time the specified test pressure was first applied. At the end of the four-hour period, the pressure shall be pumped up to the test pressure for the last time.

2. The leakage shall be considered as the total amount of water pumped into the pipeline during the four-hour period, including the amount required in reaching the test pressure for the final time. Leakage shall not exceed the rate of 30 gallons per inch of diameter per mile of pipe per 24 hours for Class 200 pipe.

3. The following table indicates the leakage allowance for various sizes of pipe for Class 200 pipe and is equal to the number of gallons per the four-hour test per 1,000 feet of pipe being testing:

LEAKAGE ALLOWANCES				
Pipe Size (Inches)	Class 150 Pipe Test Pressure (psi)	Class 150 Pipe Allowable Leakage (Gallons per four hours per 1,000 feet of pipe)	Class 200 Pipe Test Pressure (psi)	Class 200 Pipe Allowable Leakage (Gallons per four hours per 1,000 feet of pipe)
4	200	0.38	250	0.43
6	200	0.57	250	0.64
8	200	0.76	250	0.85
10	200	0.96	250	1.07
12	200	1.15	250	1.28
16	200	1.53	250	1.71
18	200	1.72	250	1.92
24	200	2.29	250	2.56
30	200	2.87	250	3.20
36	200	3.44	250	3.85
42	200	4.01	250	4.49
48	200	4.59	250	5.13
54	200	5.16	250	5.77
60	200	5.73	250	6.41
66	200	6.31	250	7.05

4. PVC Force Mains and Pressure Pipelines

   a. The required test pressure shall be maintained for the following specified durations by restoring it whenever it falls by an amount of 5 psi: pipe of 18 inches in diameter and smaller, 4 hours; over 18 inches to 36 inches in diameter, 8 hours; and over 36 inches in diameter, 24 hours.

   b. One to three days shall be allowed for the filled pipeline to soak and to release entrapped air. The test pressure shall be applied with a positive displacement pump. A snubber and dampener shall be provided between the pump and the pipeline to reduce instantaneous pressure pulses to 10% of the specified test pressure. Water shall be drawn from containers in which the volume of water can be readily measured or through a positive displacement meter. The amount of water used to maintain the test pressure during the test period shall be considered the leakage. The allowable leakage shall be determined by the following formula:

$$L = \frac{ND(P)^{1/2}}{7400}$$

where	L is	the allowable leakage in gallons per hour
	N is	the number of rubber-gasketed pipe joints in the test section
	D is	the inside pipe test diameter in inches
	P is	the pipe test pressure (psig), which is defined as the average of the highest and lowest test pressures in the pipe section being tested.

   c. Note the allowable leakage rate for pipeline sections with flanged, welded, and / or grooved-end joints shall be zero.

H. Repetition of Test

If the actual leakage exceeds the allowable, the faulty work shall be located and corrected and the test repeated. The work shall be restored, and all damage resulting from leaks repaired. All visible leakage shall be eliminated.

I. Bulkhead and Test Facility Removal

After a satisfactory test, water shall be drained, test bulkheads and other test facilities removed, and pipe coatings restored.

END OF SECTION

SECTION 15043: LEAKAGE & INFILTRATION TESTING OF NON-PRESSURE PIPELINES

PART - 1 GENERAL

A. Description

This section describes the requirements and procedures for leakage and infiltration testing of gravity sewer systems, in accordance with ANSI/ASTM C828, Low Pressure Air Test of Vitrified Clay Pipelines.

B. Related Work Specified Elsewhere

1. PVC Lined Reinforced Concrete Pipe: Section 02705.

2. Hydrostatic Testing of Pressure Pipelines: Section 15042.

3. Vitrified Clay Pipe: Section 15059

C. Testing

1. General: All tests shall be made in the presence of the District Representative.

2. Leakage: Each section of sewer between two successive manholes shall be tested for leakage and the leakage test shall be made on all sections of sewer.

3. Infiltration: The infiltration test shall be made where excessive groundwater is encountered.

4. Retesting: Even though a section may have previously passed the leakage or infiltration test, each section of sewer shall be tested subsequent to the last backfill compacting operation if, in the opinion of the District Representative, heavy compaction equipment or any of the operations of the Contractor or others may have damaged or affected the structural integrity or watertightness of the pipe, structure, and appurtenances.

5. Other Utilities: Official District tests will not be made until after all the other utilities have been installed and their trenches are compacted. A memorandum from the geotechnical consultant referencing all test results shall be turned in to the District representative.

6 Excessive Leakage or Infiltration: If the leakage or infiltration rate is greater than the amount specified, the pipe joints shall be repaired or, if necessary, the pipe shall be removed and relaid by the Contractor.

7. Acceptance: The sewer will not be accepted until the leakage or infiltration rate, as determined by test, is less than the maximum allowable.

8. Sewer Laterals: When sewer laterals are added after the sewer main has been constructed by connecting to a previously installed wye fitting or to a newly cut-in wye-branch fitting, the new sewer lateral shall be plugged at the sewer main by use of a test plug and air tested to the satisfaction of the District Representative.

PART 2 - MATERIALS

The Contractor shall furnish all equipment and materials required for testing.

PART 3 - EXECUTION

A Air Test for VCP Gravity Sewers

1. Test Section: Each section of sewer between two successive manholes shall be tested by plugging all pipe outlets with suitable test plugs. All test plugs shall be secured in place to prevent movement or slippage.

2. Addition of Air: Air shall be slowly added until the internal pressure is raised to 4.0 pounds per square inch gage (psig). The compressor used to add air to the pipe shall have a blowoff valve set at 5 psig to ensure that at no time the internal pressure in the pipe exceeds 5 psig.

3. Internal Pressure: The internal pressure of 4 psig shall be maintained for at least two minutes to allow the air temperature to stabilize, after which the air supply shall be disconnected and the pressure allowed to decrease to 3.5 psig.

4. Minimum Time for Allowable Pressure Drop: The time in seconds that is required for the internal air pressure to drop from 3.5 psig to 2.5 psig shall be measured and the results compared with the minimum permissible pressure holding times indicated in the following tables.

5. Retest: If the pressure drop from 3.5 psig to 2.5 psig occurs in less time than specified, the pipe shall be repaired and, if necessary, replaced and relaid until the joints and pipe shall hold satisfactorily under this test.

AIR TEST TABLES

(courtesy of NATIONAL CLAY PIPE INSTITUTE)

MINIMUM HOLDING TIME IN SECONDS
REQUIRED FOR PRESSURE TO DROP
FROM 3½ TO 2½ PSIG

(FOR USE WHEN TESTING ONE DIAMETER ONLY)

LENGTH	PIPE DIAMETER (FOR USE WHEN TESTING ONE DIAMETER ONLY)													
	4	6	8	10	12	15	18	21	24	27	30	33	36	39
25	4	10	18	28	40	62	89	121	158	200	248	299	356	418
50	9	20	35	55	79	124	178	243	317	401	495	599	713	837
75	13	30	53	83	119	186	267	364	475	601	743	898	1020	1105
100	18	40	70	110	158	248	356	485	634	765	851	935	1020	1105
125	22	50	88	138	198	309	446	595	680	765	851	935	1020	1105
150	26	59	106	165	238	371	510	595	680	765	851	935	1020	1105
175	31	69	123	193	277	425	510	595	680	765	851	935	1020	1105
200	35	79	141	220	317	425	510	595	680	765	851	935	1020	1105
225	40	89	158	248	340	425	510	595	680	765	851	935	1020	1105
250	44	99	176	275	340	425	510	595	680	765	851	935	1020	1105
275	48	109	194	283	340	425	510	595	680	765	851	935	1020	1105
300	53	119	211	283	340	425	510	595	680	765	851	935	1020	1105
350	62	139	227	283	340	425	510	595	680	765	851	935	1020	1105
400	70	158	227	283	340	425	510	595	680	765	851	935	1020	1105
450	79	170	227	283	340	425	510	595	680	765	851	935	1020	1105
500	88	170	227	283	340	425	510	595	680	765	851	935	1020	1105
550	97	170	227	283	340	425	510	595	680	765	851	935	1020	1105
600	104	170	227	283	340	425	510	595	680	765	851	935	1020	1105
650	113	170	227	283	340	425	510	595	680	765	851	935	1020	1105

LENGTH OF 6" DIAMETER MAIN LINE IN FEET

LENGTH OF 4" LATERAL	25	50	75	100	125	150	175	200	225	250	275	300	400	500
25	14	24	34	44	54	64	74	84	94	103	113	123	163	168
50	19	29	39	48	58	68	78	88	98	108	118	128	166	167
75	23	33	43	53	63	73	83	92	102	112	122	132	164	165
100	28	37	47	57	67	77	87	97	107	117	127	136	162	163
125	32	42	52	62	72	81	91	101	111	121	131	141	160	162
150	36	46	56	66	76	86	96	106	116	125	135	145	159	161
175	41	51	61	70	80	90	100	110	120	130	140	150	157	159
200	45	55	65	75	85	95	105	114	124	134	144	153	156	158
225	50	59	69	79	89	99	109	119	129	139	149	151	154	157
250	54	64	74	84	94	103	113	123	133	143	149	150	153	156
275	58	68	78	88	98	108	118	128	138	146	147	149	152	155
300	63	73	83	92	102	112	122	132	142	145	146	147	151	154
350	72	81	91	101	111	121	131	140	141	143	144	145	149	152
400	80	90	100	110	120	130	136	138	139	141	142	143	147	150
450	89	99	109	119	129	132	134	136	138	139	141	142	145	149
500	98	108	118	126	129	131	133	135	136	138	139	140	144	147

MINIMUM HOLDING TIME IN SECONDS
REQUIRED FOR PRESSURE TO DROP
FROM 3½ TO 2½ PSIG

LENGTH OF 8" DIAMETER MAIN LINE IN FEET

LENGTH OF 4" LATERAL	25	50	75	100	125	150	175	200	225	250	275	300	400	500
25	22	40	57	75	92	110	128	145	163	180	198	216	223	224
50	26	44	62	79	97	114	132	150	167	185	202	218	220	221
75	31	48	66	84	101	119	136	154	172	189	207	214	217	219
100	35	53	70	88	106	123	141	158	176	194	209	211	214	216
125	40	57	75	92	110	128	145	163	180	198	206	207	211	214
150	44	62	79	97	114	132	150	167	185	201	202	204	209	212
175	48	66	84	101	119	136	154	172	189	197	199	201	206	210
200	53	70	88	106	123	141	158	176	192	194	197	199	204	208
225	57	75	92	110	128	145	163	180	189	192	194	196	202	206
250	62	79	97	114	132	150	167	183	186	189	191	193	200	204
275	66	84	101	119	136	154	172	181	184	187	189	191	198	202
300	70	88	106	123	141	158	174	178	181	184	187	189	196	200
350	79	97	114	132	150	166	170	174	177	180	183	185	192	197
400	88	106	123	141	157	162	166	170	174	176	179	181	189	194
450	97	114	132	148	154	159	163	167	170	173	176	178	186	191
500	106	123	140	146	151	156	160	164	167	170	173	175	183	189

LENGTH OF 8" DIAMETER MAIN LINE IN FEET

LENGTH OF 6" LATERAL	25	50	75	100	125	150	175	200	225	250	275	300	400	500
25	28	45	63	80	98	116	133	151	168	186	204	221	224	225
50	37	55	73	90	108	126	143	161	178	196	214	220	222	223
75	47	65	83	100	118	135	153	171	188	206	217	217	220	221
100	57	75	93	110	128	145	163	181	198	214	214	215	218	220
125	67	85	102	120	138	155	173	190	208	211	212	213	216	218
150	77	95	112	130	148	165	182	200	207	209	210	211	214	217
175	87	105	122	140	157	175	192	204	206	207	208	209	213	215
200	97	114	132	150	167	185	201	202	204	205	206	207	211	214
225	107	124	142	160	177	195	199	201	203	204	205	206	210	213
250	117	134	152	169	187	195	198	199	201	202	203	204	209	212
275	127	144	162	179	192	194	196	198	200	201	202	204	208	210
300	136	154	172	187	190	192	195	196	198	200	201	202	207	209
350	156	174	181	185	187	190	193	194	196	198	199	200	205	208
400	173	178	181	184	186	189	191	192	194	196	197	198	203	206
450	173	177	180	183	185	187	189	190	192	194	195	196	201	204
500	173	177	180	182	184	186	188	189	191	192	193	194	200	203

MINIMUM HOLDING TIME IN SECONDS
REQUIRED FOR PRESSURE TO DROP
FROM 3½ TO 2½ PSIG

LENGTH OF 10" DIAMETER MAIN LINE IN FEET

LENGTH OF 4" LATERAL	25	50	75	100	125	150	175	200	225	250	275	300	400	500
25	32	59	87	114	142	169	197	224	252	277	277	278	279	280
50	36	64	91	119	146	174	201	229	256	271	272	273	275	277
75	41	68	96	123	151	178	206	233	261	265	267	268	272	274
100	45	73	100	128	155	183	210	238	258	260	262	264	268	271
125	50	77	105	132	160	187	214	242	253	255	257	259	264	268
150	54	81	109	136	164	191	219	244	248	251	253	255	261	265
175	58	86	113	141	168	196	223	239	243	246	249	251	258	262
200	63	90	118	145	173	200	228	235	239	242	245	248	255	260
225	67	95	122	150	177	205	226	231	235	239	242	244	252	257
250	72	99	127	154	182	209	222	227	231	235	238	241	249	255
275	76	103	131	158	186	211	218	223	228	231	235	238	247	253
300	80	108	135	163	190	208	214	220	224	228	232	235	244	250
350	89	117	144	172	194	201	208	213	218	222	226	229	239	246
400	98	125	153	179	188	196	202	208	213	217	221	224	235	242
450	107	134	162	174	183	191	197	203	208	212	216	220	230	238
500	116	143	160	170	179	186	193	198	203	208	212	215	226	235

LENGTH OF 10" DIAMETER MAIN LINE IN FEET

LENGTH OF 6" LATERAL	25	50	75	100	125	150	175	200	225	250	275	300	400	500
25	37	65	92	120	147	175	202	230	257	277	278	278	279	280
50	47	75	102	130	157	185	212	240	267	271	272	273	276	277
75	57	85	112	140	167	195	222	250	265	266	267	269	272	274
100	67	95	122	150	177	205	232	257	260	262	263	265	269	271
125	77	105	132	160	187	215	242	253	255	257	259	261	266	269
150	87	114	142	169	197	224	245	248	251	254	256	257	263	266
175	97	124	152	179	207	234	241	245	248	250	252	254	260	264
200	107	134	162	189	217	233	237	241	244	247	249	251	258	262
225	117	144	172	199	225	230	234	238	241	244	246	248	255	260
250	127	154	182	209	222	227	231	235	238	241	243	246	253	258
275	136	164	191	213	219	224	229	232	236	238	241	243	251	256
300	146	174	201	211	217	222	226	230	233	236	239	241	249	254
350	166	192	200	207	212	217	222	226	229	232	235	237	245	250
400	181	190	197	203	209	214	218	222	225	228	231	233	241	247
450	180	188	195	201	206	211	215	218	222	225	227	230	238	244
500	179	186	193	198	203	208	212	215	219	222	224	227	235	241

MINIMUM HOLDING TIME IN SECONDS
REQUIRED FOR PRESSURE TO DROP
FROM 3½ TO 2½ PSIG

LENGTH OF 12" DIAMETER MAIN LINE IN FEET

LENGTH OF 4" LATERAL	25	50	75	100	125	150	175	200	225	250	275	300	400	500
25	44	84	123	163	202	242	282	321	332	333	334	334	336	336
50	48	88	128	167	207	246	296	323	324	326	327	328	331	333
75	53	92	132	172	211	251	290	316	317	319	321	323	327	339
100	57	97	136	176	216	255	295	308	311	313	316	317	323	326
125	62	101	141	180	220	260	297	301	304	308	310	312	319	323
150	66	106	145	185	224	264	290	295	299	302	305	308	315	319
175	70	110	150	189	229	268	283	289	293	297	300	303	311	316
200	75	114	154	194	233	271	277	283	288	292	296	299	308	313
225	79	119	158	198	238	265	272	278	283	288	291	295	304	310
250	84	123	163	202	242	259	267	273	278	283	287	291	301	308
275	88	128	167	207	244	254	262	269	274	279	283	287	298	305
300	92	132	172	211	239	249	257	264	270	275	279	283	295	302
350	101	141	180	218	231	241	249	256	262	268	272	276	289	297
400	110	150	189	210	223	233	242	249	255	261	266	270	283	292
450	119	158	189	204	216	227	235	243	249	255	260	264	278	288
500	128	166	184	198	210	221	229	237	243	249	254	259	273	283

LENGTH OF 12" DIAMETER MAIN LINE IN FEET

LENGTH OF 6" LATERAL	25	50	75	100	125	150	175	200	225	250	275	300	400	500
25	50	89	129	168	208	248	287	327	331	332	333	333	335	336
50	59	99	139	178	218	257	297	321	323	325	326	327	330	332
75	69	109	149	188	228	267	307	314	316	318	320	321	326	328
100	79	119	158	198	238	277	302	306	309	312	314	316	321	325
125	89	129	168	208	248	287	295	300	303	306	309	311	317	321
150	99	139	178	218	257	284	289	294	298	301	304	306	314	318
175	109	149	188	228	267	278	284	289	293	296	299	302	310	315
200	119	158	198	238	265	272	278	284	288	292	295	298	306	312
225	129	168	208	248	260	268	274	279	284	288	291	294	303	309
250	139	178	218	246	255	263	269	275	280	284	287	290	300	306
275	149	188	228	242	251	259	266	271	276	280	284	287	297	304
300	158	198	227	238	248	255	262	268	272	277	281	284	294	301
350	178	208	221	232	241	249	255	261	266	271	274	278	289	296
400	189	204	217	227	236	243	250	256	261	265	269	273	284	292
450	187	201	213	223	231	239	245	251	256	260	264	268	279	288
500	186	199	210	219	227	234	240	246	251	256	260	263	275	284

B. Air Test for PVC Gravity Sewers

1. Test Section: Each section of sewer between two successive manholes shall be tested by plugging all pipe outlets with suitable test plugs. All test plugs shall be secured in place to prevent movement or slippage.

2. Addition of Air: Air shall be slowly added until the internal pressure is raised to 4.0 pounds per square inch gage (psig). The compressor used to add air to the pipe shall have a blowoff valve set at 5 psig to ensure that at no time the internal pressure in the pipe exceeds 5 psig.

3. Internal Pressure: The internal pressure of 4 psig shall be maintained for at least two minutes to allow the air temperature to stabilize, after which the air supply shall be disconnected and the pressure allowed to decrease to 3.5 psig.

4. Minimum Duration for Allowable Pressure Drop: The time in minutes that is required for the internal air pressure to drop from 3.5 psig to 3.0 psig shall be measured. The results shall not be less than the minimum permissible duration for air test pressure drop shown in Table I.

TABLE I

MININUM DURATION FOR AIR
TEST PRESSURE DROP

Pipe Size (Inches)	Time (Minutes)
4	2½
6	4
8	5
10	6½
12	7½
15	9½

5. Retest: If the pressure drop from 3.5 psig to 3.0 psig occurs in less time than the above-tabulated or calculated values, the pipe shall be overhauled and, if necessary, replaced and relaid until the joints and pipe shall hold satisfactorily under this test.

C. Infiltration Test

1. Preparation of Test Section: The end of the sewer at the upper structure shall be closed to prevent the entrance of water, and pumping of groundwater shall be discontinued for at least three days, after which the section shall be tested for infiltration.

2. Allowable Infiltration Rate: The infiltration shall not exceed 0.025 gpm per inch of diameter per 1,000 feet of main line sewer being tested, not including the length of laterals entering that section.

3. Excessive Infiltration: Where infiltration in excess of the allowable amount is discovered before completion and acceptance of the sewer, the sewer shall be immediately uncovered and the amount of the infiltration reduced to a quality within the specified amount of infiltration, before the sewer is accepted.

4. Individual Leaks: Even if the infiltration is less than the allowable amount, any individual leaks that may be observed shall be stopped as ordered by the District Representative.

5. Completion of Tests: All tests must be completed before the street or trench is resurfaced, unless otherwise directed by the District Representative.

D. Deflection Test

1. General: All flexible and semi-rigid main line pipe shall be tested for deflection, joint displacement, or other obstruction by passing a rigid mandrel through the pipe by hand, not less than 30 days after completion of the trench backfill, but prior to permanent resurfacing. The mandrel shall be a full circle, solid cylinder, or a cylinder, approved by the DISTRICT as to design and manufacture. The circular cross section of the mandrel shall have a diameter of at least 95 percent of the specified average inside pipe diameter of the pipe.

E. Manhole Test

1. General: Water tightness of manholes shall be tested in connection with tests of sanitary sewers, or at the time the manhole is completed and backfilled.

2. Plugs: All manhole inlets and outlets shall be plugged with approved stoppers or plugs.

3. Fill Level: The manhole shall be filled with water to 2-inches below the bottom of the tapered cone section, with a minimum depth of 4 feet and a maximum depth of 20 feet. The water shall stand in the manhole for a minimum of one hour to allow the manhole material to reach maximum absorption. Before the test is begun, the manhole shall be refilled to the original depth as needed.

4. Test Requirements: The drop in water surface shall be recorded after a period of from 15 minutes to one hour. The time of the test shall be determined by the District Representative and may be varied to fit the various field conditions. The maximum Allowable drop in the water surface shall be 1/2 inch for each 15-minute period of testing.

5. Visible Leaks: Even though the leakage is less than the specified amount, the Contractor shall stop any leaks that may be observed, to the satisfaction of the District Representative.

END OF SECTION

SECTION 15051: INSTALLATION OF PRESSURE PIPELINES

PART 1 - GENERAL

A. Description

This section describes the installation of: pressure pipelines fabricated of polyvinyl chloride, ductile iron, and welded steel, including pipeline closures and connections and pipeline encasement.

B. Related Work Described Elsewhere

1. Trenching, Backfilling, and Compacting: 02223.
2. Concrete: 03300.
3. Painting and Coating: 09900.
4. Chlorination of Water Mains for Disinfection: 15041
5. Hydrostatic Testing of Pressure Pipelines: 15042.
6. Air-Release and Vacuum-Release Valves: 15089
7. Reclaimed Water Facilities Identification: 15151
8. Cathodic Protection and Joint Bonding: 16640

C. Submittals (for Contracts between the District and Contractor)

1. Shop drawings shall be submitted in accord with the General Provisions and the following.
2. An installation schedule (tabulated layout) shall be submitted which includes:
    a. Order of installation and closures.
    b. Pipe centerline station and elevation at each change of grade and alignment.
    c. Elements, curves, and bends, both in horizontal and vertical alignment including elements of the resultant true angular deflections in cases of combined curvature.
    d. The location, length, size, design designation, and number designation of each pipe section and pipe special.
    e. Locations of junction structures.
3. Welder qualification certificates shall be submitted.

PART 2 - MATERIALS

A. Installation Material

Refer to the various referenced sections on pipe by type for material requirements.

B. Piping Schedule

Unless noted otherwise on the plans or in the specifications, pipe shall be furnished in accord with the following materials schedule.

DIAMETER	DOMESTIC WATER	RECLAIMED WATER	SEWER FORCE MAIN
2-inch and smaller	Copper	Copper with purple tape wrap	--
4-inch through 12-inch	PVC C900 DIP	Purple PVC C900 DIP with purple PE tubing	PVC C900, Class 200 Fusion Welded HDPE
14-inch through 24-inch	PVC C905 DIP CML&C Steel	Purple PVC C905 DIP with purple PE tubing CML&C steel with purple PE tubing	PVC C905, Class 235 Fusion Welded HDPE
Above 24-inch and through 36-inch	PVC C-905 DIP CML&C Steel	DIP with purple PE tubing CML&C steel with fully-welded joints and purple warning tape	PVC C905, Class 165 CCFRPM (Hobas) Pressure Pipe
42-inch and larger	DIP CML&C Steel	DIP with purple PE tubing CML&C steel with fully-welded joints and purple warning tape	Special design

Notes: DIP - Ductile iron pipe per Section 15056.
Copper - Per Section 15057.
PVC C900 - PVC pressure pipe per Section 15064.
CML&C - Cement mortar lined and coated steel pipe per Section 15076. Fully welded joints for diameters ≥24".

PART 3 - EXECUTION

A. Delivery and Temporary Storage of Pipe at Site

1. Onsite Storage Limitation: Onsite pipe storage shall be limited to a maximum of one week, unless exception is approved by District.

2. Care of Pipe: Care shall be taken to avoid cracking of the cement mortar coating and/or lining on steel pipe. If necessary, plastic sheet caps shall be used to close pipe ends and keep coatings and linings moist.

B. Handling of Pipe

1. Moving Pipe: Pipes shall be lifted with handling beams or wide belt slings as recommended by the pipe manufacturer. Cable slings shall not be used. Pipe shall be handled in a manner to avoid damage to the pipe. Pipe shall not be dropped or dumped from trucks or into trenches under any circumstances.

2. Internal Pipe Braces: Internal braces placed in steel pipes shall be maintained until backfilling and compaction are completed.

3. Pipe Caps: Plastic caps placed over the ends of steel pipe shall not be removed until the pipe is ready to be placed in the trench. Plastic caps may be opened temporarily to spray water inside the pipe for moisture control.

4. Inspection of Pipe: The pipe and accessories shall be inspected for defects prior to lowering into the trench. Any defective, damaged or unsound pipe shall be repaired or replaced. All foreign matter or dirt shall be removed from the interior of the pipe before lowering into position in the trench.

C. Placement of Pipe in Trench

1. General: Dewatering, excavation, shoring, sheeting, bracing, backfilling material placement, material compaction, compaction testing, and pipe laying requirements and limitations shall be in accord with Section 02223: Trenching, Backfilling and Compacting.

2. Sanitation of Pipe Interior: During laying operations, tools, clothing, or other materials shall not be placed in the pipe.

3. Prevention of Entry into Pipe: When pipe laying is not in progress, including lunch-hour, the ends of the pipe shall be closed using plugs constructed in a manner to prevent entry by any debris, animal or vermin.

4. Laying Pipe on Grades over 5 Percent: Pipes shall be laid uphill with the bell or collared joints on the uphill end of each pipe length, whenever the grade exceeds five (5) percent.

5. Pipe Base Thickness: Pipe base thickness shall be as specified in Section 02223, Trenching, Backfilling, and Compacting.

6. Depressions at Joints and Pipe Sling Points: Depressions shall be dug into pipe base material to accommodate the pipe bell and external joint filler form ("diapers"), and to permit removal of the pipe handling slings.

7. Placement of Pipe on Pipe Base: Pipe shall be lowered onto the bedding and installed to line and grade its full length on firm bearing except at the bell and at sling depressions. Unless specified otherwise, the tolerance on grade shall be ¼-inch; the tolerance on line shall be 1-inch. Grade shall be measured along the pipe invert.

8. Pipe Installation: Pipe shall be installed without springing, forcing, or stressing the pipe or any adjacent connecting valves or equipment. Precautions shall be taken to prevent pipe from being displaced by water entering trench. Damaged or displaced pipe shall be replaced or returned to specified condition and grade.

9. Trench Curvature and Pipe Deflection: The radius of curvature of the trench shall be determined by the maximum length of pipe section that can be used without exceeding the allowable deflection at each pipe joint and without causing deviation from the District's trench width requirements. Refer to the various referenced sections on pipe by type for allowable deflection. The deflection at any flexible joint shall not exceed that prescribed by the manufacturer of the pipe. The manufacturer's printed installation guide outlining the radius of curvature that can be negotiated with pipe sections of various lengths shall be followed.

10. Equipment for Installation of Pipe: Proper implements, tools, and facilities as recommended by the pipe manufacturer's standard printed installation instructions shall be provided and used by the Contractor for safe and efficient execution of the work. All pipe, fittings, valves, and accessories shall be carefully lowered into the trench using suitable equipment in such a manner as to prevent damage to pipe and fittings. Under no circumstances shall pipe or accessories be dropped or dumped into the trench.

11. Cutting and Machining Pipe: Cutting and machining of the pipe shall be accomplished in accord with the pipe manufacturer's standard procedures for this operation. Pipe shall not be cut with a cold chisel, standard iron pipe cutter, nor any other method that may fracture the pipe or produce ragged, uneven edges.

D. Assembling Rubber-Gasketed Joints

1. Cleaning Ends of Pipe: The ends of the pipe to be joined shall be cleaned of foreign material.

2. Lubrication: After placing pipe in trench, a nontoxic water soluble vegetable soap solution shall be applied to the inside of the bell of the pipe in the trench and to the rubber gasket and spigot of the pipe to be installed. The rubber gasket shall be stretched into the groove in the bell-end of the pipe and distributed uniformly around the circumference.

3. Joint Assembly: Without tilting the pipe to be installed, the spigot shall be inserted into the bell of the pipe. Come-a-longs or pipe jacks shall be used to drive spigot end into the bell until properly seated. The joint recess recommended by pipe manufacturer for made-up joints shall be maintained. Where deflections at joints are required for curved alignment, the manufacturer's recommended allowable joint opening on one side shall not be exceeded. A feeler gauge shall be used to verify proper placement of each gasket.

E. Flanged Connections

1. Bolthole Alignment: Pipe shall be set with flange boltholes straddling the pipe horizontal and vertical centerlines.

2. Nuts and Bolts: Nuts and bolts shall be lubricated with anti-seize prior to installation.

3. Flange Wrapping: Flanges which connect with buried valves or other equipment shall be wrapped with sheet polyethylene film or wax tape material as specified for the valves and equipment. The wrap shall be extended over the flanges and bolts and secured around the adjacent pipe circumference with tape.

F. Installation of Bends, Tees, and Reducers

Fittings shall be installed utilizing standard installation procedures. Fittings shall be lowered into trench by means of rope, cable, chain, or other acceptable means without damage to the fittings. Cable, rope, or other devices used for lowering fitting into trench, shall be attached around exterior of fitting for handling. Under no circumstances shall the cable, rope or other device be attached through the fittings interior for handling. Fittings shall be carefully connected to pipe or other facility, and joint shall be checked to insure a sound and proper joint.

G. Installing Threaded Piping

Threaded piping shall be reamed, deburred, and cleaned before making up joints. Thread lubricant approved by the District's representative shall be applied to threaded pipe ends before installing fittings, couplings, unions, or joints.

H. Completion of Interior Joints for Mortar-Lined Pipes 20-Inches in Diameter and Smaller

1. Preparation: A tight-fitting swab or squeegee shall be inserted in the joint end of the pipe to be joined.

2. Application of Cement Mortar: When ready to insert the spigot, the face of the cement mortar lining at the bell shall be coated with a sufficient amount of stiff cement mortar to fill the space between adjacent mortar linings of the two pipes to be joined.

3. Removal of Excess Mortar: Immediately after joining the pipes, the swab or squeegee shall be drawn through the pipe to remove all excess mortar and expel it from the open pipe end.

I. Completion of Interior Joints for Mortar-Lined Pipes 24-Inches in Diameter and Larger

1. Backfill Requirement: The trench shall be backfilled, compacted, and meet compaction requirements before applying mortar at joints.

2. Cleaning and Application of Cement Mortar: Working inside the pipe, foreign substances which adhere to the steel joint rings shall be removed, the surface cleaned, and stiff cement mortar packed into each joint. The mortar shall be finished with a steel trowel to match the lining in the adjoining pipes.

3. Removal of Excess Mortar: Excess mortar and other construction debris shall be removed from the pipe interior.

J. Pipeline Closure Assemblies

1. General: Pipeline closure assemblies shall be employed to unite sections of pipeline laid from opposite directions; to adjust the field length of the pipeline to meet structures, other pipelines, and points established by design stations; and to close areas left open to accommodate temporary test bulkheads for hydrostatic testing. Either follower ring design or butt strap design shall be used. Follower ring closures shall be installed as recommended by the pipe manufacturer.

2. Butt Straps: As shown in the District Standard Drawings, shaped steel butt straps a minimum of 10-inches in width shall be centered over the ends of the pipe sections they are to join. On pipes 39 inches in diameter and smaller, butt straps shall be welded to the outside of the pipes with complete circumferential fillet welds equal in size to the thinnest part being joined. The details shown on the drawings shall be referred to when joining larger pipes.

3. General Requirements for Cement Mortar Lining for Closure Assemblies: Closure assemblies shall be cement-mortar lined to a mortar thickness at least equal to the adjoining standard pipe sections. The steel shall be cleaned with wire brushes and a cement and water wash coat applied prior to applying the cement mortar. Where more than a 4-inch joint strip of mortar is required, welded wire mesh reinforcement having a 2-inch by 4-inch pattern of No. 13 gage shall be placed over the exposed steel. The mesh shall be installed so that the wires on the 2-inch spacing run circumferentially around the pipe. The wires on the 4-inch spacing shall be crimped to support the mesh 3/8 inch from the metal surface. The interior mortar shall have a steel-trowled finish to match adjoining mortar lined pipe sections.

4. Lining Closure Assemblies: As shown in the District Standard Drawings, butt straps with 5-inch diameter hand holes shall be provided for lining of closure assemblies on pipelines 20-inches in diameter and smaller.

5. Mortar Coating Exterior Surfaces of Closure Assemblies: The exterior of closure assemblies shall be reinforced with wire mesh as described in Paragraph 3 above. The surface shall be coated with mortar, or a poured concrete encasement to cover all steel to a minimum thickness of 1½ inches. Exterior mortar shall be protected to retard drying while curing. Concrete shall be poured and vibrated on one side of the closure assembly only, until mortar is visible on the opposite side, after which the coating can be completed over the top of the assembly.

K. Welded Joints

1. Locations: Welded joints shall be provided where detailed on the plans and in every location where the operating pressure shall be greater than 150 psi.

2. Reference Standard: Welding shall be in accord with AWWA C206. Welder's qualification shall be in accord with Section IX of the ASME Boiler and Pressure Vessel Code. Current certifications shall be provided for all welders.

3. Sequence: Interior joints shall not be welded before backfilling, compaction, and compaction testing are successfully completed.

4. Joint Rings: Joint rings (butt-straps or weld collars) that are rusted or pitted where weld metal is to be deposited shall be cleaned by brushing or sand blasting.

5. Restrictions: Concrete or other coating adjacent to the joint rings shall not be heated.

6. Cleaning Requirements: Each layer of deposited weld metal shall be cleaned using a power-driven wire brush or ginder prior to depositing the next layer of weld metal.

L. Operations Incidental to Joint Completion

1. Hydrostatic Testing: Joint completion shall be planned to accommodate temporary test bulkheads for hydrostatic testing.

2. Bonding Pipe: Metallic jumper bonds or bars shall be installed on all metallic pipe, as shown on plans and as specified within Section 16640: Cathodic Protection and Joint Bonding.

M. Completion of Exterior Pipe Joint for Cement-Mortar Coated Pipe

Outside joint recess shall be filled with cement-mortar grout using a fabric form (joint diaper) placed around the joint and secured with steel straps. Grout shall be poured and rodded from one side only until it is visible on the opposite side. After approximately one hour, the joint shall be topped off with additional grout.

N. Thrust Restraint and Anchor Blocks

1. Location: Thrust restraint and anchor blocks shall be provided on all pressure pipelines, and shall be installed as shown on the plans and at all rubber gasketed fittings that are not otherwise restrained. Thrust restraint blocks or anchor blocks shall be installed at all valves, tees, crosses, ends of pipelines, and at all changes of direction of the pipeline greater than 10 degrees deflection either vertically or horizontally when joints are not otherwise restrained.

2. General Requirements: Thrust restraint and anchor blocks shall be of not less than 3,000 psi concrete (Class C); and shall provide a thrust bearing area to resist horizontal or downward thrust; and shall be of sufficient gross weight and area to give bearing against undisturbed vertical earth banks sufficient to absorb the thrust, allowing an earth bearing of 1500 pounds per square foot maximum.

3. Thrust Restraint not Called for on the Plans: Thrust restraint elements, where not called for on the plans, shall be sized for 150 percent of operating pipeline pressure or the pipeline test pressure, whichever is greater. Prior to construction, thrust and anchor block sizing shall be submitted to the District for approval.

4. Concrete Placement: Concrete shall be placed against wetted and undisturbed soil, and the exterior of the fitting shall be cleaned and wetted to provide a good bond with the concrete. The concrete interface with the fitting shall be an area of not less than the projected area of the fitting normal to the thrust resultant and centered on the resultant.

5. Accessibility to Joints and Fittings: Unless otherwise directed by the District, thrust restraint and anchor blocks shall be placed so that the pipe and fitting joints are accessible for repair. Placement shall include isolation of adjacent utilities and shall ensure that bearing is against undisturbed soil.

6. Harness and Tie-Rods: Metal harness or tie-rods and pipe clamps shall be used to prevent movement if shown on the plans or directed by the District. The rods and clamp harnessing arrangement shall be installed utilizing flanged harness hold-downs or lugged fittings and pipe with saddle clamps placed (where feasible and practical) to bear against the pipe bells. Saddle clamps around the barrel of the pipe, which depend on friction to prevent sliding of the clamp, are acceptable. However, restraints with pointed set-screws which bear into the pipe wall, are not acceptable and shall not be used. All surfaces of exposed and buried steel rods, reinforcing steel, bolts, clamps, and other metal work shall be coated prior to backfilling, and touched up after assembly as specified in Section 09900, Painting and Coating, System D-1, "Buried Metal Coating Systems".

7. In-line Valves: Reinforcing steel tiedown rods shall be used on all in-line valves. Refer to the District Standard Drawings for typical valve anchor and thrust restraint details. Exposed metal portions shall be coated with bitumastic material as specified in Section 09900, Painting and Coating, System D-1, "Buried Metal Coating Systems".

O. Blowoff Assemblies

1. General: In-line type or end-of-line type blowoff assemblies shall be installed in accord with the plans at locations noted, and at such additional locations as required by the District for removing water or sediment from the pipeline.

2. Location: The assembly shall be installed in a level section of pipe. The tap for blowoff in the line shall be no closer than 18 inches to a valve, coupling, joint, or fitting unless it is at the end of the main. No tap will be permitted in any machined section of asbestos cement pipe.

3. Restrictions: Blowoffs shall not be connected to any sewer, submerged in any stream, or installed in any manner that will potentially allow back siphoning into the distribution system.

P. Combination Air and Vacuum Release Valves

1. General: Air release valve assemblies and combination air and vacuum valves shall be installed at each point in the pipeline as shown on the drawings or as specified by the District, and in accord with Section 15089: Air and Vacuum-Release Valves.

2. Location: The tap for the air valves shall be made in a level section of pipe no closer than 18 inches to a bell, coupling, joint, or fitting. No tap shall be permitted in any machined section of asbestos cement pipe.

Q. Above-ground Piping Installation/Support

1. General: Installation of aboveground pipeline materials and appurtenances include requirements for buried pipeline materials and appurtenances as applicable.

2. Supports: All exposed pipe shall be adequately supported with devices of appropriate design. Where details are shown, the supports shall conform thereto and shall be placed as indicated; provided, that the support for all piping shall be complete and adequate as herein specified, whether or not supporting devices are specifically called for.

3. Grooved-End Pipe and Fittings: Grooved-end pipe and fittings shall be installed in accord with the coupling manufacturer's recommendations and the following:

   a. Loose scale, rust, oil, grease, and dirt shall be cleaned from the pipe or fitting groove. Lubricate the coupling gasket in accord with the manufacturer's recommendations.

   b. Coupling shall be tightened alternately and evenly until coupling halves are seated properly.

R. Cathodic Protection and Joint Bonding

All ferrous metal pipes and all pipes specified or shown on the plans to be cathodically protected shall be completed in accord with Section 16640: Cathodic Protection and Joint Bonding.

S. Warning and Locator Tape

Warning and locator tape shall be installed on all pipelines. The pipe identification shall be in accord with Section 15151.

T. Disinfection

All potable water pipelines shall be disinfected in accord with Section 15041, Chlorination of Water Mains for Disinfection.

U. Testing

All piping shall be hydrostatically pressure tested in accord with Section 15042, Hydrostatic Testing of Pressure Pipelines.

END OF SECTION

SECTION 15053: CARBON STEEL PIPE AND FITTINGS

PART 1 - GENERAL

A. Description

This section describes materials and installation of steel pipe and fittings. This pipe may serve general purposes such as for steel casing pipe, compressed air, and miscellaneous piping applications where Specification Section 15076 does not apply. This section applies to piping applications which do not exceed a maximum operating pressure of 300 psi.

B. Related Work Specified Elsewhere

1. Painting and Coating, Section 09900.
2. Installation of Pressure Pipelines, Section 15051.
3. Cement Mortar Lined and Coated Steel Pipe, Section 15076.

C. Submittals (for Contracts between the District and Contractor)

1. Shop drawings shall be submitted in accord with the General Provisions and the following.

2. Submit materials list showing material of pipe and fittings with ASTM reference and grade.

D. Measurement and Payment

1. Payment for the work in this section shall be in accord with the General Provisions and the following:

2. Payment shall be by the linear foot for each diameter and for each pipe strength designation measured horizontally over the pipe centerline, exclusive of the distance between the inside faces of junction or other structures.

E. Inspection

The District reserves the right to inspect materials, production, or testing of pipe at the manufacturer's plant.

PART 2 - MATERIALS

A. Pipe

Pipe shall be black carbon steel, conforming to ASTM A 53, Type E or S, Grade A or ASTM A 135, Grade A. Pipe 12-inches in diameter and smaller shall be Schedule 40 or 80, as shown on plans, per ANSI B36.10. Pipe larger than 12-inches in diameter shall be standard weight per ANSI B36.10. Design thickness of the pipe shall be schedule 40 at a minimum. Pipe shall conform to AWWA C200, AWWA M11, with a minimum wall thickness of 0.2500 inches and as specified herein.

B. Threaded Nipples

Threaded nipples shall be of the same material as the pipe. Threads shall conform to ANSI B2.1.

C. Fittings and Joints

1. 3-Inches in Diameter and Smaller: Fittings 3-inches in diameter and smaller shall be threaded forged steel fittings (ASTM A 105) conforming to ANSI B16.11, 3,000-pound CWP may be used.

2. Buried Fittings: Fittings for buried pipe larger than 3-inches in diameter shall be flanged or butt-welded, conforming to ANSI B16.9. Material shall conform to ASTM A 234, Grade WPB. Wall thickness shall be the same as the pipe.

3. Above Ground Fittings Larger than 3-Inches in Diameter: Fittings for above ground or exposed pipe larger than 3-inches in diameter shall be grooved end or flanged, conforming to ANSI B16.9. Material shall conform to ASTM A 234, Grade WPB. Wall thickness (except for grooved ends) shall be the same as the pipe. Grooved-end joints shall comply with AWWA C606. Smooth radius forged steel fittings are preferred in-lieu of fabricated steel fittings.

D. Unions

Unions shall be Class 300, malleable iron (ASTM A 47, Grade 35018) brass to iron seat, conforming to ANSI B16.39. Ends shall be threaded per ANSI B1.2.01.

E. Grooved-End Couplings

Grooved-end couplings shall be malleable iron, ASTM A 47, Grade 35018, or ductile iron, ASTM A 536, Grade 60-40-18. Bolts shall conform to ASTM A 183, 110,000-psi tensile strength. Gaskets shall be EPDM and shall conform to ASTM D 2000. Couplings shall be flexible type, square cut groove, per AWWA C606. Couplings shall be Victaulic Style 77, Gustin-Bacon Figure 100, or for contracts between District and Contractor, approved equal.

F. Thread Lubricant

Teflon thread lubricating compound or Teflon tape shall be used for threaded joints.

G. Pipe Lining and Coating

1. Cement Mortar Lining and Coating: Where indicated on the plans, buried and exposed pipe shall be cement-mortar lined and coated in the shop per AWWA C205, and as specified in Section 15076, Cement Mortar Lined and Coated Steel Pipe.

2. Buried Piping: Where indicated on the plans, buried pipe shall be factory lined and coated per Section 09900, Painting and Coating.

3. Exposed Piping: Piping located above ground or in vaults and structures shall be coated per Section 09900, Painting and Coating.

H. Flanges

1. General: Weld-neck flanges (conforming to ANSI B16.5) shall be provided for piping 3-inches in diameter and smaller to connect to flanged valves, fittings, or equipment. Slip-on or weld-neck flanges shall be provided for piping larger than 3-inches in diameter. Flanges shall match the connecting flanges on the adjacent fitting, valve, or piece of equipment. Flange material shall conform to ASTM A 105, A 181, or A 182. Flanges shall be flat face.

2. Pressure Class: The pressure class of flanges shall be determined based on the test pressures listed in the Special Provisions. For test pressures 200 psi and less, Class 150 flanges, ANSI B16.5 shall be used. For test pressures greater than 200 psi, Class 300 flanges, ANSI B16.5 shall be used.

I. Bolts and Nuts for Flanges

1. General: Bolts and nuts for flanges, shall be Type 316 stainless steel conforming to ASTM A 193 (Grade B8M) for bolts and ASTM A 194 (Grade 8M) for nuts.

2. Flange Insulation Kits: Bolts for flange insulation kits shall conform to ASTM A 193, Grade B7. Nuts shall conform to ASTM A 194, Grade 2H.

3. Washers: A washer shall be provided for each nut. Washers shall be of the same material as the nuts.

4. Dimensional Requirements: Dimensionally, bolts and nuts shall conform to the following ANSI Standards: Bolts-B18.2.1, Nuts-B18.2.2, Bolt Length-B16.5, Bolt and Nut threads-B1.1.

J. Gaskets for Flanges

Gaskets shall be composed of synthetic fiber with rubber binder and shall be fullface, 1/8-inch thick Garlock 3400, Anchor 441, or for contracts between District and Contractor, approved equal, conforming dimensionally to ANSI B16.21. Ring gaskets extending to the inner edge of flange bolts may be used where a raised face flange is present.

K. Outlets

1. Outlets 2-Inches in Diameter and Smaller: Outlets which are 2-inches in diameter and smaller shall be made by welding on an extra-heavy steel weld-o-let™ threaded coupling. Refer to the IRWD Standard Drawing details for water service connections to steel pipe.

2. Outlets Larger than 2-Inches in Diameter: For outlets larger than 2-inches in diameter, flanged tees with flanged nozzle outlets shall be used. Tee fittings shall be fabricated in accord with the applicable portions of the latest revision of the AWWA Manual M11, "Steel Pipe – A Guide for Design and Installation".

Smooth radius forged steel fittings are preferred in-lieu of fabricated steel fittings.

By special permission from the District when the duration of shutdown is critical, outlets for connection to existing steel water pipelines may be made using fabricated steel nozzles. In such cases nozzle outlets shall be fabricated in accord with the applicable portions of the latest revision of the AWWA Manual M11, "Steel Pipe – A Guide for Design and Installation". In all cases, a full-wrap reinforcing plate shall be welded around the outside of the pipe section; and (on the nozzle-size) a circular annular reinforcing collar plate (with minimum ¼-inch thickness) shall be welded over the top of the steel wrapper pad, around the base of the nozzle opening. Refer to the IRWD Standard Drawings for welding and plate details.

PART 3 - EXECUTION

A. Fabrication

1. Fabrication: Fabrication shall comply with ANSI B31.3, Chapter V.

2. Butt-Welded Joints: Beveled ends for butt-welding shall conform to ANSI B16.25. Slag shall be removed by chipping or grinding. Surfaces shall be clean of paint oil, rust, scale, slag, and other material detrimental to welding.

3. Weld Passes: The minimum number of passes for welded joints shall be as follows:

Steel Cylinder Thickness (inches)	Minimum Number of Passes for Welds
0.2500	2
0.2501 through 0.3750	3
0.3751 through 0.5000	4
0.5001 and greater	requires special design review

All welds shall be continuous and fully circumferential.

4. Welding Process: The shielded metal arc welding (SMAW) process shall be used for welding.

5. Welding Preparation: Welding preparation shall comply with ANSI B31.3, paragraph 328.4. Limitations on imperfections in welds shall conform to the requirements in ANSI B31.3, Tables 341.3.2 and 341.3.2B, and paragraph 341.4 for visual examination.

6. Weld Identification: Welds shall be identified in accord with ANSI B31.3, paragraph 328.5.

7. Cleaning Welds: Each layer of deposited weld metal, including the final pass, shall be cleaned with a power-driven wire brush prior to depositing the next layer of weld metal.

8. Welding Electrodes: Welding electrodes shall comply with AWS A5.1 or A5.5.

END OF SECTION

SECTION 15056: DUCTILE-IRON PIPE AND FITTINGS

PART - 1 GENERAL

A. Description

This section describes materials, installation, and testing of ductile-iron pipe and fittings.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223
2. Chlorination of Water Mains for Disinfection: 15041
3. Hydrostatic Testing of Pressure Pipelines: 15042
4. Installation of Pressure Pipelines: 15051
5. Manual Valves: 15100
6. Flexible Pipe Couplings and Expansion Joints: 15162
7. Cathodic Protection and Joint Bonding: 16640

C. Submittals (for Contracts Between District and Contractor)

1. Shop drawings shall be submitted in accord with the General Provisions and the following.
2. Affidavits of compliance with standards referenced in this specification, e.g., AWWA C-151, shall be provided.
3. Layout drawings showing the locations and dimensions of pipe and fittings shall be submitted where the proposed pipeline is to be placed along streets or alignments with a radius of curvature which dictates the use of shorter-than-standard pipe lengths. In cases where restrained joint pipe is specified, lay drawings shall clearly identify the joints, lengths, fittings, and deviations from the curved centerline of the pipe trench. Consideration for adjacent parallel utility conduits is important in developing the lay drawings to avoid conflicts and encroaching into adjacent trench areas.
4. Lining, coating and wall thickness for all piping shall be provided.
5. Joint details for all types of joints used. e.g., push-on joints shall be submitted.
6. Calculations and/or test data proving that each proposed restrained joint arrangement can transmit the required forces shall be submitted.

D. Measurement and Payment

1. Payment for the work in this section shall be in accord with the General Provisions and the following:

2. Payment shall be by the linear foot for each diameter and for each pipe strength designation measured horizontally over the pipe centerline, exclusive of the distance between the inside faces of junctions or other structures.

E. Inspection

The District reserves the right to inspect materials, production, and testing of pipes, fittings, and special pieces at the manufacturer's plant.

PART 2 - MATERIALS

A. Ductile-Iron Pipe

1. AWWA Reference Standard: Ductile-iron pipe shall be manufactured in accord with ANSI/AWWA C-151/A-21.51.

2. Minimum Wall Thickness: The minimum wall thickness for ductile-iron pipe shall be as specified in AWWA C-150 for the design pressure class, and thickness Class 53 for flanged spools, unless indicated otherwise on the plans or in the Project Technical Specifications.

3. Joints: Unless otherwise called out on the plans or Project Technical Specifications, push-on type joints shall be used. The joint dimension and gasket shall be as specified in ANSI/AWWA C-111/ A-21.11. All pipe joints shall be bonded to provide electrical continuity for corrosion monitoring and future cathodic protection. For joint-bonding details and requirements refer to the IRWD Standard Drawings and to Section 16640.

4. Flanges: Flanges for ductile-iron pipe, when required, shall be "screwed-on" type in accord with ANSI/AWWA C-115/A-21.15.

5. Restrained Joints: Where called for on the plans, pipe and fittings shall be restrained. Joint restraint type shall be as specified in this Section and shall be one of the following types:

   a. Flanged fittings, per Part 2. A. 4. above and Part 2. B. 8 below.

   b. Manufactured locking restraint pipe with fittings as manufactured by U.S. Pipe & Foundry Company, TR-Flex, American Cast Iron Pipe Company, Flex-Ring (only), Pacific States Cast Iron Pipe Company, Thrust-Lock, Clow Water Systems Company, F-128 Super-lock pipe, or for contracts between District and Contractor, approved equal.

      Field welding of ductile iron restrained joint or ductile iron components is not acceptable.

   c. Mechanical Joints with Mechanical Joint Restraints per Part 2. B. 6 and 7 herein below.

   d. Push-on joint pipe with restrained harness assembly. Restraint of push-on joints shall only be used where specifically called for on the plans. Shop drawings reflecting every part, material and dimension of the restraint assembly shall be submitted to the District for approval.

(1.) Restraint systems using lugs integral to the pipe shall be cast with the pipe or fitting by the pipe manufacturer. Attachment of angle iron; angle-clips; harness-lugs or tabs by field welding to the ductile iron pipe or fitting is strictly prohibited.

(a.) All threaded harness parts shall be manufactured of type 316 stainless steel.

(2.) Restraint of push-on joints shall be of the type utilizing cast lugs, or retainer rings bearing against the pipe shoulders at the bell or fitting.

e. Grooved pipe and fittings (for un-buried installations only), per sub-section no. 2. E. herein below. Wall thickness beneath the groove shall be equal to or greater than the minimum specified wall thickness and shall be sufficient to meet the maximum pressure.

6. Manufacturers: Ductile-iron pipe shall be as manufactured by American Cast Iron Pipe Company, Pacific States Cast Iron Pipe Company, U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Company, Griffin Pipe Products Company, McWane Cast Iron Pipe Company, Clow Water Systems Company or for contracts between District and Contractor, approved equal.

B. Ductile-Iron Fittings

1. AWWA Reference Standard: Ductile-iron fittings shall be manufactured in accord with ANSI/AWWA C-110/A-21.10 or ANSI/AWWA C-153/A-21.53.

2. Push-on Joints: All pipe fittings shall be made with push-on joints designed for use with the type of pipe to be joined unless noted otherwise on the plans.

3. Restrained Joints: Restrained joints shall be as called for on the plans. Joint restraint type shall be as specified in this Section for ductile iron pipe, and shall be either:

a. Flanged fittings, per sub-section no. Part 2. A. 4. above and sub-section no. Part 2. B. 8 below or;

b. Manufactured locking restraint pipe fittings, per sub-section no. 2. A. 5. b. above.

c. Mechanical Joints with Mechanical Joint Restraints per Sections 2. B. 6 and 7 herein below.

d. Push-on joint pipe with restrained harness assembly. This style of restraint shall only be used where specifically called for on the plans. The pipe manufacturers' standard restrained joints shall be of the type utilizing cast lugs, shop welded retainer lugs, retainer rings bearing against pipe shoulders, or retainer rings in pipe grooves.

e. Grooved pipe and fittings (for un-buried installations only), per sub-section no. 2. E. herein below. Wall thickness beneath the groove shall be equal to or greater than the minimum specified wall thickness and shall be sufficient to meet the maximum pressure.

4. Hydrostatic Pressure Test: Each fitting shall be tested before lining to one and one-half times the operating pressure for a duration of 10 seconds. Suitable controls and recording devices shall be provided so that the test pressure and duration may be adequately ascertained. Any fitting that does not withstand the test pressure shall be rejected. The Contractor may be required to notify the District in advance of the date, time, and place of inspection and testing of the fittings in order that the District may be represented at the tests. When specified in the special provisions, in some cases, the District may require a certification of compliance to these specifications.

5. Bell Ends: Bell ends shall be compatible with the pipe ends so as to provide confinement of the rubber rings and prevent damage to the ends of the pipe. Ring grooves and interior surfaces of the bell shall be smooth and free from ridges, notches, or uneven surfaces.

6. Mechanical Joints: Mechanical joint fittings will be allowed only in areas specifically called for on the project plans or as approved by the District as a substitute for other types of fittings. Mechanical joint fittings will be used in areas where there is limited room for a thrust block or in cases where the pipeline needs to be activated in a short period of time. These ductile iron fittings shall comply with ANSI / AWWA C-111/A-21.11, with a pressure rating of 250 psi. and a ANSI Class 125 and Class 150 bolt pattern. Tee-bolts for mechanical joint fittings shall be Type 316 stainless steel.

   Field applications where speed of construction to facilitate tie-ins and where there is limited space available for concrete thrust blocks, are examples of where mechanical joint fittings with retainer glands are appropriate.

7. Mechanical Joint Restraint Systems: Mechanical joints with retainer gland fittings will only be allowed in areas specifically called for on the project plans or as approved by the District as a substitute for other types of fittings. (See paragraph 6 above.) Mechanical joint fittings shall meet or exceed the ASTM A-536 requirements. Torque off bolts shall be tightened per manufacturer's recommendations and shall be inspected by the District prior to backfill. Approved manufacturers include: Ford Products, Sigma, EBAA Iron, One-Lok, Romac, RomoGrip.

8. Flanged Fittings: Unless otherwise indicated on the drawings, all fittings with flanged ends shall comply with ANSI/AWWA C110/A21.10, with a pressure rating of 250 psi. and a Class 125 ASME/ANSI B-16.1 flange or an ANSI/AWWA C-115/A-21.15 Class 125 flange. The gasket surface shall have a serrated finish of approximately 16 serrations per inch, approximately 1/32-inch deep, with serrations in either a concentric or spiral pattern. In addition, all flanges shall meet the following tolerances:

   Bolt circle drilling.. ±1/16 inch
   Bolt hole spacing .... ±1/32 inch
   Eccentricity of bolt-circle &
   facing with respect to bore center.............. ±1/32 inch

9. Manufacturers: Fittings shall be manufactured by American Pipe, Pacific States, Sigma, Star Pipe Products, U.S. Pipe, Tyler, Pipeline Components, Inc. (PCI) or for contracts between District and Contractor, approved equal.

C. Gaskets

1. Gaskets for Flanged Joints: Gaskets for flanged joints shall be 1/8 inch thick, cloth-inserted rubber. Gaskets shall be suitable for a water pressure of 350 psi at a temperature of 180°F.

2. Full Face Type Gaskets or Ring Gaskets for Flanged Joints: Full face type gaskets with pre-punched holes shall be used where both flanges are flat face. Ring gaskets extending to the inner edge of the bolts may be used where a raised face flange is present.

3. Gaskets for Push-on, Mechanical, and Restrained Joints: Gaskets for push-on, mechanical, and restrained joints shall be synthetic or natural rubber in accord with AWWA C-111.

4. Manufacturers: Gaskets shall be John Crane Company Style 777, Johns Manville No. 109, or for contracts between District and Contractor, approved equal.

D. Bolts, Nuts, and Washers

1. General: Bolts and nuts for all flanges, (including mechanical joints), shall be Type 316 stainless steel conforming to ASTM A-193, Grade B8M for bolts, and ASTM A-194, Grade 8M for nuts.

2. Washers: A Type 316 stainless steel washer shall be provided for each nut.

3. Bolt Projection: The length of each bolt or stud shall be such that between 1/4 inch and 1/2 inch will project through the nut when drawn tight.

E. Grooved-End Fittings and Couplings

Grooved-end fittings shall conform to AWWA C-606, rigid radius-cut groove. Grooved-end couplings shall be ductile iron, ASTM A-536, Grade 65-45-12. Bolts shall be Type 316 stainless steel and conform to ASTM A-183, minimum tensile strength of 110,000 psi. Gaskets shall be EPDM and shall conform to ASTM D-2000. Coupling shall be Victaulic, Style 77, Gustin-Bacon, Grinnell or for contracts between District and Contractor, approved equal. All of the threaded parts shall be Type 316 stainless steel and shall be lubricated with anti-seize compound. Where the restrained joint is of the grooved type, the wall thickness beneath the groove shall be equal to or greater than the minimum specified wall thickness.

F. Lining for Pipe and Fittings

The interior of all pipe and fittings shall be lined with cement-mortar per ANSI/AWWA C-104/A-21.4. Lining shall be the double thickness listed in AWWA C-104, Section 4.8. Lining materials shall conform to ASTM C-150, Type II.

G. Coating for Pipe and Fittings

1. Exterior Surfaces: Exterior surfaces of pipe and fittings shall be coated with an asphaltic material in conformance with ANSI/AWWA C-110/A-21.10, and ANSI/AWWA C-151/A-21.51. The coating shall be free from blisters and holes; shall adhere to the metal surface at ambient temperatures encountered in the field.

2. Coating for Bolts, Nuts, and Glands: Buried mechanical joint bolts, nuts and glands, and restrained joint bolts for field-cut closure pipe shall be coated per Section 09900, Painting and Coating. Stainless steel parts shall not be coated except for the threaded portion, which shall be assembled with a liberal coat of anti-seize compound.

H. Polyethylene Encasement

Unless specified otherwise, pipe and fittings shall be polyethylene encased in accord with ANSI/AWWA C-105/A-21.5.

I. Flange Insulation Kits

Flange insulation kits, suitable for the design pressure of the pipeline, shall be provided where shown on the drawings, and shall be as specified in Section 16640, Cathodic Protection and Joint Bonding.

J. Joint Bonding

Provide joint bonding for each fitting and pipe joint with bonding wires as specified in Section 16640, Cathodic Protection and Joint Bonding.

PART 3 - EXECUTION

A. General

Ductile-iron pipe and ductile iron fittings shall be installed in accord with the applicable sections of AWWA C-600 and as specified in Section 15051, Installation of Pressure Pipelines.

B. Installation

1. Allowable Joint Deflection for Restrained Joint Pipe and Fittings: For restrained joints, deflection of the joint shall not exceed the manufacturer's recommended maximum deflection.

2. Acceptable Line and Grade for Piping: The pipe shall be laid true to the line and grade shown on the plans within acceptable tolerances. The tolerance on grade is 1-inch. The tolerance on line is 2-inches.

3. Touch-Up Coating: All exposed flanges and other metal surfaces and all damaged coatings shall be coated after assembly per Section 09900, Painting and Coating. Stainless steel bolts shall not be coated.

C. **Wrapping pipe with Polyethylene Encasement**

All ductile-iron pipe and fittings buried underground shall be protected with a polyethylene encasement wrap in accord with AWWA C105. Wrap shall be a loose 8-mil-thick LLD polyethylene tube or a 4-mil thick HDCL polyethylene tube. All joints between plastic tubes shall be wrapped with 2-inch-wide, 10-mil thick, polyethylene adhesive tape, Polyken 900, Scotchwrap 50, or for contracts between District and Contractor, approved equal. Installation of plastic film shall conform to the following procedure, and wrapping shall be applied to the pipe in the field in the following manner:

1. Placement of Polyethylene Encasement: Using a sling, the pipe shall be picked up with a crane at the side of the trench and raised about 3 feet off the ground. The polyethylene tube, cut approximately 2 feet longer than the length of pipe, shall be slipped over the spigot end of the pipe and bunched up, accordion fashion, between end of the pipe and the sling.

2. Placement of Pipe into Trench: The pipe shall be lowered into the trench. The spigot shall be seated into the bell of the adjacent installed pipe, and the pipe lowered into the trench bottom. A shallow bell hole shall be provided in the trench bottom to facilitate the wrapping of the joint.

3. Joint Assembly: The pipe joint shall then be made up as described herein.

4. Adjustment of Polyethylene Encasement: The sling shall be removed from the center of the pipe and hooked into the bell cavity. The bell shall be raised approximately
12 inches and the tube of polyethylene film slipped along the full length of the pipe barrel. Enough of the film shall be left bunched up, accordion fashion, at each end of the pipe to overlap the adjoining pipe about 1 foot. Care shall be taken to ensure that soil that adheres to the pipe is removed as the polyethylene film is placed around the pipe.

5. Overlapped Joints: To make the overlapped joint wrap, the film shall be pulled over the bell of the pipe, folded around the adjacent spigot, and wrapped with about three circumferential turns of the plastic adhesive tape in order to seal the tube of film to the pipe. The tube on the adjacent pipe shall be then pulled over the first wrap on the pipe bell and sealed in place behind the bell, using about three circumferential turns of the polyethylene adhesive tape.

6. Attachment of Encasement: The resulting loose wrap on the barrel of the pipe shall be pulled snugly around the barrel of pipe, the excess material folded over the top and the fold held in place by means of short strips of the 2-inch wide, 10-mil thick adhesive tape at intervals 5 feet apart along the pipe barrel.

D. **Flanged Connections**

Flanged pipe and fittings shall be shop fabricated, not field fabricated. Threaded flanges shall comply with AWWA C-115 and shall be individually fitted and machine tightened in the shop.

E. **<u>Mechanical Joint Connections with Retainer Gland Restraints</u>**:

Mechanical joint connections with retainer glands shall be assembled in accord with the manufacturer's recommendations for the specific fitting and retainer gland be used. Torquing of break-off gland bolts shall be done in the presence of the District Inspector. Each fitting shall be observed by the District inspector prior to bagging and backfill. Any such fittings not observed by the District representative shall be excavated and exposed for detailed re-inspection of the fitting and bolt torque.

END OF SECTION

SECTION 15057: COPPER PIPE AND FITTINGS

PART 1 - GENERAL

A. Description

This section describes materials, installation, and testing of copper and brass pipe, and copper, brass and bronze fittings and appurtenances.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223.

2. Painting and Coating: 09900.

3. Hydrostatic Testing of Pressure Pipelines: 15042.

4. Installation of Pressure Pipelines: 15051.

5. Manual Valves: 15100.

6. Cathodic Protection and Joint Bonding: Section 16640.

C. Submittals

1. Shop drawings shall be submitted in accord with the General Provisions and the following:

2. Submit detailed layout if pipe runs in copper exceed 50 lineal feet.

3. Submit catalogue order sheets for materials of pipe, flanges, flange insulation kits, companion flanges and unions, showing metal composition and conformance to industry standards (ASTM, etc.) specified.

PART 2 - MATERIALS

A. Copper Pipe and Tubing

Copper piping shall conform to ASTM B 88. Copper pipe and tubing shall be cylindrical, of uniform wall thickness, and shall be free from any cracks, seams, or other defects. Piping located above floors or suspended from ceilings shall be Type L. Piping buried or located beneath floor slabs shall be Type K. Copper pipe shall be as manufactured by Cerro Copper Products Company, IUSA/Reading, Halstead Industries, Inc., Cambridge-Lee Industries, Inc., Mueller Manufacturing Entities c/o Mueller Industries, Inc., or for contracts between District and Contractor, approved equal.

B. Copper Fittings

Copper fittings shall be copper conforming to ASTM B 75 and ANSI B16.22, with solder end joints. Fittings ⅜ - inch and smaller may have flared end connections or compression joint connections.

C. Solder

Solder shall be tin-silver solder conforming to ASTM B 32, latest revision, Grade Sn94, Sn95 or Sn96. Cored solder shall not be used. Solder and flux used in joints of potable waterlines shall contain no more than 0.2 percent lead.

D. Brass Pipe and Nipples

Short threaded nipples and brass pipe shall conform to ASTM B 43, regular wall thickness, except that nipples and pipe of sizes 1 inch and smaller shall be extra strong. Threads shall conform to ANSI B1.20.1.

E. Bronze Appurtenances

1. General: All items specified herein shall be manufactured of bronze conforming to ASTM B62, "Composition Brass or Ounce Metal Castings."

2. Service Saddles: Service saddle bodies shall be manufactured of bronze, stainless steel or nylon-coated malleable iron as called for in the IRWD Standard Drawings for the various types of pipe connections. Saddles shall be tapped with a female iron pipe thread outlet. The seal with the outer wall of the pipe shall be effected with either a rubber gasket or an O-ring, except for the stainless steel full-circle style repair clamp connection, which shall have a full-circle rubber gasket. Service saddles shall be as manufactured by Jones, Mueller, A.Y. McDonald, Smith-Blair, Romac, Ford, Cambridge Brass, Rockwell, Total Piping Solutions, Inc. – EZ-MAX or for contracts between District and Contractor, approved equal.

   a. Service saddles shall be double strap type for all sizes of asbestos-cement or ductile iron pipe. The straps (or bails) shall be flat and shall be manufactured of Everdur or Silnic bronze or stainless steel. Refer to Standard Drawings for details.

   b. Service saddles for C-900 PVC pipe shall be manufactured of bronze and shall be cast in two sections for pipe up to and including 8-inches in diameter. Service saddles for use on 10-inch and 12-inch diameter C-900 PVC pipe may be cast in two or three sections. Each saddle shall accurately fit the contour of the pipe O.D. without causing distortion of the pipe. The sections shall be securely held in place with type 316 stainless steel hex-head screws or bolts. Casting sections may be hinged and secured with stainless steel pins. The casting sections shall be tapped to receive the screws or bolts.

3. Corporation Stops: Corporation stops shall be manufactured of bronze. The inlet fitting shall be a male iron pipe thread when used with saddle and the outlet connection shall be a compression type or iron-pipe thread. Corporation stops shall be "ball style" as manufactured by Jones, Mueller, A.Y. McDonald, Ford, Cambridge Brass or for contracts between District and Contractor, approved equal.

4. Angle Meter Stops: Angle meter stops shall be of the "ball valve" style and shall be manufactured of bronze. The inlet connection shall be a compression type or iron-pipe thread and the outlet fitting shall be a meter flange or meter coupling. The inlet and outlet shall form an angle of 90 degrees on a vertical plane through the centerline of the meter stop. A rectangular lug and lock wing shall be provided on the top of the fitting to operate the shutoff mechanism.

Two-inch angle meter stops shall be with "slotted" holes for 1½-inch or 2-inch meters. Angle meter stops shall be of the "ball valve" style and shall be as manufactured by Jones, Mueller, A.Y. McDonald, Cambridge Brass, Ford, or for contracts between District and Contractor, approved equal.

5. Customer Service Valve: Customer service valves shall be "ball valve" style manufactured of bronze with lever-type turn handle. The inlet connection shall be a meter flange or a meter coupling and the outlet female iron pipe thread. Customer service valves shall be of the insulating style as manufactured by Mueller Corporation, or approved equal. Customer service valves shall be purchased from the District.

F. Connections & Cathodic Insulation

1. Underground pipe connections

   For connections to underground piping, refer to the IRWD Standard Drawings pertaining to water service connections. Detail is provided to address the appropriate connection method for each different type of piping material being connected. Those details provide for insulation and address cathodic protection concerns. In general, the practice of using threaded PVC or nylon bushings shall not be allowed.

2. Above-ground & exposed pipe connections (in vaults):

   Pipe, fittings, and appurtenances (air vacs, pressure gauges, etc.) made of dissimilar metals shall be isolated from each other. For applications where pipeline pressures exceed 150 psi, and where the pipe tap for the appurtenance into the main is larger than 1-inch in diameter, a 2½-inch extra heavy carbon steel coupling shall be provided as the outlet, and the fitting/ appurtenance shall be isolated from the main by means of a 2½ by 2-inch 316 stainless steel bushing, 2-inch 316 stainless steel nipple, and 2-inch stainless steel ball valve.

G. Flanges, Gaskets, Bolts and Nuts

1. Flanges for Valves and Fittings: Copper pipe shall be connected to flanged valves and fittings with bronze companion flanges conforming to ANSI B16.24, Class 125 (150 lb. Rating) to match the connecting flange. Solder end companion flanges shall be used for copper and threaded companion flanges shall be used for brass, bronze or stainless steel pipe connections.

2. Gaskets: Gaskets for flanged-end fittings shall be made of synthetic rubber binder and shall be full-face, 1/8-inch thick Johns-Manville, John Crane Co. "Cranite", or for contracts between District and Contractor, approved equal.

3. Flanged Connections: All flanged connections shall be made using, Type 316 stainless-steel bolts and nuts conforming to ASTM A 193, Grade B8M, for bolts and ASTM A 194, Grade 8M, for nuts. Washers shall be provided for each nut. Washers shall be of the same material as the nuts.

4. Flange Insulating kits:

   Flange insulation kits, suitable for the design pressure of the pipeline, shall be provided where shown on the drawings and/or wherever pipelines of dissimilar metals are joined together. Insulation kits and materials shall be as specified in Section 16640, Cathodic Protection and Joint Bonding.

H. Unions

Unions for copper piping systems (non-buried applications) shall conform to the following. Unions shall be the same size as the pipe, and shall be of the three part type, with silver soldered "sweat" hub-end connections. Unions shall be bronze, conforming to ASTM B 61 or B 62. Unions shall be Jones, Ford, A. Y. McDonald, Mueller, Lee Brass or for contracts between District and Contractor, approved equal.

PART 3 - EXECUTION

A. General

Pipe shall be installed without springing, forcing, or stressing the pipe or any adjacent connecting valves or equipment. Pipe hangers and supports, and pipe penetrations through walls, slabs, and floors shall be as detailed on the drawings.

B. Installing Flange Bolts and Nuts

1. Bolt Thread Lubrication: Bolt threads shall be lubricated with an anti-seize compound prior to installation. Anti-seize compound shall be as manufactured by Tri-Flow, Permatex or Crouse-Hinds.

2. Flange Alignment: Flanged pipe shall be set with the flange boltholes straddling the pipe horizontal and vertical centerlines. This is referred to as the "two holing" procedure.

C. Installation

1. Related Installation Specification: Pipe shall be installed in accord with the requirements of Section 15051, Installation of Pressure Pipelines.

2. Pipe/Tubing Preparation: Tubing shall be cut square and burrs removed. Both the inside and outside of fitting and pipe ends shall be cleaned with steel wool and muriatic acid before soldering. Care shall be taken to prevent annealing by over-heating of fittings and tubing when making connections. Miter joints shall not be permitted in lieu of elbows. Notching straight runs of pipe in lieu of tees shall not be permitted.

3. Pipe Bends: Bends in soft copper tubing shall be long sweep. Bends shall be shaped with shaping tools. Bends shall be formed without flattening, buckling, or thinning the tubing wall at any point.

4. Brazing: Brazing procedures shall be in accord with Articles XII and XIII, Section IX, of the ASME Boiler and Pressure Vessel Code. Solder shall penetrate to the full depth of the bell in joints and fittings. Solders shall comply with ANSI B31.3, paragraph 328.

5. Pipe Flexibility and Minimum Cover for Service Laterals: Buried piping shall be installed with some slack to provide flexibility in the event of a load due to settlement, expansion or contraction. A minimum cover of 42-inches below the finished street grade shall be adhered to. The tubing is to be bedded and covered with sand or select material in accord with Section 02223.

6. Copper Service Laterals: All service laterals shall be either 1-inch diameter or 2-inch diameter copper tubing. Refer to the IRWD Standard Drawings. End connections for the corporation stop and angle meter stop shall be compression type fittings. All other couplings, fittings and joints shall be silver soldered. Piping for 2-inch size services shall be installed with straight lengths of soft copper water tube Type K, (with the exception of copper pipe for air-vacuum assemblies.)

   Anodes for cathodic protection shall be used on all copper pipe installations in accord with Standard Specifications Section 16640.

D. Service Saddles

1. Proximity to Valves, Couplings, Joints, and Fittings: Service saddles shall be no closer than 18-inches to valves, couplings, joints, or fittings unless it is at the end of the main. The installation of a service saddle on any machined section of asbestos cement pipe will NOT be permitted.

2. Pipe Surface Preparation: The surface of the pipe shall be cleaned, smoothed and de-burred to remove all loose material and to provide a hard, clean surface before installing the service saddle.

3. Installation: The service saddle shall be tightened firmly to ensure a tight seal; however, care shall be used to prevent damage or distortion of the pipe by over-tightening.

4. Pipe Tap: The tap into the pipe shall be made in accord with the pipe manufacturer's recommendation. Tap hole diameter shall be ⅞-inch for 1-inch service taps and shall be 1⅞-inch for 2-inch service taps.

END OF SECTION

SECTION 15064: PVC PRESSURE PIPE AND FITTINGS

PART - 1 GENERAL

A. Description

This section includes materials, installation, and testing of polyvinyl chloride (PVC) pipe for 4-inch through 36-inch diameter domestic water lines, recycled water lines, and sewer force mains, in accordance with the applicable provisions of AWWA C900 and AWWA C905.

B. Related Work Specified Elsewhere

1. Existing Facilities: 01045
2. Trenching, Backfilling, and Compacting: 02223
3. Chlorination for Disinfection: 15041
4. Hydrostatic Testing of Pressure Pipelines: 15042
5. Installation of Pressure Pipelines: 15051
6. Ductile-Iron Pipe and Fittings: 15056
7. Copper Pipe and Fittings: 15057
8. Facilities Identification: 15151

C. Submittals (for Contracts between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provision and the following.
2. Submit materials list showing material of pipe and fittings with ASTM reference and grade.

D. Measurement and Payment

1. Payment for work in this section shall be in accordance with the General Provisions and the following.
2. Payment shall be by the linear foot for each diameter and for each pipe strength designation measured horizontally along the pipe centerline.

PART 2 - MATERIALS

A. PVC Pipe

1. General: PVC pipe shall be manufactured in accordance with AWWA C900 and AWWA C905, and shall be of the sizes and pressure classes shown on the plans. The standard dimension ratio (SDR) for C900 PVC pressure pipe shall be SDR-14 or thicker walled. The standard dimension ratio (SDR) for C905 PVC pressure pipe shall be SDR-18 or thicker walled. The pipe shall have gasketed bell end or plain end with elastomeric gasketed coupling.

2. Material: Material used to produce the pipe and couplings shall be made from Class 12454-A or B virgin compounds as defined in ASTM D 1784, with an established hydrostatic design basis rating of 4,000 psi for water at 73.4°F (23°C).

3. Pipe Lengths: Laying lengths shall be 20 feet with the manufacturer's option to supply up to 15% random lengths (minimum length 10 feet).

4. Pipe Marking: Each pipe length shall be marked showing the date of manufacture, nominal pipe size and O.D. base, the AWWA pressure class, and the AWWA specification designation (AWWA C900 or C905). For potable water application, the seal of the testing agency that verified the suitability of the material for such service shall be included.

5. Manufacturers: Pipe shall be manufactured by Certainteed Corporation, Ipex, Inc., Vinyltech Corporation, and Diamond Plastics Corporation, or for contracts between District and Contractor, approved equal.

B. Fittings

1. Materials: Fittings shall be ductile-iron conforming to Section 15056, Ductile-Iron Pipe and Fittings.

2. Bell Sizes: Bell size shall be for Class 150 and Class 200 iron-pipe-size equivalent PVC pipe, including the rubber-ring retaining groove.

3. Reference Standard: All castings shall be marked "DI" or "Ductile" and ANSI/AWWA C153/A21.53.

C. Rubber Rings

Rubber rings for use in the PVC couplings and fittings shall conform to the requirements of ASTM D 1869. Rubber rings shall be stored and protected in a manner to prevent deterioration.

D. Service Saddles

Service saddles for 1-inch and 2-inch diameter outlets shall be designed for use on C900 and C905 PVC pipe and shall conform to the requirements of Section 15057, Copper Pipe and Fittings. The allowable upper pipeline diameter limit for use of service saddles shall be pipe nominally sized 12-inches in diameter. For outlets of larger than 2-inch diameter and for all outlets on larger diameter pipelines, ductile iron tees with flanged outlets shall be used. Refer to the IRWD Standard Drawings.

PART 3 - EXECUTION

A. General

1. Related Installation Specification: PVC pipe shall be installed in accordance with the requirements of Section 15051, Installation of Pressure Pipelines.

2. Restrictions: When pipe is to be installed in new streets or when street improvements require placement and/or replacement of curbs, piping shall not be installed until new curbs are in place, unless special approval by the District is obtained. If any curbing is damaged during piping installations, the damaged portions shall be repaired or replaced to the satisfaction of the agency having jurisdiction.

3. Closure Sections: Where closure sections are required, the sections shall be installed in accordance with the applicable portions of these specifications. Closures shall be made using gasketed-PVC closure collars.

4. Cover: The pipe sections shall be laid in the trench to true alignment and grade in accordance with the drawings. Where the grade is not shown, pipe shall have a cover of 42-inches in paved areas and 48-inches in unpaved areas. The pipe grade shall be approved by the District.

5. Curved Alignment: The pipe shall not be laid along curves at a radius less than that listed below. The minimum-radius curves are determined by the limit of 2-degree deflection for PVC pipe joints with factory-assembled bell couplings:

Length of Pipe Section	Minimum Curve Radius
20 feet	573 feet
10 feet	287 feet

For integral bell PVC pipe, the minimum radius curves obtained by deflecting joints shall not exceed the manufacturer's recommendation (which may be less than 2 degrees). Pipe may not be offset to a degree such that the spigot end of the pipe deflects (touches) against the end of the pipe bell. Pipe sections shall not be bent to achieve a curve.

B. Installation

1. Pipe Cutting: When pipe is cut and is to be joined to a ductile-iron fitting or another piece of pipe, the end shall be beveled in the field or shop to create a beveled end equal in workmanship to the machined ends of the pipe as furnished by the manufacturer. Such machining shall not result in undercutting the wall thickness and must be approved by the District Representative before installation.

2. Joints: Connecting parts of pipe, rings, couplings, and castings shall be cleaned before assembly. After bearing has been obtained, couplings shall be assembled in a workmanlike manner. The use of excessive lubricant will not be permitted, and the assembly of the couplings and rings shall be in accordance with the manufacturer's recommendations. Lubricant and rubber rings shall be supplied by the pipe manufacturer.

3. Pipe Storage: Pipe shall not be stored in direct sunlight. Pipe stored outdoors shall be protected from discoloration by covering it with opaque material such as canvas. The covering shall be placed in such a way as to allow adequate air circulation between the cover and the pipe. Discolored pipe shall be rejected.

C. Pipe Identification

Warning and locator tape shall be installed on all recycled water pipelines and potable water pipelines in accordance with Section 15151, Facilities Identification.

END OF SECTION

SECTION 15076: CEMENT-MORTAR LINED AND COATED STEEL PIPE

PART 1 - GENERAL

A. Description

This section describes materials, fabrication, installation, and testing of cement-mortar lined and coated steel pipe, in accordance with the applicable requirements of AWWA C-200, C-205, C-206, C-207 and C-208.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223
2. Painting and Coating: 09900
3. Interior Inspection for Cement Mortar Lined Steel Pipe: 15040
4. Chlorination for Disinfection: 15041
5. Hydrostatic Testing of Pressure Pipelines: 15042
6. Installation of Pressure Pipelines: 15051
7. Cathodic Protection and Joint Bonding: 16640

C. Submittals (For Contracts Between District and Contractor)

Shop drawings shall be submitted in accordance with the General Provisions and the following:

1. Piping layout drawings showing location and dimensions of all pipe and fittings. Include lay lengths of valves, meters, and other equipment which determine piping dimensions. Label or number each fitting or piece of pipe and provide the following information for each item:

    a. Materials of construction, including references to industry standards being met (i.e. ASTM, ANSI, AWWA, etc.).

    b. Inside diameter, steel wall thickness, internal design pressure (cement-mortar lining and coating thicknesses) for each class of pipe to be furnished.

    c. Order of installation and closure locations for length adjustment and for construction convenience.

    d. Pipe invert station and elevation of each change of grade and alignment.

    e. Elements of curves and bends, both in horizontal and vertical alignment, including elements of the resultant true angular deflections in cases of combined curvature.

    f. Paint primer type and thickness where joints and other cement-mortar holdbacks occur.

g. Call out types and sizes, and dimensions of grooved-end collars, flanges, reinforcing collars, wrapper plates, and crotch plates.

h. Limits of each reach of field-welded joints and of concrete encasement.

i. Locations of manholes and other points of access.

j. Location of valves and other mechanical equipment.

k. Locations of bulkheads for field hydrostatic testing of pipeline.

2. Manufacturer's certificates of compliance with prescribed industry standards (i.e. AWWA C-200, C-205, C-206, C-207 and C-208, ASTM C-150, etc.)

3. Detail drawings of:

a. Fittings
b. Joints
c. Butt Straps
d. Bulkheads and means of attachment to pipe.

4. Mill test reports on each heat from which steel is rolled.

5. Test reports on physical properties of elastomeric material used in gaskets.

D. <u>Measurement and Payment</u>

1. Payment for the work in this section shall be in accordance with the General Provisions and the following.

2. Payment shall be by the linear foot for each diameter and for each pipe strength designation measured horizontally over the pipe centerline, exclusive of the distance between inside faces of junction or other structures.

E. <u>Inspection</u>

The District reserves the right to inspect materials, production, or testing of pipe at the manufacturer's plant.

PART 2 - MATERIALS

A. <u>Steel Pipe</u>

1. Pipe shall conform to AWWA C-200, AWWA M-11, latest edition. Steel shall be ASTM A-36, ASTM A-1011 or A-1018, Grade 36, having a 0.25% maximum carbon content.

2. Steel cylinder thickness shall be minimum of 10 gauge (0.1345 inches) for straight runs of distribution and transmission pipe with diameters less than 30-inches and shall be a minimum of ¼-inch (0.2500 inches) for diameters 30-inches and larger.

3. Additionally, the minimum wall thickness shall be ¼-inch (0.2500 inches) for all pipe, regardless of size, within 10 feet of structures, vaults and other significant pipe appurtenances (such as blow-offs, manways, PRV vaults, valve vaults, meter vaults, pump stations, etc.); wherever the pipe is to be installed or jacked inside pipe casings; and wherever pipe penetrations are required.

B. Cement

Cement for cement-mortar lining shall be ASTM C-150, Type II or V. Cement for cement-mortar coating shall be ASTM C-150, Type V.

C. Fittings

1. Definition: A fitting shall be defined as a piece of pipe other than a straight full length joint. Elbows, manhole sections, reducers, and sections of pipe with outlets shall be considered fittings. Dimensions shall be per AWWA C-208.

2. Pressure Rating: Fittings 4 through 10-inches diameter shall be designed for 250 psi and conform to ANSI B16.9. Fittings 12-inches diameter and larger shall comply with AWWA C-208. Note, the minimum plate thickness required for Section A herein, above.

3. Materials: Material for fittings 4 through 10-inches shall comply with ASTM A-234, Grade WPB. Material for fittings larger than 10-inches but less than or equal to 30-inches in diameter shall be the same as the pipe. Cement-mortar lining and I.D. dimensions shall be the same as the specified pipe.

4. Allowable Stresses: Allowable circumferential stress at the design internal pressure shall not be greater than 40% of minimum yield stress. Minimum wall thickness of steel fitting shall be the same as the pipe of same size per ANSI B36.10 and as required in Section A, herein, above.

   a. Allowable circumferential stress at the design internal pressure shall not exceed 40% of minimum yield stress.

   b. Outlet reinforcement at branches and openings shall be determined by the procedure given in ANSI B31.3, paragraph 304.3, and Appendix H. If reinforcement is required, it shall be accomplished as described below.

      i. The type of reinforcement for fittings with outlets shall be selected from the following table:

R	Type of Reinforcement
Max. 0.5	Collar
Max. 0.7	Wrapper Plate
To 1.0	Crotch Plate

$$\text{Calc. } R = \frac{\text{I.D. outlet}}{\text{I.D. main run} \times \sin(\beta)}$$

Where ß = the angle between the longitudinal axis of the main run and the branch.

ii. For collar reinforcement, select an effective shoulder width "$\ddot{W}_s$" of a collar from the inside surface of the steel outlet to the outside edge of the collar, measured on the surface of the cylinder of the main run, shall be selected such that:

$$\ddot{W}_s = \frac{(\tfrac{1}{3} \text{ to } \tfrac{1}{2}) \times \text{I.D. outlet}}{\sin(\beta)}$$

The minimum thickness "T" of the collar is determined by:

$$T = \frac{P \times \text{I.D. main run} \times \text{I.D. outlet} \times [2 - \sin(\beta)]}{4 \times F \times W \times \sin(\beta)}$$

Where: P = Design internal pressure, psi.
F = Allowable design stress = 40% of min. yield stress
ß = As defined in part C.i., above

Collars may be oval in shape or rectangular with rounded corners.

iii. For a wrapper plate, the above collar formula shall be used except that the wrapper is of thickness "T", its total width "$\hat{W}_t$" is determined by:

$$\hat{W}_t = 2\ddot{W} + \frac{\text{I.D. outlet}}{\sin(\beta)}$$

and it wraps entirely around the main pipe.

iv. Base crotch plate design on Swanson, H. S. et al., *DESIGN OF WYE BRANCHES FOR STEEL PIPES*, summarized in AWWA Manual M-11.

v. Long Radius Curves and Vertical Curves:

For curved alignment, straight or beveled pipe of normal or ½ normal lengths pulled partially open on one side of the joint may be used with a welded mitered bend of up to 10 degrees next to the joint ring. Pipes with a bend in excess of 10 shall be designed as fittings.

Joints shall not be pulled more than one-half of the watertight extensibility provided by the bell and spigot design.

5. Grooved End Fittings: Fittings smaller than 24-inches diameter with grooved ends shall have square cut grooves, flexible type, with dimensions as shown in AWWA C-606, Table 3. Steel wall thickness shall be standard weight, ANSI B36.10. Cement-mortar lining and I.D. dimensions shall be the same as for the specified pipe.

6. Welding Fittings: Welding fittings shall be standard weight, Tube Turns, or for contracts between District and Contractor, approved equal.

D. Flanges

Flanges shall be AWWA C-207, Class D, flat face, except where Class E or Class F flanges are required.

E. Bolts, Nuts, and Gaskets for Joints and Flanges

Rubber gaskets shall be furnished for all joints, along with other parts, including flange gaskets, bolts, nuts, washers, jumper rods, and flange insulation kits. One bolt/gasket set shall be provided for each flange.

1. Materials: Bolts and nuts for flanges shall be Type 316 stainless steel conforming to ASTM A-193, Grade B8M for bolts, and ASTM A-194, Grade 8M for nuts.

2. Washers: A washer shall be provided for each nut. Washers shall be of the same material as the nuts.

3. Gaskets: Gaskets shall be composed of synthetic fiber with rubber binder and shall be "full-faced", 1/16-inch-thick Garlock 3400, Anchor 441, or for contracts between District and Contractor, approved equal, conforming dimensionally to ANSI B16.21. Ring gaskets extending to the inner edge of flange bolts may be used where a raised face flange is present.

4. Bolts for Flange Insulation Kits: Bolts and nuts for flange insulation kits shall conform to the same requirements as outlined in paragraph 2., E., 1 above.

F. Flange Insulation Kits

Flange insulation kits suitable for the design pressure of the pipeline shall be provided where shown on the drawings and shall be as specified in Section 16640, Cathodic Protection and Joint Bonding.

G. Grooved-End Couplings

Grooved-end couplings shall be malleable iron, ASTM A-47, or ductile iron, ASTM A-536. Bolts and nuts for couplings shall be type 316 stainless steel and shall conform to ASTM A-193 and A-194. Gaskets shall be EPDM and shall conform to ASTM D-2000. Couplings for pipe 24-inches in diameter and smaller shall be flexible type, square cut groove, per AWWA C-606, and shall be Victaulic Style 77, Gustin-Bacon Figure 100, or for contracts between District and Contractor, approved equal.

H. Outlets

1. Outlets 2-inches in Diameter and Smaller: Outlets of sizes 2-inches in diameter and smaller shall be of the "Thread-o-let" type, per AWWA Manual M-11, Figure 13.26. Outlets shall be 3,000 pound WOG forged steel per ASTM A-105 or ASTM A-216, Grade WCB. Threads shall comply with ASNI B2.1. Outlets shall be Bonney Forge Co. "Thread-o-let", Allied Piping Products Co. "Branch-let," or for contracts between District and Contractor, approved equal.

2. Outlets larger than 2-inches in Diameter: For outlets larger than 2-inches in diameter, flanged tees shall be used.

I. Length of Pipe Sections

Pipe sections shall be limited to 40 feet or less. For sections longer than 30 feet, spreader beams, and lifting straps shall be used to lift pipe sections at the third points.

J. Joints

1. Above Ground Joints: Joints above ground or in vaults and structures shall be flanged or grooved end, unless specifically indicated otherwise on the project plans.

2. Buried Joints: Buried joints shall be:

   a. Bell-and-spigot lap welded.

   b. Butt-strap joints. Closure pieces may also require Butt-strap joints with "hand-holes" and threaded-steel plugs welded into place (for proper repair of the lining of the interior pipe joints.)

3. Grooved-End Joints: Grooved-end joints shall be flexible, square-cut grooved, per AWWA C-606, Table 5.

K. Product Marking

Each length of straight pipe and each special shall be plainly marked inside and out at the bell end to identify the design pressure or head, the steel wall thickness, the date of manufacture, and the proper location of the pipe item by reference to the layout schedule. For beveled pipe, the degree of bevel and the point on the circumference to be laid uppermost shall be shown.

L. Painting and Coating

1. General: Unless noted otherwise, buried pipe shall be cement-mortar coated per AWWA C-205.

2. Exposed Pipe: Pipe located above ground or in vaults and structures shall be painted in accordance with Section 09900, Painting and Coating. Primer shall be shop applied.

3. Grooved-End Couplings: Grooved-end couplings shall be coated the same as the adjacent pipe.

M. Lining

Unless noted otherwise, pipe and fittings shall be cement-mortar lined per AWWA C-205.

PART 3 - EXECUTION

A. Fabrication

1. Reference Standards: Fabrication shall comply with ANSI B31.3, Chapter V. Welding procedure and performance qualifications shall be in accordance with Section IX, Articles II and III, respectively, of the ASME Boiler and Pressure Vessel Code.

2. Welding

a. The pipe cylinder shall be fabricated by butt welding, spiral seam, or straight seam. Girth welds shall be limited to two per pipe section, butt welded. Longitudinal welds shall be limited to one seam. Longitudinal joints of adjacent shell courses shall be staggered.

b. For field welding, the shielded metal arc welding (SMAW) process shall be used. For the shop fabrication of special fittings and appurtenances, the submerged arc welding (SAW) process and the flux cored arc welding (FCAW) process are acceptable alternates. All welding shall be done by qualified, certified welders.

c. Welds shall be in accordance with ANSI B31.3, paragraph 327.4.

d. Welding preparation shall comply with ANSI B31.3, paragraph 327.3. Limitations on imperfections in welds shall conform to the requirements in ANSI B31.3.

e. For the SMAW process, welding electrodes shall comply with AWS A5.1. For the SAW process welding electrodes shall comply with AWS A5.17. For the FCAW process welding electrodes shall comply with AWS A5.20.

f. Each layer of deposited weld metal shall be cleaned using a power-driven wire brush prior to depositing the next layer of weld metal. The final pass shall be cleaned by a power-driven wire brush.

g. For field welds using the SMAW process, a minimum of three passes shall be used for welded joints on pipes 36-inches in diameter and larger. Welds shall be full circumferential.

1. For controlled shop welding processes using SAW or FCAW, weld joints may be made with two passes.

h. Beveled ends for butt welding shall conform to ANSI B16.25. Slag shall be removed by chipping or grinding. Surfaces shall be clean of paint, oil, rust, scale, slag, and other material detrimental to welding. When welding the reverse side, slag shall be chipped out before welding.

B. Joint Ring Protective Coating

The exposed portion of joint rings shall be coated with a 3-mil minimum thickness organic zinc pigmented coating meeting U.S. Federal Specification TT-P-641.

C. Shop Hydrostatic Test

The steel cylinder with joint rings shall be stressed to 75% of the minimum yield stress of the steel.

D. **Shop Testing of Fittings**

1. Dye Penetrant Test: Seams in fittings which have not been previously shop hydrostatically tested shall be tested by the dye penetrant method as described in ASME Boiler and Pressure Vessel Code Section VIII, Appendix B.

2. Air-Soap Test: In addition to the dye penetrant method of testing, the air-soap method with air at 5 psi shall be used on joints susceptible to being tested by such a method.

3. Pressure Test in Lieu of Dye Penetrant Test: In lieu of the dye penetrant method of testing, completed fittings may be hydrostatically tested using the field hydrostatic test pressure or 125% of the design pressure, whichever is higher.

E. **Delivery of Small Parts**

Small parts, consisting of gaskets, bolts, nuts, washers, jumper rods, and flange insulation kits, shall be delivered to the job site in suitable containers, each marked to identify the contents.

F. **Installation**

Pipe shall be installed in accordance with the requirements of Section 15051, Installation of Pressure Pipelines.

G. **Field Inspection of Cement Mortar Lining and Interior Pipe Joints**

The contractor shall perform closed circuit television (CCTV) inspection of the interior of all pipeline segments with diameters less than 30-inches; and for all sections of pipe, regardless of diameter, which are deemed not readily accessible for inspection personnel by the District. Interior pipe inspection shall be in accordance with the requirements of Section 15040, Interior Inspection for Cement Mortar Lined Steel Pipe, 4-inch to 30-inch Diameter.

END OF SECTION

SECTION 15089: COMBINATION AIR RELEASE AND VACUUM RELIEF VALVES

PART 1 - GENERAL

A. Description

This section describes materials and installation of combination air release and vacuum relief valves, hereafter referred to as “valves”, for 4-inch and smaller valves used for potable and non-potable water systems.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900
2. Hydrostatic Testing of Pressure Pipelines: 15042
3. Manual Valves: 15100

C. Submittals (For Contracts Between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.
2. Submit manufacturer's catalog data. Show dimensions, materials of construction by ASTM reference and grade, and protective coating and lining.

PART 2 - MATERIALS

A. Valves

1. Valves shall be 1-inch, 2-inch, 3-inch or 4-inch in diameter and shall include:
   a. A float assembly and large venting orifice to exhaust large quantities of air from pipelines when being filled and to admit large quantities of air when pipelines are being drained. Valves shall have a body with a flanged or threaded top containing the air release orifice. The float shall rise with the water level in the valve body to close the orifice by sealing against a synthetic rubber seat. The float shall withstand an external pressure of 1,000 psig without collapsing.
   b. 1-inch and 2-inch valves and shall include a 3/8-inch threaded outlet with stainless steel plug in the top cover or near the bottom of the valve body. 3-inch and 4-inch valves shall include a 1-inch threaded outlet with stainless steel plug near the bottom of the valve body or on the side of the valve body above the minimum water level.

2. Materials of construction for valves shall be as follows:

Item	Material	Specification
Body and cover	Cast iron or stainless steel with reinforced nylon	ASTM A 126, Class B
Float	Stainless steel or foamed polypropylene	Stainless steel: AISI Type 316, ASTM A 240 or A 276 Foamed Polypropylene: ASTM-1895-89
Guide rod, guide bushings	Stainless steel	AISI Type 316, ASTM A 240 or A 276
Seat	EPDM	---
Valve trim	Stainless steel	AISI Type 316, ASTM A 240 or A 276
Cover bolts	Stainless steel	AISI Type 316, ASTM A 193, GR B8M

3. Valves shall be designed for an operating pressure of 150 psi unless otherwise specified in the plans or specifications. Valves shall be APCO 140C/150C series; Val-Matic Model 200C series, A.R.I. D-040 ST, or Crispin UL series, or for contracts between District and Contractor, approved equal.

B. Valve End Connections

1. Applications: 1-inch and 2-inch valves shall have threaded ends at the bottom of the body. 3-inch and 4-inch valves shall have flanged ends.

2. Threaded Connections: Threaded ends shall comply with ANSI B1.20.1.

3. Flanged Connections: Flanges for Class 150 valves shall comply with ANSI B16.1, Class 125. Flanges for Class 300 valves shall comply with ANSI B16.1, Class 250.

C. Bolts and Nuts for Flanged Valves

1. Bolts and nuts for flanged valves and flanges shall be Type 316 stainless steel conforming to ASTM A 193, Grade B8M, for bolts and ASTM A 194, Grade 8M, for nuts.

2. Washers shall be provided for each nut, shall be of the same material as the nut, and shall be installed adjacent to the nut, between the nut and the flange.

3. The length of each bolt or stud shall be such that between 1/4 inch and 1/2 inch will project through the nut when drawn tight.

D. Gaskets

Gaskets for flanged end valves shall be as described in the individual piping specifications.

E. Coating

Valves shall be coated on the exterior in accordance with Section 09900, Painting and Coating. Prime coat shall be shop-applied at the place of manufacture. Finish coat shall be applied in the field. Color of finish coat shall match the color of the adjacent piping.

F. Lining

Interior surfaces of the valves shall be coated in accordance with Section 09900, Painting and Coating, System No. G-1. Seating areas and plastic, stainless steel, or other high alloy parts shall not be coated.

G. Vented Cover

1-inch and 2-inch valves shall be enclosed inside a removable vented cover as shown in the IRWD Standard Drawings. Vented covers shall be manufactured of linear-low-density polyethylene (LLDPE) as made by Armorcast Products or by Pipeline Products, Inc.

3-inch and 4-inch valves shall be enclosed inside a removable, cylindrically-shaped, vented cover fabricated of welded steel pipe, hot dip galvanized after fabrication and painted in accordance with Section 09900, Painting and Coating.

PART 3 - EXECUTION

A. Installation

Valves shall be installed in accordance with the IRWD Standard Drawings.

1. Tap: The tap for the valves shall be made in a level section of pipe no closer than 18 inches to a bell, coupling, joint, or fitting.

2. Threaded Connections: Threaded joints shall be cleaned by wire brushing or swabbing. Teflon joint compound or Teflon tape shall be applied to pipe threads before installing threaded valves. Joints shall be watertight.

3. Flanged Connections: Flanges shall be cleaned by wire brushing before installing flanged valves. Flange bolts and nuts shall be cleaned by wire brushing, and threads shall be coated with anti-seize compound. Nuts shall be tightened uniformly, and in the sequence pattern and torque setting recommended by the manufacturer. If flanges leak under pressure testing, nuts and bolts shall be loosened or removed, the gasket reseated or replaced, the bolts and nuts reinstalled or retightened, and joints retested. Joints shall be watertight.

B. Valve Pressure Testing

Valves shall be pressure tested at the same time that the connecting pipelines are pressure tested. See Section 15042, Hydrostatic Testing of Pressure Pipelines, for pressure testing requirements. Valves, operators, or control and instrumentation systems whose pressure rating is less than the test pressure shall be protected or isolated during pressure testing.

END OF SECTION

SECTION 15100: MANUAL VALVES

PART 1 - GENERAL

A. Description

This section describes materials, testing, and installation of manually operated valves and check valves.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900
2. Hydrostatic Testing of Pressure Pipelines: 15042

C. Submittals (For Contracts Between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.

2. Submittals shall include the following information at a minimum. Factory signed and dated certification of compliance shall accompany all submittals. Signatures of agents or distributors of the factory will not be accepted.

   a. Manufacturer's catalog data and detail construction sheets showing all valve parts and describing materials of construction by material and specification (such as AISI, ASTM, SAE, or CDA).

   b. Valve dimensions including laying lengths.

   c. Dimensions and orientation of valve actuators, as installed on the valves.

   d. Valve linings and coatings.

   e. Factory torque sheets minimally supplying actuator output and valve input torque requirements. Method for calculating input torque shall be the same as per AWWA Class 150B designation.

   f. Manufacturer’s warranty. Where electric motor actuators are used, the valve manufacturer shall include the electric motor actuator warranty and shall be the responsible party for both the valve and the electric actuator. Electric motor actuators shall be installed by the valve manufacturer to maintain both manufacturer warranties.

D. Valve Selection Criteria

Selection of the type of valve for a given application within IRWD's distribution and transmission system shall follow the criteria defined below.

Selection Criteria			
Nominal Valve Diameter (inches)	**Normal System Static Operating Pressure (0 to 100 psi)**	**Normal System Static Operating Pressure (100 to 150 psi)**	**Normal System Static Operating Pressure (150 to 250 psi)**
3 and smaller	Ball	Ball	Ball
4	Gate	Gate	CL 250 Butterfly
6	Gate	Butterfly	CL 250 Butterfly
8	Gate	Butterfly	CL 250 Butterfly
10	Gate	Butterfly	CL 250 Butterfly
12 and larger	Butterfly	Butterfly	CL 250 Butterfly

PART 2 - MATERIALS

A. <u>General</u>

Valves shall be provided complete with operating hand-wheels, levers, chain-wheels, extension stems, floor stands, worm gear actuators, operating nuts, chains, and wrenches as required for operation.

Valves shall have the name of the manufacturer and the size of the valve cast or molded onto the valve body or bonnet or shown on a permanently attached corrosion-resistant plate.

B. <u>Resilient Seated Gate Valves, 4-inch through 10-inch</u>:

Resilient seated wedge-type, gate valves shall conform to AWWA C-509 and the following requirements.

1. Valves shall have a wedge-type resilient seat fully encapsulated in peroxide-cured EPDM.

2. Valves shall be designed for a minimum working pressure of 200 psi.

3. Valves shall have non-rising stems fabricated of Type 304 or 316 stainless steel. As an alternate, stem material may be high strength bronze alloy. Stem nuts shall be independent of the gate and shall be made of bronze.

   Materials of construction shall be as follows:

Component	Material	Specification
Body, Operating Nut, Bonnet, Seal Plate	Cast Iron or Ductile Iron	ASTM A-126, Class B; or ASTM A-536, Grade 65-45-12
Gate	Cast Iron or Ductile Iron	ASTM A-126, Class B; or ASTM A-536, Grade 65-45-12
Stem	Stainless Steel or high-strength, low zinc Bronze	AISI 430F; ASTM A-582 or Type 316; ASTM B-584 CDA 867
Stem Nut	Bronze	ASTM A-116 CDA 844
Nuts & Bolts	Stainless Steel	ASTM A-276, Type 316
Valve Seat	EPDM Rubber	ASTM D-412
O-Rings	Synthetic Rubber	ASTM D-2000

Low friction, torque reduction thrust bearings shall be provided both above and below the stem collar. Stuffing boxes shall be O-ring seal type with two rings located in stem above thrust collar.

Each valve shall have a smooth unobstructed waterway free from any sediment pockets. Gates shall be of the wedge-type and shall be encapsulated in peroxide-cured EPDM rubber.

Valves shall be American AVK, Clow RW, M&H Style 4067, Matco Norca, Mueller A2360, U.S. Pipe or for contracts between District and Contractor, approved equal.

C. **Butterfly Valves 4-inch and Larger:**

Butterfly valves shall be short body, flanged type, conforming to AWWA C-504, Class 150B. Wafer style valves shall not be used.

Unless otherwise noted, minimum working differential pressure across the valve disc shall be 150 psi.

Valve ends shall be as shown on the drawings and in all cases shall match the class rating of the valve. For example, Class 150 valves shall have 150-lb flanges and Class 250 valves shall have 250-lb flanges. Flanged ends shall be Class 125, ANSI B-16.1 unless otherwise specified. Note that all butterfly valves 12-inch in diameter and larger are required to have flanged ends to meet the requirements for valve leakage testing. Refer to Part 3, sub-section D, paragraph 2 for testing requirements.

Valve shafts shall be Type 304 or 316 stainless steel for Class 150 valves and 17-4 PH stainless steel for Class 250 valves. Valve shafts may be stub shaft or one-piece units extending completely through the valve disc.

Materials of construction shall be as follows:

Component	Material	Specification
Body	Cast Iron or Ductile Iron	ASTM A-126, Class B; or ASTM A-536, Grade 65-45-12
Valve Shaft (CL 150)	Stainless Steel	Type 304 or Type 316
Valve Shaft (CL 250)	Stainless Steel	Type 17-4
Exposed body cap screws, bolts & nuts (including squeeze-pins)	Stainless Steel	ASTM A-276, Type 316
Discs	Cast Iron or Ductile Iron	ASTM A-48, Class 40; or ASTM A-536, Grade 65-45
Valve Seat	EPDM Rubber	ASTM D-412
O-Rings	Synthetic Rubber	ASTM D-2000

The rubber seat shall be made from peroxide-cured EPDM rubber and shall be fastened integrally within the valve body. Rubber seats fastened to the disc by any means shall not be allowed.

Valves shall be Crispin K-Flo Series 47 or 500, Dezurik BAW, Mueller Lineseal, Pratt Groundhog, or for contracts between District and Contractor, approved equal.

D. Other Valves

The following valves shall be used as specified in the Contract Documents.

1. Above Ground Valves 3-inch and Smaller:

Ball valves shall be used for above ground valves 3-inch and smaller.

Ball valves for water service shall be the three-piece body style and shall be Type 316 stainless steel. The minimum design operating pressure rating shall be 300 psi WOG at a temperature of 150° F.

Valves shall have plastic coated stainless steel lever actuators with a locking mechanism. Valves shall have full-bore ports, female iron pipe thread screwed ends, and non-blowout stems.

Materials of construction shall be as follows:

Component	Material	Specification
Body, Ball, Stem	Stainless Steel	Type 316, ASTM A-276
Seat, Seals	Teflon	--

Valves shall be Apollo, Sharpe, Stockham Figure S-127, Xomox, or for contracts between District and Contractor, approved equal.

2. Ball Valves 4-inch through 12-inch:

Ball valves 4-inch through 12-inch shall be rated for a minimum working pressure of 150 psi. Ball valves shall meet or exceed the requirements of AWWA C-504 and C-507 and shall have flanged ends. Valves shall have Proof of Design testing with documentation per AWWA C507.

Valves shall be of the "double-seated" style and shall provide drip-tight closure in both directions.

Materials of construction shall be as follows:

Component	Material	Specification
Body, Ball	Ductile Iron	ASTM A-536, 65-45-12; ASTM A-395/395M
Stem, Shaft	Stainless Steel	18-8 Type 304 or 17-4 Type 630
Seat, Seals	EPDM Rubber	--

External valve trim and all exposed threaded components shall be corrosion resistant alloys of stainless steel, Type 316L or District approved equival.

Valves shall be Jamesbury Series 9000, Pratt rubber-seated, or for contracts between District and Contractor, approved equal.

3. Lubricated Plug Valves 6-inch through 20-inch:

Lubricated plug valves of sizes 6-inch through 20-inch shall have cast iron (ASTM A-126, Class B) bodies and plugs. Valves shall be of the regular pattern with bolted glands and resilient packing. Plug coating shall be Teflon, permanently bonded to the plug. Unless noted otherwise on the drawings, valve ends shall be flanged, with face-to-face dimensions conforming to ANSI B-16.1, Class 125. Valve shall have a pressure rating of 200-psi WOG. Valves shall be enclosed worm gear operated and watertight for submerged service. Valves shall be lubricated with the manufacturer's recommended lubricant for cold-water service.

External valve trim and all exposed threaded components shall be corrosion resistant alloys of stainless steel, Type 316L.

Valves shall be Galli & Cassina, Nordstrom, or for contracts between District and Contractor, approved equal.

4. Eccentric Plug Valves, 4-inch through 12-inch:

Eccentric plug valves, 4-inch through 12-inch shall be of the non-lubricated type. Minimum pressure rating shall be 175 psi. Unless noted otherwise on the drawings, ends shall be flanged, Class 125 per ANSI B-16.1. Plugs shall be provided with Polytetrafluoroethylene (PTFE) grit excluders to protect the upper and lower journal bearings. Materials of construction shall be as follows:

Component	Material	Specification
Body	Cast Iron	ASTM A-126, Class B
Plug	Cast Iron, Ductile Iron	ASTM A-126, Class B; ASTM A-536, Grade 65-45-12
Journal Bearings	Sintered Stainless Steel	ANSI 316

Plugs shall have neoprene, Buna-N facing to provide drip-tight shutoff.

Valve body seats shall have a raised welded-in overlay of not less than 90 percent nickel. Plug shall be of the one-piece design. Proof of design shall accompany submittals and leak tests shall accompany shipment.

External valve trim and all exposed threaded components shall be corrosion resistant alloys of stainless steel, Type 316L.

Valves shall be Dezurik Series 100 PEC, Pratt-Milliken 600 series, or for contracts between District and Contractor, approved equal.

5. Check Valves 4-inch and Larger:

a. Swing Check Valves: Swing check valves shall conform to AWWA C-508, and shall be iron body, bronze mounted with the following materials of construction:

Component	Material	Specification
Disc, disc seat ring, valve body seat ring	Bronze or Brass	ASTM B-62, B-16, or B-584 (alloys C-84400 or C-87600)
Body and Cap	Cast Iron or Ductile Iron	ASTM A-126, Class B; or ASTM A-536, Grade 65-45-12
Hinge or Arm	Cast Iron	ASTM A-126, Class B
Hinge Pin	Stainless Steel	ASTM A-276, Type 303, 304 or 410
Cover Bolts & Nuts	Stainless Steel	ASTM A-193, Grade B8M; ASTM A-194, Grade 8M

Ends shall be flanged, Class 125, ANSI B-16.1. Valves shall be designed for a minimum working pressure of 150 psi.

Valve shall be equipped with outside lever and spring.

Valves shall be Clow 1106 M&H Style 259, Pratt Series 8001, or for contracts between District and Contractor, approved equal.

b. Silent Check Valves, Class 150: Silent check valves shall be designed to be installed between the flanges of the adjoining pipe. Valves shall be equipped with a spring mechanism to provide for non-slam closure of the valve without backflow, in any position, and shall not be dependent on gravity or backflow for closure.

Materials of construction shall be as follows.

Component	Material	Specification
Body	Cast Iron or Ductile Iron	ASTM A-126, Class B; or ASTM A-536, Grade 65-45-12
Disc	Bronze or aluminum bronze	ASTM B-584 or ASTM B-148
Spring, Pin, Stops	Stainless Steel	ANSI Type 316
Seat	EPDM Rubber	ASTM D-412

Valves shall be APCO Series 600, Pratt Series 821, Titan CV 50-DI-B or for contracts between District and Contractor, approved equal.

6. <u>Solenoid Valves 1-1/2-inch and Smaller</u>:

Solenoid valves of sizes 1/4-inch through 1-1/2-inch for water and air service shall have forged brass (Alloy C-23000) or bronze (ASTM B-62) bodies with Teflon main seats. Internal plunger, core tube, plunger spring, and cage assembly shall be stainless steel (Types 302, 304, or 305). Solenoid enclosures shall be NEMA Type 4. Valve actuators shall be 120-volt AC or 24-volt DC as stated on the plans. Seals shall be Teflon. Valves shall have a maximum operating pressure and a maximum differential pressure of 250 psi.

Solenoid valves shall be energized to open or close, as required. Valves shall be ASCO "Red Hat" only, and there are no equals.

7. <u>Tapping Valves</u>:

Tapping valves shall conform with the requirements for resilient wedge gate valves 4-inch and larger. Valve ends shall be flanged, and the flange at one end shall have slotted bolt holes to fit standard tapping machines. Seat rings shall be oversized to permit the use of full-size cutters. Tapping valves shall be Kennedy, Mueller, or for contracts between District and Contractor, approved equal.

E. Valve Actuators

1. <u>General Requirements for Gear Actuators</u>:

   a. Gear actuators shall be enclosed, suitable for operating in grease with seals provided on shafts to prevent entry of dirt and water into the actuator.

      i. External trim and all threaded parts of the actuator shall be Type 316 stainless steel material.

   b. Gear actuators shall be of the totally enclosed design, proportioned to permit operation of the valve under full operating head in either direction, with a maximum pull of 80 pounds on the handwheel or with a maximum input of 150 ft-lbs applied to the AWWA wrench nut. Design and torque capacity shall consider flow and shut-off in "BOTH" directions.

   c. Actuators shall be provided with "open" and "closed" position stop limiting devices. Actuators shall be of the self-locking type to prevent the valve disc or plug from creeping.

2. <u>Standard Opening Direction</u>: Valve actuators, handwheels, or levers shall open by turning counterclockwise. (Commonly stated as, "open-left – close-right".)

3. <u>AWWA wrench nut</u>: Valves for buried and submerged applications shall be provided with a 2-inch square AWWA wrench nut. The wrench nut shall have an arrow cast thereon, indicating the direction of opening. The wrench nut shall be suitably fastened to the actuator input shaft. If the shaft is smooth, the wrench nut shall be fastened to the input shaft by means of a 5/16-inch diameter stainless steel pin passing entirely through the shaft and the wrench nut. Key with keyway shall also be acceptable. If the shaft is splined, the wrench nut shall be formed to fit the splined shaft.

   a. <u>Operating Torque Requirement</u>: The actuator shall be designed to produce the specified torque with a maximum input of 150 ft-lbs applied to the wrench nut (at the maximum rated pressure and a velocity of 16 cfs.)

4. <u>Handwheels</u>: Valves for aboveground applications shall be provided with a handwheel with a minimum diameter of 12-inches. The handwheel shall have an arrow thereon, indicating the direction of the opening. The handwheel shall be suitably fastened to the actuator input shaft.

   a. <u>Operating Torque Requirement</u>: Actuators equipped with handwheels shall be designed to produce the specified torque with a maximum pull of 80 pounds of the handwheel rim.

5. <u>Position Indicators</u>: Valve position indicators shall be provided for all above ground valves. Submerged and buried valves shall have a water tight seal plate in place of the valve position indictor. No rotating part indicating position shall be allowed for valves intended for buried service.

6. <u>Operators for Exposed Valves Smaller than 6-inch</u>: Unless otherwise called for on the plans or specifications, lever or wrench actuators having adjustable, open stop memory positions shall be provided for exposed valves smaller than 6-inch.

7. <u>Actuators for Valves 4-inch and Larger</u>

   a. Butterfly Valves

      i. 4-inch through 20-inch diameter butterfly valves shall have gear actuators of the "traveling nut type". Traveling nut actuators shall be furnished on all valves in this size range unless torque or pressure conditions dictate a “worm gear type”.

      ii. 24-inch through 54-inch diameter butterfly valves shall have gear actuators of the "worm gear type". Worm gear actuators shall be furnished on all valves in this size range.

   b. Ball and Plug Valves

      i. Ball and plug valves 6-inch and larger shall have actuators of the "worm gear type"

8. <u>Requirements for Traveling Nut Gear Actuators</u>

   a. Traveling nut actuators shall withstand 450 foot pounds of input torque against the stop limiting devices without causing damage.

   b. Signed factory compliance shall accompany submittals stating that these specifications and applicable standards have been adhered to.

   c. All exposed threaded parts, including cap screws, case bolts, carriage bolts, cover screws, machine screws, set screws, bonnet bolts on the housing or any other exterior location on the actuator, its cover or housing shall be Type 316 stainless steel.

   d. Traveling nut type gear actuators shall be able to rotate the valve element (disc, plug, or ball) from the fully "closed" position to the fully "open" position with a number of turns of the actuator nut or wheel. For 4-inch through 10-inch valves, the number of turns shall not be fewer than twenty nine (29) turns. For 12-inch through 20-inch valves, the number of turns shall not be fewer than twenty nine (29) turns and not more than three (3) times the number of diameter inches.

      i. Where the number of turns may fall outside of the range for turn limits, the use of a factory attached spur gear reducer shall be used to provide the appropriate number of rotations from the fully "open" to the fully "closed" position. Spur gear assemblies shall be mounted integrally to the actuator by approved means and shall meet all of the other component and torque requirements listed herein.

e. Actuators shall be Dezurik M-Series, Mueller MDT, Pratt MDT, or for contracts between District and Contractor, approved equal.

f. Refer to the following table for actuator selection and characteristics for traveling nut gear operators for 150 and 250 psi:

Valve Actuator Selection – Traveling Nut							
Nominal valve diameter (inches)	**IRWD Specified Range of Valve Turns (number)**	**Dezurik Actuator Model**	**Actuator Turns – open to close (number)**	**Mueller Actuator Model**	**Actuator Turns – open to close (number)**	**Pratt Actuator Model**	**Actuator Turns – open to close (number)**
4	29	MB-3	29	MDT-2S	32	MDT2S	32
6	29	MB-3	29	MDT-2S	32	MDT2S	32
8	29	MB-3	29	MDT-2S	32	MDT2S	32
10	29	MB-3	29	MDT-2S	32	MDT2S	32
12	29 - 36	MB-3	29	MDT-2S	32	MDT2S	32
14	29 - 42	MB-3	29	MDT-3S	30	MDT3S	30
16	29 - 48	MB-7	42	MDT-3S	30	MDT3S	30
18	29 - 54	MB-7	42	MDT-4S	40	MDT4S	40
20	29 - 60	MB-7	42	MDT-4S	40	MDT4S	40

9. <u>Requirements for Worm Gear Actuators</u>

a. Worm gears shall be of the "self-locking" one-piece design of gear bronze material (ASTM B-427), accurately machine cut.

b. The worm shall be hardened alloy steel (ASTM A-322, Grade G 41500; or ASTM A-148, Grade 105-85), with threads ground and polished.

i. The reduction gearing shall run in a proper lubricant inside a ductile iron housing.

c. All exposed (at the exterior of the actuator) threaded parts, including cap screws, case bolts, carriage bolts, cover screws, machine screws, set screws, bonnet bolts on the housing or any other exterior location on the actuator, its cover or housing shall be Type 316 stainless steel.

d. Actuator components shall be designed to withstand a pull of 200 pounds for handwheel or chain wheel actuators between the input and stop limiting devices without damage, and an input torque of 300-foot-pounds for operating nuts when operating against the stops.

e. Gear actuators shall be able to rotate the valve element (disc, plug, or ball) from the fully "closed" position to the fully "open" position with a number of turns of the actuator nut or wheel, not fewer than one-and-a-half (1.5) times the number of diameter inches and not more than three (3) times the number of diameter inches.

i. Where the number of turns may fall outside of the range for turn limits, the use of a factory attached spur gear reducer shall be used to provide the appropriate number of rotations from the fully "open" to the fully "closed" position. Spur gear assemblies shall be mounted integrally to the actuator by approved means and shall meet all of the other component and torque requirements listed herein.

g. Actuators shall be Auma GS Series, EIM Model WB Series, or Limitorque Model HBC or PT Series, and there are no equals.

h. Refer to the following tables for actuator selection and characteristics for worm gear actuators for 150 psi valves and for 250 psi valves:

150 psi Valve Actuator Selection – Worm Gear							
Nominal valve diameter (inches)	**IRWD Specified Range of Turns (number)**	**AUMA Make & Model [model/gear]**	**Turns open - close (number)**	**EIM Actuator Make & Model**	**Turns open - close (number)**	**Limitorque Make & Model [model/gear]**	**Turns open - close (number)**
24	36 - 72	GS125.3	* 13	EIM WB52	64	PTA30/3.5	60
30	45 - 90	GS 160.3/GZ 160.3 4:1	* 54.5	EIM WB52	64	PTA65/3.1	47
36	54 - 108	GS 160.3/GZ 160.3 4:1	* 54.5	EIM WB54	70	PTA120/6.3	95
42	63 - 126	GS 200.3/GZ 200.3 8:1	* 108.5	EIM WB54	70	PTA120/6.3	95
48	72 - 144	GS 250.3/GZ 250.3 8:1	* 103	EIM WB65	* 148	PTA250/6	96
54	81 - 162	GS 250.3/GZ 250.3 8:1	* 103	EIM WB65	148	PTA250/18	* 288
250 psi Valve Actuator Selection – Worm-Gear							
Nominal valve diameter (inches)	**IRWD Specified Range of Turns (number)**	**AUMA Make & Model [model/gear]**	**Turns open - close (number)**	**EIM Actuator Make & Model**	**Turns open - close (number)**	**Limitorque Make & Model [model/gear]**	**Turns open - close (number)**
24	36 - 72	GS125.3	* 13	EIM WB52	64	PTA30/3.5	60
30	45 - 90	GS 160.3/GZ 160.3 4:1	* 54.5	EIM WB52	64	PTA65/3.1	47
36	54 - 108	GS 160.3/GZ 160.3 4:1	* 54.5	EIM WB54	70	PTA120/6.3	95
42	63 - 126	GS 200.3/GZ 200.3 8:1	* 108.5	EIM WB65	* 148	PTA120/6.3	95
48	72 - 144	GS 250.3/GZ 250.3 8:1	* 103	EIM WB65	* 148	PTA250/6	96
54	81 - 162	GS 250.3/GZ 250.3 8:1	* 103	EIM WB74	* 270	PTA250/18	* 288

* indicates number of turns does not meet IRWD requirement and spur-gear reduction is required to correct. Spur-gear submittal is required. See paragraph 9.e.i above.

F. Valve Boxes, Risers and Lids for Buried Valves

1. General:

   Valve riser shall be 8-inch Schedule 40 PVC pipe, or 8-inch SDR 35 PVC pipe.

2. Valve Box Lids:

   Valve box lids shall be cast-iron and shall be designed to rest without a frame on a cast-in-place concrete ring surrounding the valve extension pipe. The lid skirt shall be 6 inches deep. The minimum weight of nominal 10-inch lid shall be 40 pounds. The lids shall be in accordance with IRWD Standard Drawing W-22.

   Lids shall be coated per Section 09900, Painting and Coating, System No. C-1.

3. Manufacturers:

   Valve boxes for potable water lines shall be round in shape and shall be Brooks 3-RT, Eisel Enterprises, Inc. H & C No. 10, or for contracts between District and Contractor, approved equal.

   Valve boxes for recycled and raw water lines shall be triangular in shape and shall be Brooks 4-TT, Eisel Enterprises, Inc. H & C 4TT, or for contracts between District and Contractor, approved equal.

G. Extension Stems for Buried Valve Operators

Where the depth of the valve is such that its operating nut is more than 5 feet below grade, operating extension stems shall be provided to bring the operating nut to a point between 24 to 36 inches below the surface of the ground and/or box cover.

Extension stems shall be solid Type 316 stainless steel, and shall be complete with 2-inch square operating nut.

No pinned couplings are permitted.

Extension stems shall conform to IRWD Standard Drawings.

H. Bolts, Nuts, and Washers for Flanged Valves

1. Bolts and nuts for flanged valves and flanges shall be Type 316 stainless steel conforming to ASTM A 193, Grade B8M, for bolts and ASTM A 194, Grade 8M, for nuts.

2. Washers shall be provided for each nut, shall be of the same material as the nut, and shall be installed adjacent to the nut, between the nut and the flange.

3. The length of each bolt or stud shall be such that between 1/4 inch and 1/2 inch will project through the nut when drawn tight.

I. **Gaskets for Valves**

Gaskets for flanged end valves shall be as described in the individual piping specifications.

J. **Painting and Coating for Valves and Extensions:**

1. Exterior Coating:

   Metal valves (except bronze and stainless steel valves) shall be coated in accordance with Section 09900, System No. D-1 or System No. G-1 and shall be holiday free.

   a. The specified prime coat shall be applied at the place of manufacture.

   b. Finish coat shall match the color of the adjacent piping.

   c. Exposed portions of the valve shaft shall not be coated.

2. Interior Coating:

   Metal valves shall be coated on the interior metal parts, excluding seating areas and bronze and stainless steel pieces, per Section 09900, Painting and Coating, System No. G-1 or System No. G-2.

   a. Coating shall be factory applied by the valve manufacturer.

   b. Valve coatings will be field spark tested and shall be holiday-free.

PART 3 - EXECUTION

A. **Joints**

1. Flanged Joints: Bolt holes of flanged valves shall straddle the horizontal and vertical centerlines of the pipe run to which the valves are attached. Flanges shall be cleaned by wire brushing before installing flanged valves. Flange bolts and nuts shall be cleaned by wire brushing, threads shall be lubricated with anti-seize compound, and nuts shall be tightened uniformly and progressively.

   If flanges leak under pressure testing, nuts and bolts shall be loosened or removed, the gasket shall be reseated or replaced, the bolts and nuts shall be reinstalled or re-tightened, and the joint retested. Joints shall be watertight.

2. Threaded Joints: Threaded joints shall be cleaned by wire brushing or swabbing. Teflon joint compound or Teflon tape shall be applied to pipe threads before installing threaded valves. Joints shall be watertight.

B. **Valve Installation**

1. Valves in Vertical Piping: Valves on vertical runs of pipe that are next to walls shall be installed with their stems horizontal, away from the wall. Valves on vertical runs of pipe that are not located next to walls shall be installed with their stems horizontal, oriented to facilitate valve operation.

2. Buried Valves: Buried valves shall be wrapped with two layers of 8-mil polyethylene wrap per AWWA C-105.

3. Valve Supports: Valves shall be anchored in concrete as shown on IRWD Standard Drawing W-16 or on the valve detail drawings. Supports are not required for buried valves bolted to flanged pipe or other fixed or supported fittings. Supports shall be installed prior to pressurizing the system.

C. Valve Boxes

Valve boxes shall be firmly supported and shall be kept centered and plumb over the operating nut of the valve.

Beveled sections of pipe shall not be allowed at the top of the valve riser pipe. The top cut shall be square and machine made.

In new tracts, and where pavement has not been placed, the valve extension risers for "key valves" shall extend well above the ground level to permit ease of location in the event of the need for emergency shut-off. The final valve box elevation shall be flush with the finished pavement surface, or at the level shown on IRWD Standard Drawing W-22.

D. Valve Leakage Testing

1. Field Hydrostatic Testing:

   Valves shall be tested for leakage at the same time that the connecting pipelines are hydrostatically tested. See Section 15042, Hydrostatic Testing of Pressure Pipelines, for pressure testing requirements.

2. Pressure Testing:

   All butterfly valves 12-inch in diameter and larger, shall be flanged to facilitate testing. Valves 12-inch through 30-inch in diameter shall be tested in a horizontal position. Valves 36-inch in diameter and larger shall be tested in the vertical position (valve flange face oriented 90 degrees from the horizontal ground surface plane; with the shaft axis parallel to the ground).

   All valves shall be tested bi-directionally after the actuator is installed and the adjustment stops are set. Each side of the valve shall be tested for a duration of at least 5 minutes at the pressure class rating of the valve with zero loss or leakage. Valve bodies shall be tested at a pressure equal to twice the design working pressure.

   The pressure test shall be witnessed by an IRWD representative. Final tests shall be performed within 20 miles of the project site. The Contractor shall provide a minimum of 72 hours notice to IRWD in advance of the pressure test.

Factory hydrostatic testing shall be conducted in advance of the final leakage testing. The District shall be given an opportunity to send a representative to witness the factory test. The Contractor shall notify an IRWD representative in writing 28 days in advance of all factory leakage tests.

END OF SECTION

SECTION 15112: BACKFLOW PREVENTERS

PART 1 - GENERAL

A. Description

This section includes materials, installation, and testing of backflow prevention assemblies.

B. Related Work Specified Elsewhere

1. Copper Pipe and Fittings: 15057.
2. Manual Valves: 15100.
3. Meters: 15150.

C. Submittals (For Contracts Between the District and Contractor)

1. Submit shop drawings in accordance with the General Provisions and the following.
2. Submit certification showing that the backflow device is approved by the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, School of Engineering.

PART 2 - MATERIALS

A. Shut-Off Valves

1. Gate Valves: The shut-off valves shall be resilient wedge gate valves conforming to Section 15100, except that these valves shall have outside stems and yokes.
2. Ball Valves: Valves two-inches and smaller shall be ball valves conforming to the requirements of Section 15100.

B. Fireline By-Pass Piping

By-pass piping shall be copper or brass conforming with Section 15057, Copper Pipe and Fittings. The by-pass shall include a meter conforming to the requirements of Section 15150 and an approved backflow prevention assembly. Refer to the IRWD Standard Drawings.

C. Backflow Prevention Assembly

Backflow prevention assemblies shall conform to the latest editions of AWWA C510 or C511 and the "Manual of Cross-Connection Control", Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, School of Engineering.

D. By-Pass Meter and Backflow Prevention Assembly

The by-pass meter shall conform with the requirements of Section 15150, Meters, and shall be compatible with the main backflow device to which it is installed. The backflow prevention assembly and the by-pass meter and by-pass backflow prevention assembly shall all be furnished as one complete unit. The by-pass meter shall be 5/8-inch by 3/4-inch size.

PART 3 - EXECUTION

A. Installation

Installation shall comply with the requirements of the IRWD Standard Specifications and Standard Drawings and the latest edition of the Manual of Cross-Connection Control, and with the latest plumbing codes and applicable local agency requirements.

B. Testing

Upon completion of the installation of the device, a test shall be performed and a certificate of the adequacy and operational compliance shall be furnished to the District. The test shall be performed by an approved testor by the Orange County Health Department. An initial test shall be provided at the time the device is placed into service. Recurring tests are required annually thereafter.

END OF SECTION

SECTION 15120: HYDRAULICALLY CONTROLLED DIAPHRAGM-ACTUATED VALVES

PART 1 - GENERAL

A. Description

This section describes materials and installation of hydraulically controlled diaphragm-actuated valves acting as pressure reducing valves, pressure sustaining valves, solenoid control valves, booster pump control valves, and altitude valves.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900

2. Hydrostatic Testing of Pressure Pipelines: 15042

C. Submittals (For Contracts Between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.

2. Submit dimensional drawings for each size and type of valve provided.

3. Provide listing of materials of construction, with ASTM reference and grade. Show valve lining and paint primer coating with coating manufacturer and coating system number or designation.

4. Submit electrical drawings, (including P&ID's) showing wire and terminal connections, for valves that are electrically controlled.

5. Submit manufacturer's recommended maximum operating pressure and minimum and maximum recommended flows.

PART 2 - MATERIALS

A. Valve Design

1. General: Valves shall be hydraulically actuated diaphragm type. The body shall contain a removable seat insert. A resilient rubber disc shall form a drip-tight seal with the valve seat when pressure is applied above the diaphragm. The diaphragm assembly shall form a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure.

2. Component Parts: The pilot control system shall include a fixed or variable orifice, and all major components of this system, except solenoid pilots, shall be manufactured by the same company that manufactures the main valve.

   Elastomers shall be EPDM rubber material. The diaphragm shall not be used as a seating surface.

The valve stem shall be center guided or top and bottom guided. The stem orientation is to be vertical. For top and bottom stem guides, bearings in the valve cover and in the valve seat shall be provided. For center guided valve stems, a bearing in the valve cover shall be provided. Stem sleeves or bearings shall have an anti-scale treatment or other approved friction reducing surface.

A valve position limit switch shall be provided.

Repairs and modification other than the replacement of the main valve body shall be possible without removing the main valve from the line.

B. Valves

1. Class 125 (150 psi) or Class 250 (300 psi) Pressure-Reducing Valves: Pressure reducing valves shall automatically maintain a constant downstream pressure regardless of changing flow rates and/or varying inlet pressures. The pilot control shall be direct-acting, spring loaded, diaphragm valve, designed to permit flow when controlled pressure is less than the spring setting. The pilot control system shall be provided with a strainer, isolation valves, opening speed control, closing speed control, and, where required for low flow, a flow stabilizer or V-port throttling plug. See General Requirements, Division 1 for pressure ranges and initial pressure settings. The valve shall be globe pattern Cla-Val 90-01 Series or Ames ACV 910 Series "Mustang Valve" and there is no equal.

2. Class 125 (150 psi) or Class 250 (300 psi) Pressure Sustaining or Pressure Relief Valves: Pressure sustaining/relief valves shall maintain a constant upstream pressure by relieving excess pressure without causing surges. The pilot control system shall operate such that as excess line pressure is dissipated, the valve shall slowly close. The pilot control shall be a direct acting, spring-loaded, diaphragm valve, designed to permit flow when controlling pressure exceeds a spring setting. The pilot control system shall be provided with a strainer, isolation valves, opening speed control (pressure sustaining valves only), and closing speed control. See General Requirements, Division 1 for pressure ranges and initial pressure settings. The valve shall be globe pattern Cla-Val 50-01 Series or Ames ACV 920 Series "Mustang Valve" and there is no equal.

3. Class 125 (150 psi) or Class 250 (300 psi) Solenoid Control Valves: Solenoid control valves shall provide on or off service for controlling flow. The pilot control shall be a three-way solenoid valve as specified herein. The pilot control system shall be provided with strainers, isolation valves, opening speed control, and closing speed control. See General Requirements, Division 1 for energized-to-open or de-energized-to-open requirements. The valve shall be globe pattern Cla-Val Series 136-03 or Ames ACV 300 Series, "Mustang Valve" and there is no equal.

4. Class 125 (150 psi) or Class 250 (300 psi) Booster Pump Control Valve: Booster pump control valves shall be designed for installation on the discharge of booster pumps to eliminate pipeline surges caused by starting and stopping of pumps. Control of valve operation shall be by means of an externally mounted solenoid pilot valve. The solenoid pilot valve shall be as specified herein. Self-cleaning strainers shall be used to protect the control system. Valves shall utilize line pressure for operation. A limit switch shall be provided to be adjustable over entire valve travel. Valve shall be equipped with a check feature to prevent

reversal of flow. The valve shall be globe pattern Cla-Val 60-11 Series or ACV 980 Series "Mustang Valve" and there is no equal.

5. Class 125 (150 psi) or Class 250 (300 psi) Altitude Valve: Altitude valves shall be designed to control the high water level in reservoirs. The valve shall be a non-throttling type, remaining fully open until the set-point in the reservoir is reached. Unless noted otherwise, the valve shall provide one-way flow, opening when the water level in the reservoir lowers below the set-point level, and shall be equipped with a check feature to prevent reverse flow. The pilot control shall be a three-way diaphragm valve that operates on the differential force between the height of the water in the reservoir and an adjustable spring load. The valve shall be globe pattern Cla-Val 210 Series or Ames ACV 960 Series, "Mustang Valve" and there is no equal.

C. Materials of Construction

Materials of construction for Class 125 and Class 250 valves shall be as follows:

Item	Material
Main valve body and cover	Ductile Iron, ASTM A 536 Grade 60-40-18
Main valve trim and seat	Type 303 Stainless Steel, ASTM A 276, or A 351
Pilot control system	Type 303 Stainless Steel, ASTM A 276, or A 351
Piping and tubing	Type 303 Stainless Steel, ASTM A 276, or A 351
Bonnet studs	Type 304 Stainless Steel
Bonnet nuts & Body plugs	Type 316 Stainless Steel

D. Valve End Connections

1. Applications: 1-inch and 2-inch valves shall have threaded ends at the bottom of the body. 3-inch and 4-inch valves shall have flanged ends.

2. Threaded Connections: Threaded ends shall comply with ANSI B1.20.1.

3. Flanged Connections: Flanges for valves shall be ductile-iron meeting the requirements of ASTM A 536. Flanges shall be Class 125 flanges (for 150 psi) and Class 250 flanges (for 300 psi) conforming to ANSI B16.1.

E. Bolts, Nuts and Washers for Flanged Valves

1. Bolts and nuts for flanged valves and flanges shall be Type 316 stainless steel conforming to ASTM A 193, Grade B8M, for bolts and ASTM A 194, Grade 8M, for nuts.

2. Washers shall be provided for each nut, shall be of the same material as the nut, and shall be installed adjacent to the nut, between the nut and the flange.

3. The length of each bolt or stud shall be such that between 1/4 inch and 1/2 inch will project through the nut when drawn tight.

F. <u>Gaskets</u>

Gaskets for flanged end valves shall be as described in the individual piping specifications.

G. <u>Coating</u>

Valves shall be coated on the exterior in accordance with Section 09900, Painting and Coating. Prime coat shall be shop-applied at the place of manufacture. Finish coat shall be applied in the field. Color of finish coat shall match the color of the adjacent piping.

H. <u>Lining</u>

Interior surfaces of the valve shall be coated in accordance with Section 09900, Painting and Coating, System No. G-1. Seating areas, stainless steel, or other high alloy parts shall not be coated.

PART 3 - EXECUTION

A. <u>Installation</u>

1. <u>Threaded Connections</u>: Threaded joints shall be cleaned by wire brushing or swabbing. Teflon joint compound or Teflon tape shall be applied to pipe threads before installing threaded valves. Joints shall be watertight.

2. <u>Flanged Connections</u>: Flanges shall be cleaned by wire brushing before installing flanged valves. Flange bolts and nuts shall be cleaned by wire brushing, and threads shall be coated with anti-seize compound. Nuts shall be tightened uniformly, and in the sequence pattern and torque setting recommended by the manufacturer. If flanges leak under pressure testing, nuts and bolts shall be loosened or removed, the gasket reseated or replaced, the bolts and nuts reinstalled or retightened, and joints retested. Joints shall be watertight.

B. <u>Valve Pressure Testing</u>

Valves shall be pressure tested at the same time that the connecting pipelines are pressure tested. See Section 15042, Hydrostatic Testing of Pressure Pipelines, for pressure testing requirements. Valves, operators, or control and instrumentation systems whose pressure rating is less than the test pressure shall be protected or isolated during pressure testing.

END OF SECTION

SECTION 15139: FIRE HYDRANTS

PART 1 - GENERAL

A. Description

This section includes materials, installation, and testing of wet-barrel type fire hydrants.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223.
2. Concrete: 03300.
3. Painting and Coating: 09900.
4. Hydrostatic Testing of Pressure Pipelines: 15042.
5. Ductile Iron Pipe and Fittings: 15056.
6. Manual Valves: 15100.

C. Submittals (For Contracts Between the District and Contractor)

Submit shop drawings in accordance with the General Provisions.

PART 2 - MATERIALS

A. Hydrant Top Section

1. General: Fire hydrants shall be of the wet barrel type, with individual valves for each outlet, and shall conform with the requirements of AWWA C-503.
2. Outlets: Hydrants for residential shall have one 2½ -inch outlet and one 4-inch outlet. Hydrants for industrial or commercial shall have one 2½ -inch inch outlet and two 4-inch outlets. All outlets shall be removable and have National Standard Hose Threads.
3. Materials of Construction: The hydrant top section shall be manufactured of bronze conforming to ASTM B-62 or type 304 stainless steel conforming to CF-8 ASTM A-351. All interior working parts, including stems, shall be of bronze containing no more than 7% zinc or 2% aluminum.
4. Operating Nuts: Hydrants are to be provided with 1½ -inch sized pentagon-shaped operating nut, and 1½ -inch capnuts.
5. Outlet Caps: Plastic outlet nozzle caps shall be provided for all outlets.
6. Flanges: Hydrant flanges shall be drilled with a 6-hole pattern. The flange shall be drilled with ¾ -inch diameter holes located on a 9⅜ -inch bolt circle.
7. Manufacturer Identification: All fire hydrants shall have the name of the manufacturer cast or welded onto the fire hydrant body.

B. Bury Section

1. Materials: The bury section shall be ductile iron and shall be cement lined in conformance with Section 15056, Ductile Iron Pipe and Fittings.

2. Inlet Connection: Inlet size is to be a 6-inch push-on joint (for short-side hydrant installations) and shall be flanged (for long-side hydrant installations), unless otherwise specified on the plans.

~~3.~~ Bury Depth: Bury depth will normally be 42-inches for distribution mains and 48-inches for transmission mains. Field conditions may require different depth fire hydrant buries to fit abnormal pipe.

4. Flanges: Bury flanges shall be drilled with a 6-hole pattern. The flange shall be drilled with ¾ -inch diameter holes located on a 9⅜ -inch bolt circle.

5. Break-Away Spools: Ductile iron break-away spools shall be provided for each hydrant installation as shown in the IRWD Standard Drawings. Each spool shall have a scored groove placed circumferentially around the spool near the hydrant end of the spool. The score shall be placed above-grade. Only one score shall be made in the hydrant break-away spool piece. Spool flanges shall be a 6-hole pattern to match both hydrant and bury.

6. Approved Manufacturers: Bury and extension sections shall be as manufactured by Clow, Tyler, South Bay Foundry or for contracts between District and Contractor, approved equal.

C. Break-Away Bolts

Type 316 stainless steel breakaway bolts shall be used to join the break-away spool section to the hydrant top section.

D. Shut-Off Valve

The shut-off valve shall be a gate or resilient-seated gate valve per Section 15100, Manual Valves.

E. Gaskets

Gaskets shall be full face, and of rubber composition, ⅛ -inch thick. Full face type gaskets with pre-punched holes shall be used where both flanges are flat face. Ring gaskets extending to the inner edge of the bolts may be used where a raised face flange is present.

F. Manufacturers

1. Residential Use: For residential applications, fire hydrants shall be James Jones 3700R (Hydrant Head and Fluted Spool), Clow El Rancho Series Model 2050, American AVK Company Series 24, or for contracts between District and Contractor, approved equal.

2. Commercial and Industrial Use: For commercial and industrial applications, fire hydrants shall be James Jones 3775R (Hydrant Head and Fluted Spool), Clow Model No. 2065, American AVK Company Series 24, or for contracts between District and Contractor, approved equal.

PART 3 - EXECUTION

A. <u>General</u>

Fire hydrant assemblies shall be installed in accordance with IRWD Standard Drawings, detail drawings, and as specified herein, and shall include the connection to the main, the fire hydrant, hydrant bury, break-away spool, shutoff valve, valve box, connection piping, concrete thrust blocks, and appurtenances.

B. <u>Location</u>:

Fire hydrant assemblies shall be located as shown on IRWD Standard detail drawings, or as approved by the District Representative.

C. <u>Valve and Valve Box</u>

The valve and valve box shall be installed in accordance with Section 15100.

D. <u>Break-Away Bolts</u>

Breakaway bolts shall be installed with the threads toward the top of the hydrant. Bolts shall be packed with clear silicon sealant.

E. <u>Concrete</u>

The concrete pad and thrust blocks shall be Class C concrete placed per Section 03300.

F. <u>Painting</u>

All above ground portions of the fire hydrant and bury shall be painted with one prime coat and two finish coats of traffic safety yellow paint in the field, after the fire hydrant has been installed, in accordance with Section 09900, Painting and Coating. The second finish coat shall be applied just prior to the final inspection.

G. <u>Testing</u>

Hydrants shall be tested at the same time that the connecting pipeline is pressure tested. See Section 15042, Hydrostatic Testing of Pressure Pipelines, for pressure testing requirements.

END OF SECTION

SECTION 15150: METERS

PART 1 - GENERAL

A. Description

This section describes the materials, installation, and testing of meter assemblies.

B. Related Work Specified Elsewhere

1. Structure Earthwork: 02220
2. Concrete: 03300
3. Precast Concrete Vaults and Meter Boxes: 03462
4. Painting and Coating: 09900
5. Hydrostatic Testing of Pressure Pipelines: 15042
6. Installation of Pressure Pipelines: 15051
7. Ductile-Iron Pipe and Fittings: 15056
8. Copper Pipe and Fittings: 15057
9. Manual Valves: 15100

C. Submittals (For Contracts Between District and Contractor)

Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.

D. Measurement and Payment

1. For contracts between Contractor and District, payment for the work in this section shall be in accordance with the General Provisions.
2. For contracts between Contractor and an entity (Developers, other agencies, etc.) other than the District, meters shall be furnished by the entity in accordance with the requirements of the District's Procedural Guidelines and General Design Requirements.

PART 2 - MATERIALS

A. General

This specification covers Positive Displacement Meters, Single-Jet Meters, and Turbine Meters. Compound Meters shall not be allowed for any applications. Positive Displacement Meters shall be used for small diameter applications (5/8-inch through 2-inch) requiring very accurate low-flow ranges. For larger metered connections (2-inch through 10-inch), low-flow applications (non-irrigation) shall be metered with Single-Jet Meters, high-flow and continuous average flow applications (such as irrigation) shall be metered with Turbine Meters.

All meters shall be new and of current design, and all parts of the meters of the same size and model shall be interchangeable. All meters shall be NSF 61 approved.

B. Register

1. Reading Dials: Register shall have straight reading dial with 360° test circle(s), sweep hand(s), and low flow (leak) detector.

2. Registration Units: Register shall be calibrated to read in cubic feet increments. 5/8-inch, 3/4-inch, and 1-inch meters shall measure at a minimum 1 cubic foot volume per sweep hand revolution. 1 1/2-inch through 6-inch, meters shall measure at a minimum 10 cubic feet volume per sweep hand revolution.

3. Totalizer Display: Register shall be direct read and shall measure volume in cubic-feet increments. 5/8-inch, 3/4 inch, and 1-inch meters shall totalize in 1 cubic-foot increments; 1 1/2-inch through 6-inch meters shall totalize in 100 cubic-feet increments. This may require the stamping of a zero or zeroes on the register dial face. The last two digits including the zero or zeroes stamped on the register dial face shall be easily distinguishable from the balance of the digits either by contrast of white numbers on black, red numbers on white, or silver numbers on black.

4. Registers: Registers for all meters shall be hermetically sealed, and shall not have replaceable change gears.

5. Gears: Register gears shall be self-lubricating molded plastic or brass unless stated otherwise.

6. Drives: Registers shall be driven by magnetic coupling or directly shaft driven.

7. Lenses: All register lenses shall be tempered glass.

8. Serial Number: The serial number of each meter shall be imprinted on both the register box cover and the main casing.

C. End Connections

Unless otherwise specified herein, all meters shall have standard flanged connections, with Type 316 stainless steel bolts, nuts, capscrews, studs, and washers.

D. Positive Displacement Meters (5/8-Inch through 2-Inch)

1. General: Meters shall conform to the material and performance requirements of AWWA C-700 as applicable and the specifications herein.

2. Certification: The manufacturer shall furnish certified results for each meter showing that it has been tested for accuracy of registration according to the manufacturer specifications. Meter shall be ± 1.5% for the normal flow range when tested in accordance with AWWA Manual M6.

3. Materials: Meter bodies shall be bronze. Casing bolts shall be stainless steel or bronze. All internal hardware shall be stainless steel.

4. End Connections: 5/8-inch through 1-inch meters shall have external straight threads.

5. Dimensions: The face to face length of the meter shall be as follows:

Meter Size (inches)	Face-to-Face Dimensions (inches)
5/8	7 1/2
5/8 by 3/4	7 1/2
3/4	9
1	10 3/4
1 1/2	13
2	17

6. Measuring Chamber: Measuring chambers shall be non-hydrolyzing synthetic polymer.

7. Pistons or Disks: Pistons or nutating disks shall be vulcanized rubber or plastic.

8. Strainers: If recommended by the manufacturer, meters shall have plastic or stainless steel strainers. If a strainer is not required, manufacturer must explicitly state this in the warranty certificate.

9. Register and Register Box Connection to Meter Case: Registers and register boxes shall be secured to the main case by acceptable tamper-proof means. Safety wiring of standard bolts and screws is not considered an acceptable method of tamper proofing. Register boxes and covers shall be either bronze or a suitable synthetic material.

10. Warranty: Positive Displacement Meters shall be supplied with the following guarantee:

    a. Guaranteed new-meter accuracy (± 1.5 %) for 5 years.

    b. Measuring chambers and disks or pistons guaranteed for 15 years.

    c. Registers guaranteed for 25 years.

11. Acceptable Manufacturers: Positive Displacement meters shall be Sensus SR-II, Badger 5/8-inch by 3/4-inch, Recordall Model M25, or Neptune T-10. No other manufacturers are allowed.

E. Single-Jet Meters (2-Inch through 6-Inch)

1. General: Meters shall conform to the material and performance requirements of AWWA C-712 as applicable and the specifications herein.

2. Certification: The manufacturer shall furnish certified test results for each meter showing that it has been tested for accuracy of registration according to manufacturer specifications. Meter shall be ± 1.5% for the normal flow range when tested in accordance with AWWA Manual M6.

3. Materials: Meters shall have a low lead brass body, and a polypropylene impeller. Register boxes and covers shall be either bronze or a suitable synthetic material.

4. Dimensions: The face to face length of the meter shall be as follows:

Meter Size (inches)	**Face-to-Face Dimensions (inches)**
2	17
3	24
4	29
6	36 1/2

5. Straightening Vanes: Not required.

6. Calibration Adjusting Vane: Not required.

7. Rotors and Shafts: Rotors shall be thermoplastic or stainless steel with graphite or tungsten carbide bearings rotating on a stainless steel shaft. Motion shall be transmitted from the rotor to the register through a magnetic coupling or directly driven shaft. Worm gears shall not be permitted.

8. Register and Register Box Connection to Meter Case: Registers and register boxes shall be secured to the main case by acceptable tamper-proof means. Safety wiring of standard bolts and screws is not considered an acceptable method of tamper proofing. Register boxes and covers shall be either bronze or a suitable synthetic material.

9. Strainers: Strainers are optional. When strainers are used they shall comply with Part 2, F.9 of this specification.

10. Measuring Chamber and Strainer Cover: Measuring chamber and strainer cover shall be Type 316 stainless steel.

11. Warranty: Single-Jet meters shall be supplied with the following guarantee:

    a. Guaranteed new-meter accuracy (± 2 %) for 5 years.

    b. Measuring chambers and meter body guaranteed for 20 years.

    c. Registers guaranteed for 5 years (Encoded output registers).

12. Acceptable Manufacturers: Single-Jet meters shall be Metron-Farnier Spectrum or Enduro Series Single-Jets. No other manufacturers are allowed.

13. Application: Single-Jet meters shall be used where there are low or mixed flow conditions as determined by the District.

F. Turbine Meters (2-Inch through 10-Inch)

1. General: Meters shall conform to the material and performance requirements of AWWA C701 Class II as applicable and the specifications herein.

2. Certification: The manufacturer shall furnish certified test results for each meter showing that it has been tested for accuracy of registration according to manufactures specifications. Meter shall be ± 1.5% for the normal flow range when tested in accordance with AWWA Manual M6.

3. Materials: Meters shall have bronze or ductile iron main cases.

4. Dimensions: The face to face length of the meter shall be as follows:

Meter Size (inches)	**Face-to-Face Dimensions (inches)**
2	17
3	24
4	29
6	36 1/2
8	43 1/2
10	60

5. Straightening Vanes: Straightening vanes shall be provided in the main case.

6. Calibration Adjusting Vane: A calibration-adjusting vane located in the measuring chamber shall be provided.

7. Rotors and Shafts: Rotors shall be thermoplastic or stainless steel with graphite or tungsten carbide bearings rotating on a stainless steel shaft. Motion shall be transmitted from the rotor to the register through a magnetic coupling or directly driven shaft. Worm gears shall not be permitted.

8. Register and Register Box Connection to Meter Case: Registers and register boxes shall be secured to the main case by acceptable tamper-proof means. Safety wiring of standard bolts and screws is not considered an acceptable method of tamper proofing. Register boxes and covers shall be either bronze or a suitable synthetic material.

9. Strainers: Meters shall be equipped with strainers. The strainer body and cover shall be bronze, cast iron or ductile iron. Cast iron or ductile iron strainers shall be epoxy lined in accordance with Section 09900, Painting and Coating, System No. G-1. Strainers shall be furnished with stainless steel screens with an effective open area at least double the area of the meter.

10. Measuring Chamber and Strainer Cover: Measuring chamber and strainer cover shall be Type 316 stainless steel or epoxy coated ductile iron.

11. Warranty: Positive Displacement Meters shall be supplied with the following guarantee:

    a. Guaranteed new-meter accuracy (± 1.5 %) for 5 years.

    b. Measuring chambers and disks or pistons guaranteed for 15 years.

    c. Registers guaranteed for 25 years.

12. <u>Acceptable Manufacturer</u>: Turbine Meters shall be Sensus Omni T2. No other manufacturers are allowed.

13. <u>Application</u>: Turbine Meters shall be used only in constant high flow conditions as determined by the District.

G. Totalizer - Transmitter

1. <u>General</u>: Totalizer - transmitters shall be furnished with all necessary mounting hardware for operation from the meter.

2. <u>Operation</u>: The transmitter shall have integrally mounted electronic circuitry to convert to both a true 2-wire 4-20 mA DC output linear to flow rate and a true 2-wire scaled pulse.

    a. The 4-20 mA DC output shall operate from an external regulated 18-30 volt DC power supply with load capacity of 575 ohms at 28 volts DC. The accuracy of the 4-20 mA output shall be better than ± 0.5% of scale.

    b. The pulse output shall operate from an external regulated 10-30 volts DC power supply which can be either the 4-20 mA DC power supply or a separate power supply. The pulse circuit voltage drop across the transmitter shall be 3 volt DC or less. Each pulse shall represent the volume of the least significant totalizer digit.

H. Manual Valves

Valves shall be per IRWD Standard Drawings and conform with Section 15100, Manual Valves. Valves on by-pass shall be lockable in the closed position.

PART 3 - EXECUTION

A. Meter Installations

1. <u>Residential Meters</u>: Residential meters shall be installed as shown on the plans, or per IRWD Standard Drawings W-1 and W-2.

2. <u>3-inch and Larger Meters</u>: 3-inch and larger meters shall be installed as shown on the plans or per IRWD Standard Drawing W-5.

B. Service Piping

All piping for service lines and by-pass lines shall be installed in conformance with Section 15057, Copper Pipe and Fittings, and Section 15051, Installation of Pressure Pipelines.

C. Test Tap

On services 3-inch and larger, a 2-inch service saddle and corporation stop shall be installed on the spool downstream of the meter. The tap shall be located a minimum of two pipe diameters downstream of the meter. In lieu of a test tap, a tee with a tapped blind flange may be installed immediately downstream of the meter.

D. Painting and Coating

Exposed and buried piping, and meter lids on all potable and recycled water services shall be painted or coated in accordance with Section 09900, Painting and Coating.

E. Testing

Meter services shall be hydrostatically pressure tested during the testing of pipeline in accordance with Section 15042, Hydrostatic Testing of Pressure Pipelines. Meters 3-inch and larger will be tested by the District to verify accuracy prior to being placed into service.

END OF SECTION

SECTION 15151: FACILITIES IDENTIFICATION

PART 1 - GENERAL

A. Description

This section describes materials and installation of potable and recycled water facilities identification for pipe, valves, valve boxes, and other pipeline appurtenances.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900

2. Manual Valves: 15100

3. Cathodic Protection and Joint Bonding: 16640

C. Submittals (For Contracts Between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.

2. Submit material samples of warning tape.

3. Submit drawings showing location and size of warning labels and signs.

PART 2 - MATERIALS

A. Buried Piping Warning and Locator Tape

Warning tape shall be an inert plastic film specifically formulated for prolonged underground use. The minimum thickness shall be 4 mils and the overall width of the tape shall be 12-inches (for 8-inch diameter pipe and larger) and 6-inches (for 6-inch diameter and smaller pipe).

Locator tape shall be installed over non-metallic pipe, shall be similar to warning tape, and shall include a metallic substance that can be registered by a magnetic field location device. Locator tape shall be 3-inches wide. Warning tape and locator tape shall be as supplied by Griffolyn Co., Inc., Terra Tape, Division of Reef Industries, or for contracts between District and Contractor, approved equal.

1. Potable Water Pipelines: Blue warning tape with white lettering identifying the potable waterline, shall be used on all metallic pipelines 1-inch and larger. For copper services, warning tape shall be placed over the top of the pipe and shall be taped to the copper pipe at 5 foot intervals. The warning tape shall extend up into the meter box, air-vacuum release assembly or other appurtenances a minimum of 12-inches, so that it can be read clearly by opening the box or enclosure. Lettering shall be a minimum of 2-inch high letters with the wording: "CAUTION: DOMESTIC WATERLINE BURIED BELOW".

2. Recycled Water Pipelines: Purple warning tape with black lettering identifying the recycled waterline, shall be used on all metallic pipelines 1-inch and larger. For copper services, warning tape shall be placed over the top of the pipe and shall be taped to the copper pipe at 5 foot intervals. The warning tape shall

extend up into the meter box, air-vacuum release assembly or other appurtenances a minimum of 12-inches, so that it can be read clearly by opening the box or enclosure. Lettering shall be a minimum of 2-inch high letters with the wording: "CAUTION: RECYCLED WATER – DO NOT DRINK".

3. Cathodic Protection Wiring: Red warning tape with black lettering shall be used for cathodic protection wiring. The warning tape shall be 3-inch wide. The tape shall have a minimum tensile strength of 60 pounds per 3-inch strip. The ink used to print the lettering on the tape shall be permanent and not be removable by normal handling or upon prolonged underground burial. Lettering shall be a minimum of 2-inch high letters with the wording: "CAUTION CATHODIC PROTECTION CABLE BURIED BELOW".

B. Warning Encasement for Underground Recycled Metallic Water Pipelines

Unless otherwise specified, pipe and fittings shall be polyethylene encased in accordance with ANSI/AWWA C-105/A-21.5 and shall be "purple" in color and shall bear the water identification markings called for in Section D, Warning Labels and Tags, sub-paragraph 2, Recycled Water Identification.

C. Purple PVC Pipe for Recycled Water Pipelines

1. General: PVC pipe used for recycled water use shall conform to the requirements of Section 15064, PVC Pressure Distribution Pipe and Fittings, and shall be colored purple.

2. PVC Pipe Coloring and Markings: PVC pipe shall be purple, and shall be marked on both sides of the pipe with the wording: "CAUTION: RECYCLED WATER - DO NOT DRINK." Lettering shall be a minimum of 1/2-inch high black letters, and shall be repeated every 12-inches. The purple pipe color shall be achieved by adding pigment to the PVC material as the pipe is being manufactured.

D. Warning Labels and Tags

Labels shall be inert plastic film specifically formulated for prolonged exposure. The minimum thickness shall be 4 mils for adhesive backed labels and 10 mils for tag type labels. Tag type labels shall have reinforced tie holes and shall be attached with heavy-duty nylon fasteners. The size, type of label and location shall be dictated by each individual application and subject to acceptance by the District Representative.

1. Potable Water Identification: Labels shall be prepared on a blue field, and shall have the words: "POTABLE WATER" printed on the field in black letters. Minimum letter height shall be 1/2-inch.

2. Recycled Water Identification: Labels shall be prepared on a purple field, and shall have the words: "CAUTION: RECYCLED WATER - DO NOT DRINK" printed on the field in black letters. Minimum letter height shall be 1/2-inch.

3. Identification Tags: The water service meter identification tag shall identify the address or unit number served by the meter. The identification tag shall be rotary engraved with identifying letters and numbers. The circular plastic tag shall be 1/16-inch thick, 2-inch diameter, and the exterior shall be UV resistant 3 ply (color on both sides) lamicoid plastic by Rowmark, Gravoply or approved equal. Color shall be Blue with a white core for potable, Purple with a white core for recycled, Light-Blue with white core for untreated, or Green with white core for

sewer. IRWD shall provide the un-engraved plastic tags to the Contractor for engraving. The Contractor shall engrave the address and/or unit number into the plastic tag.

PART 3 - EXECUTION

A. Installation of Pipe Warning Tape and Locator Tape

1. Warning Tape: Warning tape shall be installed directly on the top of the pipe longitudinally and shall be centered. The warning tape shall be installed continuously for the entire length of the pipe and shall be fastened to each pipe length by plastic adhesive tape banded around the pipe and warning tape at no more than 5-foot intervals. Taping attached to the sections of pipe before laying in the trench shall have 5-foot minimum overlap for continuous coverage. All risers between the main line and control valves shall be installed with warning tape.

2. Locator Tape: Locator tape shall be installed directly on top of the pipe zone backfill layer, and shall be centered over non-metallic pipelines.

B. Installation of Warning Labels and Signs

1. Method of Attachment: Warning labels shall be firmly attached using heavy-duty nylon fasteners, and shall be sized and installed at locations as shown on the plans.

2. Equipment Requiring Labels or Tags: Warning labels shall be installed on all appurtenances in vaults, such as, but not limited to, air release valves, blowoffs, and meters, and on designated facilities, such as, but not limited to, controller panels and washdown or blowoff hydrants for water trucks and temporary construction services. Pumps and pipe shall be identified with a painted label. Within a fenced area, at least one sign shall be posted on the fence which can be readily seen.

3. Painted Labels: Painted labels may, at the District Representative's discretion, be acceptable in lieu of plastic labels.

C. Installation of Water Identification Tags

Identification tags shall be securely attached to water meters using UV rated zip ties rated to hold 50 pounds.

END OF SECTION

SECTION 15162: FLEXIBLE PIPE COUPLINGS AND EXPANSION JOINTS

PART 1 - GENERAL

A. Description

This section describes materials and installation of flexible gasket sleeve-type compression pipe couplings for steel, asbestos-cement pipe and ductile iron pipe.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900.

2. Hydrostatic Testing of Pressure Pipelines: 15042.

3. Cathodic Protection and Joint Bondings: 16640.

C. Submittals (For Contracts Between District and Contractor)

1. Shop drawings shall be in accord with the General Provisions and the following.

2. Submit manufacturer's catalog data on flexible pipe couplings. Show manufacturer's model or figure number for each type of coupling or joint for each type of pipe material for which couplings are used.

3. Submit manufacturer's recommended torques to which the coupling bolts shall be tightened for the flexible gasket sleeve-type compression pipe couplings.

4. Show materials of construction by ASTM reference and grade. Show dimensions.

5. Show number, size, and material of construction of the rods and lugs for each thrust harness on the project.

PART 2 - MATERIALS

A. Flexible Pipe Couplings for Steel Pipe

1. General: Steel couplings shall have center sleeves made of steel conforming to ASTM A-36, A-53 (Type E or S), or A-512 having a minimum yield strength of 30,000 psi. Follower rings shall be malleable iron (ASTM A-47, Grade 32510), ductile iron (ASTM A-536), or steel (ASTM A-108, Grade 1018, or ASTM A-510, Grades 1018 or 1021). Follower ring material shall match that of the pipe being joined. ie., steel follower rings on steel pipe; malleable iron rings for ductile iron pipe. Minimum center sleeve length shall be 5-inches for pipe sizes 1-inch through 3-inches; 7-inches for pipe sized 4-inches and 10 inches for 6-inches through 24-inches.

2. Sleeve Bolts: Sleeve bolts shall have a minimum yield strength of 40,000 psi, an ultimate strength of 60,000 psi, and shall be fabricated of Type 316 stainless steel conforming to ASTM A-193 (Grade B8M) for bolts and ASTM A-194 (Grade B8M) for nuts, and shall conform to AWWA C-111.

3. Manufacturers: Flexible pipe couplings for steel pipe shall be steel, and shall be Dresser, Smith-Blair Type 411, Baker Series 200, Ford, Romac or for contracts between District and Contractor, approved equal.

B. Joint Harness

1. Tie Bolts or Studs: Tie bolts or studs shall be as shown in AWWA Manual M-11, Table 13-6, 13-7, and 13-7A. The minimum numbers and sizes of tie bolts or studs shall be as shown in the table below. Bolt or stud material shall conform to ASTM B-193, Grade B8. Nuts shall conform to ASTM A-194, Grade B8M. Lug material shall conform to ASTM A-36, ASTM A-283, Grade B, C, or D, or ASTM A-285, Grade C. Lug dimensions, plate thickness, and weld dimensions shall be as shown in AWWA Manual M-11, Figure 13-17.

TIE BOLTS OR STUD REQUIREMENTS
FOR FLEXIBLE PIPE COUPLINGS

Tie Bolt or Stud Minimum Requirements

Nominal Pipe Size (inches)	150 psi		250 psi	
	No. of Bolts or Studs	Size (inches)	No. of Bolts or Studs	Size (inches)
2	2	⅝	2	⅝
3	2	⅝	2	⅝
4	2	⅝	2	⅝
6	2	⅝	2	⅝
8	2	⅝	2	⅝
10	2	⅝	2	¾
12	2	¾	2	⅞
14	2	¾	2	1
16	2	⅞	2	1⅛
18	2	1	2	1¼
20	2	1	2	1¼
24	4	⅞	4	1⅛
30	4	1⅛	4	1⅜
36	4	1¼	4	1⅝
42	4	1½	6	1½
48	6	1⅝	6	1¾
54	6	1½	8	1¾
60	6	1⅝	10	1⅝
66	8	1⅝	12	1¾
72	8	1¾	12	1⅞
84	10	1¾	14	2
96	12	1⅞	16	2¼

2. Criteria for Number and Size of Tie Bolts or Studs: The number and size of bolts shall be selected based on the test pressure shown in Section 15042, Hydrostatic Testing of Pressure Pipelines. For test pressures less than or for contracts between District and Contractor, approved equal to 150 psi, the 150 psi design in the table above shall be used. For test pressures between 150 and 250 psi, the 250 psi design in the table above shall be used.

3. Washers: Stainless steel, type 316 washers shall be provided for each lug. Washer material shall be the same as the nuts. Minimum washer thickness shall be 1/8-inch.

4. Wall Thickness Requirement for Welded Lugs: Pipe wall to which lugs are welded shall be adequate to resist stresses. If necessary, the pipe wall thickness shall be increased.

C. Flexible Pipe Couplings for Asbestos-Cement Pipe

1. General: Flexible pipe couplings for asbestos-cement pipe shall be ductile iron, with long-style center sleeves a minimum of 7-inches in length and shall have corrosion resistant Type 316 stainless steel nuts, bolts and washers. Center sleeve and follower rings shall be epoxy coated and holiday free.

2. Sleeve Bolts: Sleeve bolts shall be corrosion resistant type 316 stainless steel with a minimum yield strength of 45,000 psi and shall conform to ASTM A-193 and AWWA C-111.

3. Manufacturers: Flexible pipe couplings for asbestos-cement pipe shall be cast or ductile iron, and shall be Dresser Style 40, Smith-Blair Type 442, Baker Series 228, Ford Style FRR, Romac Style 501, or for contracts between District and Contractor, approved equal.

D. Flexible Couplings for Ductile Iron Pipe

1. General: Ductile iron pipe couplings shall have center sleeves of ASTM A-126 Class B ductile iron with a minimum yield strength of 30,000 psi. Follower rings shall be malleable iron ASTM A-47 Grade 32510 or ductile iron ASTM A-536. Minimum center sleeve length shall be 7-inches for pipe sizes up to 6-inches and shall be a minimum of 10 inches for larger pipe diameters.

2. Sleeve Bolts: Sleeve bolts shall be corrosion resistant type 316 stainless steel with a minimum yield strength of 45,000 psi and shall conform to ASTM A-193 and AWWA C-111.

3. Manufacturers: Flexible couplings for ductile iron pipe shall be ductile iron: Dresser Style 153, Smith-Blair Type 442, Baker Series 228, Ford Style FCI, Romac Style 501, or for contracts between District and Contractor, approved equal.

E. Transition Couplings

1. Steel Pipe and Concrete Cylinder Pipe: Transition couplings for connecting steel pipe and concrete cylinder pipe having different outside diameters shall be steel: Dresser Style 62 or 162, Smith-Blair Type 413, Baker Series 212 or 240, or for contracts between District and Contractor, approved equal.

2. Ductile Iron Pipe, PVC Pipe, and Asbestos Cement Pipe: Transition couplings for connecting ductile iron pipe, PVC pipe, and asbestos cement pipe having different outside diameters shall be ductile iron, and shall be Smith-Blair Type 441, Baker Series 236, Ford Style FC2A, Romac and Dresser or for contracts between District and Contractor, approved equal.

3. Sleeve Bolts: Sleeve bolts shall have a minimum yield strength of 40,000 psi, an ultimate strength of 60,000 psi, shall be Type 316 stainless steel conforming to ASTM A-193 (Grade B8M) for bolts and ASTM A-194 (Grade B8M) for nuts, and shall conform to AWWA C-111.

F. Reducing Couplings

Reducing couplings for steel pipe shall be steel. Reducing couplings for ductile iron pipe, PVC pipe, and asbestos cement pipe shall be ductile iron. Couplings shall be Dresser Style 62, Baker Series 220 or 240, Smith-Blair Type 415 or R441, Romac and Ford, or for contracts between District and Contractor, approved equal.

G. Flanged Coupling Adapters

Flanged coupling adapters may be used, where detailed on the approved plans, to install valves, meters, and other types of flanged fittings to plain end pipe of diameter 10-inches and smaller. Flanged coupling adapters shall be Smith-Blair Type 912, Baker Series 601 or 604, Dresser Style 127, Ford Style FFCA, Romac Style FAC501, or for contracts between District and Contractor, approved equal.

H. Expansion Joints

1. General: Expansion joints shall have body, flanges, and slip pipe of carbon steel. Packing shall consist of a minimum of four rubber rings, each separated by jute packing. For installation in steel pipelines, expansion joint shall have plain ends, beveled for welding. For installation in ductile iron pipelines, expansion joint shall have plain ends. Slip pipe shall have a machined surface, and body shall be equipped with pipe stops. Where called for on the plans, limit or stop rings and limit rods shall be provided to prevent the slip pipe from pulling out of the joint.

2. Limit Rods and Body Studs, Bolts and Nuts: Limit rods and body studs, bolts, and nuts shall be Type 316 stainless steel conforming to ASTM A-193 (Grade B8M) for rods and bolts, and ASTM A-194 (Grade B8M) for nuts.

3. Manufacturers: Expansion joints shall be Baker Series 403 or 404, Smith-Blair Type 611 or 612, or for contracts between District and Contractor, approved equal.

I. Sleeve Bolts and Nuts for Flanges

1. Stainless Steel Bolts: Bolts and nuts for buried and submerged flanges, flanges in underground vaults and structures, and flanges located outdoors above ground shall be Type 316 stainless steel conforming to ASTM A-193 (Grade B8M) for bolts and ASTM A-194 (Grade B8M) for nuts.

2. Washers: Type 316 stainless steel washers shall be provided for each nut. Washers shall be of the same material as the nuts.

PART 3 - EXECUTION

A. Installation of Flexible Pipe Couplings and Expansion Joints

1. General: Oil, scale, rust, and dirt shall be cleaned from pipe ends. Gaskets in flexible pipe couplings shall be cleaned before installing. Expansion joints shall be installed per manufacturer's recommendations. Expansion joints shall be installed so that 50% of total travel is available for expansion and 50% is available for contraction.

2. Bolt Thread Lubrication: Bolt threads shall be lubricated with anti-seize compound prior to installation.

B. Painting and Coating

1. Flexible Couplings: Flexible pipe couplings (including joint harness assemblies), transition couplings, flanged coupling adapters, and expansion joints shall be coated per Section 09900, Painting and Coating; sleeves shall be coated per System G-1. After installation couplings shall be wrapped with 8-mil polyethylene wrap per AWWA C-105.

2. Interior Surface Coating: Interior surfaces of flexible coupling and transition coupling sleeves, and the body of expansion joints shall be coated per Section 09900, Painting and Coating, System G-1.

C. Bonding Flexible Pipe Couplings

Buried flexible pipe couplings that are connected to ductile-iron, cast-iron, or steel pipe shall be bonded to adjacent piping as described in Section 16640, Cathodic Protection and Joint Bonding.

D. Hydrostatic Testing

Flexible pipe couplings, expansion joints, and expansion joints shall be hydrostatically tested in place with the pipe being tested. Test shall be performed in accord with Section 15042, Hydrostatic Testing of Pressure Pipelines.

END OF SECTION

SECTION 16010 - GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

A. Description

This Section includes materials, installation, and testing of the electrical system.

B. Related Work Specified Elsewhere

1. One-year Guarantee: General Provisions
2. Permits and Licenses: General Provisions
3. Construction Facilities and Temporary Utilities: 01440
4. Testing, Training and Facility Start-Up: 01510
5. Electrical Testing: 16950

C. Submittals

1. Submit shop drawings in accord with the General Provisions and the following.
2. Complete fabrication, assembly, and installation drawings, wiring and schematic diagrams; and details, specifications, and data covering the materials used and the parts, devices, and accessories forming a part of the equipment furnished shall be submitted in accord with the submittals section.
3. Instrument tag numbers indicated on the contract drawings shall be referenced where applicable.
4. Submittal data for multifunctional instruments shall include complete descriptions of the intended functions and configurations of the instruments.
5. Submittal data shall be grouped and submitted in three separate stages. The submittal for each stage shall be substantially complete. Individual drawings and data sheets submitted at random intervals will not be accepted for review.

   a. First Stage Submittal

      i) Product catalog cut sheets clearly marked to show the model number, optional features, and intended service of the device.

      ii) A detailed list of any exceptions, functional differences, or discrepancies between the supplier's proposed system and the contract requirements.

b. Second Stage Submittal

i) Complete panel fabrication drawings and details of panel wiring, piping, and painting. Panel and subpanels drawings shall include overall dimensions, metal thickness, door swing, mounting details, and front of panel arrangement to show general appearance, with spacing and mounting height of instruments and control devices.

ii) System wiring and installation drawings for all interconnection wiring between components of the systems furnished and for all interconnecting wiring between the related equipment and the equipment furnished under this section. Wiring diagrams shall show complete circuits and indicate all connections.

iii) If panel terminal designations, device interconnections, device features and options, or other features are modified as a result of the fabrication process or factor testing, revised drawings shall be resubmitted.

iv) ELECTRONIC FILES OF SHOP DRAWINGS: Submit electronic files for all shop drawings in AutoCAD (latest version) format.

v) At the supplier's option, and for projects with very few fabrication drawings, the first stage and second stage submittal may be combined.

b. Third Stage Submittal

i) Complete system documentation, in the form of operation and maintenance manuals, shall be provided. Manuals shall include complete product instruction books for each item of equipment furnished.

ii) Where instruction booklets cover more than one specific model or range of instrument, product data sheets shall be included which indicate the instrument model number, calibrated range, and all other special features. A complete set of "as-built wiring, fabrication, and inter connection drawings shall be included with the manuals.

iii) ELECTRONIC FILES FOR SHOP DRAWINGS: Submit "AS-BUILT" electronic files for all shop drawings in AutoCAD 2000 or later version format.

D. Regulatory Agencies and Standards

1. Regulatory Agencies: Installations, materials, equipment, and workmanship shall conform to the applicable provisions of the following agencies:

a. National Electrical Code (NEC), Latest Edition.

b. State Department of Industrial Safety (CAL/OSHA).

c. Local authorities having lawful jurisdiction pertaining to the work required.

2. Underwriters' Laboratories, Inc. (UL): Materials, appliances, equipment, and devices shall conform to the applicable UL standards. The label of, or listing by, UL is required wherever applicable.

3. Standards: Where referenced in these specifications or on the drawings, the publications and standards of the following organizations apply:

   a. American Society of Testing and Materials (ASTM)

   b. National Electrical Manufacturers Association (NEMA)

   c. National Fire Protection Association (NFPA)

   d. American National Standards Institute (ANSI)

   e. Institute of Electrical and Electronic Engineers (IEEE)

   f. Insulated power Cable Engineers Association (IPCEA).

E. Industry Regulations and Laws

In case of difference between the building codes, Specifications, State law, local ordinances, industry standards, utility company regulations, fire insurance carrier’s requirements, and the contract documents, the most stringent shall govern. The Contractor shall promptly notify the DISTRICT in writing of such differences.

F. Utility Company Requirements and Fees

1. The DISTRICT will make application for electric and telephone service. The DISTRICT will pay utility company fees, cable charges, and added facilities charges.

2. The Contractor shall make any service and installation agreements that the utility companies may require.

3. Install electric service entrance equipment in accord with the serving utility's requirements. Coordinate with the servicing utility to ensure timely connection by the utility. Obtain utility company approval of service entrance and metering equipment shop drawings prior to starting fabrication.

4. Verify utility companies service point of connection prior to beginning installation.

G. Measurement and Payment

Payment for the work in this section shall be in accord with the General Provisions and in the amount stated in the Proposal..

PART 2 - MATERIALS

A. General

1. Similar materials and equipment shall be the product of a single manufacturer.

2. Provide only products which are new, undamaged, and in the original cartons or containers.

3. Materials and equipment shall be the standard products of manufacturers regularly engaged in the production of such material and shall be the manufacturer's current design.

4. Materials and equipment shall be suitable for storage, installation, and operation in an ambient temperature environment of 0º C to 50º C except where more stringent conditions are stated in individual equipment specifications.

5. Electrical equipment and panels, where called for in a material other than stainless steel, shall be factory finished with manufacturer's standard primer and enamel topcoats, unless stated otherwise in the individual equipment specifications. Provide 1 pint of the equipment manufacturer's touchup paint per 500 square feet of painted surface for repair of damaged enamel topcoats.

B. Operation, Maintenance, and Repair Manuals

1. The organization of the initial submittals as required by these contract documents shall be compatible to eventual inclusion as one volume of the operation, maintenance, and repair manuals.

2. Operation manuals shall be prepared and submitted to the DISTRICT's Representative for preliminary review in six (6) copies. When the DISTRICT's Representative is satisfied that these are complete and properly prepared, six (6) final sets shall be delivered to the DISTRICT's Representative.

3. The complete operation manual shall contain all the information included in the preliminary equipment submittal, the detailed installation submittal, programming instructions, and the additional information required herein, all bound in hard-cover binders and arranged for convenient use including tab sheets, all indexed and cross referenced, and all final as-built drawings.

4. The operation manuals shall contain:

   a) calibration and maintenance instructions;

   b) trouble-shooting instructions;

   c) instructions for ordering replacement parts.

C. As-Built Drawings

1. As-built drawings shall be submitted at the completion of work, and shall depict the final configuration of all installed equipment.

2. All shop drawings shall be updated by the originator to "As-Built" status.

3. "As-Built" drawings shall be provided to the DISTRICT in both hardcopy and digital formats. Digital files shall be AutoCAD 2000 or later format.

4. All drawings shall become property of the District.

5. The Contractor shall clearly indicate on "As-Built" plans the following information:

   a) All conduit runs exactly as installed.

   b) Location of all underground conduits.

   c) Forming, cabling, and identification of all power and control circuits within pull boxes, and terminal boxes.

   d) All changes and/or deviations in locations, routing, or dimensions or additions to any part of the Electrical work.

   e) Interior views of each pull box identifying each conduit entrance by conduit number.

   f) Complete and accurate wiring, schematic, and interconnecting wiring diagrams for all equipment supplied and all work performed.

PART 3 - EXECUTION

A. Installation

1. The drawings indicate connections for typical equipment only. If the equipment furnished is different from what is shown, provide the modifications necessary for a safe and properly operating installation in accord with the equipment manufacturer's recommendations.

2. The drawings indicate diagrammatically the desired location and arrangement of outlets, conduit runs, equipment, and other items. Field determine exact location based on physical size and arrangement of equipment, finished elevations, and obstructions.

3. Work or equipment not indicated or specified which is necessary for the complete and proper operation of the electrical systems shall be accomplished without additional cost to the DISTRICT.

B. Foreign Power Isolation in Equipment Enclosures

1. Provide foreign power circuit isolation devices in equipment enclosures. PLC input/output circuits for example, are a source of foreign power when they exist in an equipment enclosure such as a local control panel which has a separate source of control power. Circuits which are a source of foreign power shall pass through an isolation device where the wiring enters the equipment enclosure. Isolation devices are required in control cabinets, MCC buckets, etc., to provide an easily accessible isolation point, whenever the power source for the circuit would be considered foreign power in the enclosure. Isolation devices shall be clearly labeled.

2. Equipment manufacturers shall supply isolation devices integral with their equipment whenever possible (isolation switches integral with disconnect handles on MCC buckets for example).

3. Devices shall allow for the operation of equipment with doors open to allow for testing and/or maintenance.

4. The Contractor shall be responsible for supplying isolation devices as needed such that the complete system of power distribution installed at the facility complies with this specification.

C. Identifications and Signs

Mark each individual panelboard, motor controller, power panel, transformer, circuit breaker, disconnect switch, timer, relay, and contactor to identify each item with its respective service or function and unique identification number as shown on the drawings. Provide polycarbonate nameplates with engraved lettering not less than 1/4 inch high. Use black-on-white laminated polycarbonate plastic, attached with sheet metal screws or self-adhesive backs.

D. Performance Tests

1. After the electrical installation is complete, test it to demonstrate that the entire system is in proper working order and in accord with the drawings and specifications.

2. Testing requirements for Telemetry cable system installations are described in specification 16650, "Telemetry Cable System".

3. Perform Electrical Testing per section 16950, "Electrical Testing". The testing shall demonstrate the proper installation and integrity of the electrical power distribution, electrical protection, and major equipment (MCC, Transformers, motors, etc.).

4. Perform Equipment Startup and Performance Test requirements per section 01510, "Testing, Training and Facility Start-Up". The tests specified in section 01510 involve equipment performance tests and integrated testing of systems.

E. Coordination Study

1. The Contractor shall provide a complete coordination study of relays, fuses, circuit breakers, and all other protective devices.

2. The coordination study shall include the entire distribution system starting with the smallest 480 volt, 3 phase, 60 Hz circuit protective device on the load end, to the nearest protective device on the power company's line side, or for work in the DISTRICT's existing facilities, to the nearest protective device on the DISTRICT's distribution system.

3. The study shall include, but not be limited to, the following:

   a. A tabulation of all protective relay and circuit breaker trip settings and recommended fuse sizes and types.

b. Motor starting profiles for all motors sized 50 hp and above.

c. Transformer damage curves and protection evaluated in accord with ANSI/IEEE C57.109.

d. Coordination curve(s) from the power company if available.

4. The Contractor shall be responsible for obtaining all of the required relay, fuse, and circuit breaker coordination curves; transformer damage curves; motor data; etc., for all new and existing electrical equipment.

5. The Contractor shall be responsible for coordinating with the Power Company to obtain the required protective device curves.

6. The Contractor shall be responsible for all field work required to obtain necessary data on existing relays, circuit breakers, fuses, and transformers to be included in the coordination study.

7. The coordination study shall be bound in a standard 8½ by 11 inch sized report. The study shall be provided in accord with the submittal section. Final selection of all protective device settings or sizes shall be subject to review and acceptance by the Engineer.

END OF SECTION

SECTION 16051 - MISCELLANEOUS ELECTRICAL DEVICES

PART 1 - GENERAL

A. Description

1. This section includes materials and installation of miscellaneous electrical devices and equipment, such as disconnect switches, and thermostats.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010.

2. Control Panel Requirements: 17400.

C. Submittals

1. Submit shop drawings in accord with the General Provisions and Section 16010

2. Submit ratings and characteristics including voltage ratings, continuous current ratings, conduit entry restrictions, and enclosure type and dimensions.

PART 2 - MATERIALS

A. Disconnect Switches

1. Provide nonfusible or fusible disconnect switches with ampere rating and number of poles as indicated on the drawings. Switches for use on circuits 240 volts and below shall be NEMA heavy-duty Type HD. Switches for use on 480-volt circuits shall be NEMA heavy-duty Type HD. Mechanisms shall have quick-make and quick-break operating handles and provisions for padlocking in the "OFF" position. The switch shall have an interlock to prevent unauthorized opening of the hinged cover when the switch is in the "ON" position and an interlock to prevent closing the switch mechanism with the hinged cover open. Fusible switches shall be equipped with rejection feature. On the front of the enclosure, attach a nameplate that identifies the load per Section 16010.

   a. Indoor Dry Locations: NEMA Type 1

   b. Outdoor/Wet Locations: NEMA Type 4X Stainless Steel

B. Pushbuttons

1. Remote-mounted pushbuttons located outdoors shall be NEMA rated heavy duty, oil-tight type with synthetic rubber boots and any special gasketing required to make the completed station watertight. Provide NEMA Type 4X watertight, corrosion-resistant enclosures constructed of stainless steel or glass polyester.

2. Install provisions for locking pushbuttons in the OFF position wherever lockout provisions are indicated. Provide Allen-Bradley Bulletin 800H; Square D Class 9001, Type SK; or equal.

C. **Thermostats**

1. Thermostats shall be line voltage, heavy-duty type. Thermostats shall have off-auto switch with thermometer, 50º F to 140º F set point range, and motor current rated contacts.

2. Thermostats shall be Honeywell T631C-1020 or equal.

D. **Control Relays**

1. Control relays shall have 120-volt AC or 24-volt DC coils, except as noted; contacts shall be rated for the various circuit applications shown on the drawings. Control relays shall be 10-ampere, multiple-contact, 300-volt, plug-in type with dust cover and sockets. If additional contacts are required, they shall be ganged.

2. Control relays for 120 volt AC application shall be as follows:

   a.) DPDT - Allen Bradley 700-HA32A1

   b.) Relay Base: 700 HN 125, 10 amp, 300 volt

   c.) TPDT - Allen Bradley 700-HA33A1

   d.) Relay Base: 700-HN126, 10 amp, 300 volt

3. Control relays for 24-volt DC application shall be as follows:

   a.) DPDT - Allen Bradley 700-HA32Z24

   b.) Relay Base: 700-HN125, 10A, 300V

   c.) TPDT - Allen Bradley 700-HA33Z24

   d.) Relay Base: 700-HN126, 10 amp, 300 volt

4. Timing Control relays for 120 volt AC application shall be as follows:

   a.) DPDT – Allen Bradley 700-HR52TA17

   b.) Relay Base: 700 HN 101, 10 amp, 300 volt

   c.) Retainer Clip: 700-HN131

5. Timing Control relays for 24 volt DC application shall be as follows:

   a.) DPDT – Allen Bradley 700-HR52TZ24

   b.) Relay Base: 700 HN 101, 10 amp, 300 volt

   c.) Retainer Clip: 700-HN131

E. **Circuit Breakers, 120 volt**

1. Circuit breakers shall be single-pole, 120 volt, 20-ampere rating.

F. Terminal Blocks, Control Circuits, 120 volt

1. Terminal Blocks: Terminal blocks shall be molded plastic with barriers and box lug terminals and shall be rated 25 amperes at 300 volts. White marking strips, fastened securely to the molded sections shall be provided and wire numbers or circuit identifications shall be marked thereon with permanent marking fluid.

2. Terminal blocks shall be Phoenix Contact USK-4 or USK-10 with mounting rack no equal.

G. Intrusion Switches for Doors and Hatch Covers

1. Switches shall be Normally Open switches, held closed by the door or hatch. Intrusion switches shall be Allen Bradley 802T-AP, with roller lever arm 802T-W2B, no equal.

H. Indicating Lights

1. Indicating lights shall be oiltight type, push to test, complete with color of lens indicated on drawings and legend plate.

2. Lamps shall be 120-volt AC, push-to-test, GE model #CR104PLT22 or equal by Allen-Bradley, only. 120 volt lamp type PSB120. Provide color lens as indicated on the drawings.

I. Underground Vault Ventilation Blowers

1. Blowers shall be high performance, with fiberglass reinforced polyester housings, and PVC wheels.

2. Blowers shall be rated 1/3 horsepower, 1725 rpm, 115 volt AC, 60 Hz, 1 phase, and deliver 1065 cfm at 1/8" SP and 800 cfm at 1" SP. Blower shall be McMaster-Carr Model 2093K13, or equal.

J. Intrusion Override Switches

1. Switches shall be 2-Postion Key Operator, key removal left and right positions, Cutler-Hammer part number 10250T15113.

2. Contact block, shall be 1 N.C., 1 N.O, Cutler-Hammer part number 10250T1.

3. Key for key operator shall be Cutler-Hammer part number 10250ED824, for Key number contact IRWD Electrical Engineer at 453-5569.

4. Name plates for intrusion alarm override switches shall be as follows:

10250TS36	Custom Engraved Legend Plate, "INTRUSION ALARM", Position A
10250TM36	Custom Engraved Legend Plate, "NORMAL", Position A4 "OVERRIDE", Position D4

K. Time-of-Use Override Switches

1. Switches shall be 2-Postion Key Operator, key removal left position only, Cutler-Hammer part number 1025016H.

2. Contact block, shall be 2 N.O, Cutler-Hammer part number 10250T2.

3. Key for key operator shall be Cutler-Hammer part number, 10250T15112H501, Key #501CH.

4. Name plates for Time-of-Use override switches shall be as follows:

10250TS36	Custom Engraved Legend Plate, "TOU OVERRIDE", Position A
10250TM36	Custom Engraved Legend Plate, "OFF", Position A4 (Left) "ON", Position D4 (Right)

L. Intrinsically Safe Barrier

1. Intrinsically safe barrier for 24-volt DC dry contacts/relays shall be Ingram Products Two Channel Relay with Intrinsically Safe Inputs, Model Number: ISR2-24V-10K, or equal.

2. Intrinsically safe barrier for 120-volt AC dry contacts/relays shall be Warrick Series 27A1DO, or equal.

M. Voltage Converter – 12 VDC to 24 VDC

1. DC/DC Converter, Manufactured by Analytic Systems, model VTC-120-I-12-24, 12 VDC to 24 VDC, 10 amp, isolated output, no equal.

N. Battery Charger

1. Battery Charger, manufactured by Xantrex, TrueCharge, 10 amp, model number TC10TB, part number 804-0111, no equal

O. Diode Block

1. Diode Block, manufactured by Phoenix Contact, Power Diodes, 10 amp, model number Quint Diode/40, Phoenix part number 2938963, no equal.

PART 3 - EXECUTION

A. Spares

1. Provide three spare fuses of each type and ampere rating installed.

END OF SECTION

SECTION 16110 - RACEWAYS, PULL BOXES, AND FITTINGS

PART 1 – GENERAL

A. Description

This section describes materials and installation of raceway systems, whether concealed or exposed, above or below grade.

B. Related Work Specified Elsewhere

1. Earthwork and Grading: 02201
2. Concrete: 03300
3. General Electrical Requirements: 16010
4. Telemetry Cable System: 16650

C. Submittals

1. Submit shop drawings in accord with the General Provisions and the following.
2. Submit material list for all conduits, fittings, boxes, conduit boxes, mounting hardware, and related accessories.
3. Submit installation drawing including individual conduit numbers, routing, conduit sizes, circuit numbers contained in each conduit, and number and size of wires in each conduit.

PART 2 – MATERIALS

A. Conduit Related Materials

1. Conduit Mounting Strut:
    a) Type 316 stainless steel for mounting of PVC coated rigid steel conduit and PVC non-metallic conduit.
    b) Hot dipped galvanized for other conduit types.
2. Conduit Thruwall Seals:
    a) Hot-dip galvanized.
    b) PVC oversize sleeve.
    c) Manufacturers: O-Z/Gedney, Type "WSK".
3. Couplings Connectors and Fittings:
    a) Threaded.
    b) Manufactured with same materials and process as corresponding conduit.

4. Condulet Fittings:

    a) With wedge nut covers (Form 7), weathertight when located outdoors or in wet or corrosive locations (indicated on the Drawings), matching type for corresponding conduit systems.

    b) Manufacturers: Crouse-Hinds, Appleton.

5. Galvanized Rigid Steel conduit Expansion Fittings for Exposed Locations:

    a) Manufacturers: O-Z/Gedney, Type AX with jumper.

6. Galvanized Rigid Steel Conduit Expansion Fittings at Structural Expansion Joints:

    a) Manufacturers: Spring City, Type D.

7. Conduit Seals:

    a) Manufacturers: Appleton, Crouse-Hinds EYS and EYD.

    b) Electrical Metallic Tubing Indentor Fittings:

    c) Prohibited.

    d) PVC Coated Rigid Steel Conduit Couplings:

    e) One provided loose with each length of conduit.

8. Fasteners for PVC Coated Rigid Steel conduit:

    a) PVC coated steel fasteners with Type 316 stainless steel bolts, nuts and hardware.

9. Fasteners for Galvanized Steel Conduit:

    a) Galvanized Steel fasteners with Type 316 stainless steel bolts, nuts and hardware.

B. <u>Rigid Nonmetallic (PVC) Conduit and Fittings</u>

1. PVC conduit shall be heavy wall, Schedule 40 conduit, and UL labeled for above ground and underground uses. The PVC conduit shall conform to NEMA TC-2 and UL-651.

2. Manufacturers shall be Cantex, JM eagle, or Prime Conduit.

C. <u>PVC-Coated Steel Conduit and Fittings</u>

1. PVC-coated steel conduit and fittings shall be UL listed and shall conform to ANSI C80.1 and to UL-6. The thickness of the PVC-coating shall be .040-inch minimum. Conduit and fittings shall be Occidental, Robroy, and there is no equal.

2. Supports, hangers, unistrut, and clamps shall be Type 316 stainless steel. Bolts and nuts shall be Type 316 stainless steel.

3. A two-part urethane chemically cured coating shall be applied at a nominal 2-mil thickness to the interior of all conduit and fittings. The coating shall be sufficiently flexible to permit field bending of the conduit without cracking or flaking of the coating.

4. Every Female opening shall have a PVC sleeve extending one conduit diameter or 2 inches beyond the opening, whichever is less. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit before coating. The wall thickness of the sleeve shall be at least 40 mils.

5. All fittings, FS and FD boxes, condulets, mounting hardware, and accessories shall be PVC coated. All conduit fittings shall be coated with the same interior urethane coating as described above. The screw heads on condulets shall be encapsulated with corrosion – resistant material by the manufacturer.

6. Manufacturers shall be Ocal, Inc. or Robroy Industries, only, no equal.

D. <u>Galvanized Rigid Steel Conduit</u>

1. Galvanized Rigid Steel conduit shall be domestic raw steel, made smooth, clean, and free of burrs and rough spots to enhance wire pulling.

2. Interior and exterior surfaces shall be coated with solid, unbroken layer of zinc.

3. Entire surface finish shall be coated with secondary bichcromate treatment applied over galvanizing able to extend surface protection and prevent oxidation.

4. Threads shall be protected by color coded end caps to provide quick trade size identification.

5. Manufacturers shall be LTV Steel Tubular Products Company, Galvite, Triangle PWC, Inc., Allied Tube and Conduit Corp., or OCAL, Inc.

E. <u>Liquid-Tight Flexible Conduit and Connectors</u>

1. Single strip steel, hot-dipped galvanized on all four sides prior to conduit fabrication. Overall PVC plastic jacket. Conduit sizes 1 1/4 inches and smaller shall include an integral copper bonding conductor wound spirally in the space between each convolution on the inside of the conduit. Conform to UL-360.

2. Compression-type bushing, manufactured with same material and process as corresponding conduit, and insulated throat and sealing 0-ring.

3. Manufacturers shall be American Brass Co., or General Electric.

F. <u>Outlet and Pull Boxes</u>

1. Provide boxes for installation of electrical work, in compliance with codes and regulations. Use only deep boxes Type FD.

2. Provide one-piece galvanized pressed steel knockout-FD type boxes, minimum size 4 inches square by 1 1/2 inches, in flush-mounted or concealed locations unless otherwise indicated. Boxes for use in concrete shall have square corner tile type covers with ribs or extensions for casting in concrete.

3. Use PVC-coated steel boxes for surface-mounted or exposed locations.

4. Provide pull boxes constructed of code-gage sheet steel finished with one coat of metal primer and one coast of primer sealer for pull boxes in dry locations. Box material shall match the conduit material.

G. <u>Junction Boxes</u>

Junction boxes shall be aluminum, stainless steel, or fiberglass, rated per the area in which they are installed.

H. <u>Explosion Proof Conduit Sealing Fittings</u>

Use Appleton "Type ESU" or Crouse-Hinds "EYS" sealing fittings.

I. <u>Conduit Identification Tags</u>

Identification tags shall be 19-gauge stainless steel, with 1/2 inch stamped letters and numbers.

PART 3 – EXECUTION

A. <u>Installation</u>

1. Conduit runs are shown schematically. Supports, pull boxes, junction boxes, and other ancillary equipment are not usually shown. Provide pull boxes and junction boxes where shown. In addition, provide pull boxes and junction boxes to permit pulling of wires without damage to the conductors or insulation.

2. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings, for circuit numbers indicated on the Drawings.

3. Install conduit system to provide firm mechanical assemblies with electrical conductivity throughout.

4. Install ground bushings on all conduit not installed in to threaded hubs.

5. Install exposed conduits parallel to or at right angles to the lines of the building. Make right-angle bends in exposed conduit runs with standard elbows, threaded conduit fittings, or conduit bent to radii not less than those of standard elbows.

6. Route exposed conduit to preserve headroom, access space, and work space. Install conduit runs to they do not interfere with proper and safe operation of equipment and not block or interfere with ingress or egress, including equipment removal hatches.

7. Treat threaded joints of rigid steel conduit before installation of fittings. Coating material shall be T&B "Kor-Shield" or Crouse Hinds "STL", or equal.

8. Treat exposed threads of threaded joints of rigid steel conduit, after installation of fittings, with Enterprise Galvanizing "Galvabra", or equal.

9. Terminate rigid steel conduits with Meyers type hubs with bushings. Install conduit squarely.

10. When terminating in threaded hubs, screw the conduit or fitting tight into the hub so that the end bears against the fire protection shoulder. When chase nipples are used, install the raceway and coupling square to the box and tighten the chase nipple with no exposed threads.

11. Label conduits with a label designating the destination of the conduit.

12. Conduits shall be capped during construction to prevent entrance of dirt, trash, and water.

13. Concealed conduit for future use shall be terminated in equipment or by galvanized couplings plugged flush with structural surfaces.

14. All conduits that enter enclosures shall be terminated by fittings that ensure that the NEMA rating of the enclosure is not affected for changed.

15. Unless otherwise indicated on the drawings, no conduit shall be less that 3/4-inch.

16. After completing installation of 2-inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of diameter not less than 85% of nominal diameter of conduit. Remove and replace conduits through which the mandrel will not pass.

17. Clean and ensure that conduit runs are not crushed or creased. Verify that no foreign objects or obstructions are present in conduit prior to installing conductors.

18. Install runs between pull boxes or junction boxes with total bends equaling not more than 270 degrees. Install NEC required pull boxes at locations acceptable to the Engineer. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of dirt, moisture and rodents.

19. Install ductbank raceway to external conduit size transitions at pullboxes and manholes.

B. <u>Conduit Usage</u>

Install the following types of raceway in the locations listed, unless otherwise indicated on the drawings.

1. Exposed Outdoor, Underground Vaults, Corrosive Indoor Locations and all Exposed Locations at Michelson Water Reclamation Plant: PVC-coated steel conduit.

2. Exposed Dry Indoor Locations (except at Michelson Water Reclamation Plant): Rigid Steel Conduit.

3. Underground: PVC-coated rigid steel conduit, or Schedule 40 PVC pipe with red colored concrete encasement. Use PVC coated rigid steel conduit for stub-outs (see below).

4. Underground Below Concrete: PVC-coated rigid steel conduit, or Schedule 40 PVC pipe. Use PVC coated rigid steel conduit for stub-outs (see below).

5. Final Connections to Motors or Vibrating Equipment: Liquid tight flexible conduit, limited to less than 3 feet in length for conduit less that 3 inches in diameter, and limited to less than 5 feet for conduit 3 inches and larger.

6. Connections to Lighting Fixtures: Liquid tight flexible conduit limited to less than 4 feet in length.

7. Conduit Stub-outs: All stub-outs for entering or exiting concrete, masonry, or earth, shall be PVC-coated rigid steel conduit, and shall extend a minimum of 12 inches above and below grade or finished floor. Stub-outs shall be connected to PVC-coated rigid steel 90-degree elbows before emergence.

8. A corrosion-resistant coating shall be applied to all conduits that turn-out of concrete, masonry, or earth indoors. The coating shall consist of a heavy coat of coal tar paint, or 3 wraps of 10 mil pipe wrap tape, extending 1-inch on each side of the point of turn-out.

9. Underground Ductbanks: PVC-coated rigid steel or Schedule 40 PVC conduit with red colored concrete encasement.

C. <u>Underground Conduit</u>

1. No underground conduit shall be smaller than 1-inch.

2. All concrete encasement shall be reinforced. Concrete encased conduits shall have a minimum thickness of 2 inches between conduits, 1-inch between conduit and reinforcing, and 3 inches over reinforcing.

3. Provide 30-inch minimum cover for direct burial underground conduit. (For street sections, cover minimum shall be below the bottom of the "street section". Provide 6-inch minimum sand above and below conduit or concrete encasement for PVC conduit.

4. Provide burial depth, bedding, and backfill per utility company requirements for high voltage and service entrance conduits.

5. Where other utility piping systems are encountered or being installed along a raceway route, maintain a 12-inch minimum vertical separation between raceways and other systems at crossings. Maintain a 12-inch minimum separation between raceways and systems in parallel runs. Do not place raceways over valves or couplings in other piping systems. Refer conflicts with these requirements to the District's Representative for instructions before further work is done.

6. Underground conduits shall be sloped to drain from buildings to the manholes.

7. Telephone cable raceways shall be isolated from raceways, conduits, boxes, manholes, and handholes for other circuits.

8. Intercommunication and instrumentation cables shall be separated from all power wiring in raceways, boxes, manholes, and handholes.

D. **Conduit Supports**

1. Support conduit at intervals and at locations as required by the NEC. Do not use perforated strap or plumbers tape for conduit supports.

2. Conduit on Concrete or Masonry: Use on-hole malleable iron straps with metallic expansion anchors and screws or from preset inserts. Use preset inserts in concrete when possible. Use pipe spacers (clamp backs) in wet locations. On plaster or stucco, use one-hole malleable iron straps with toggle bolts. Supports will match the conduit being used.

3. Suspended Conduit: Use factory-made, split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter). For grouped conduits, construct racks with threaded rods and preformed unistrut channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long provide rigid sway bracing. Coat all ends of unistrut channel with sealer where cuts are made.

4. Supports at Structural Steel Members: Use beam clamps. Drilling or welding may be used only where indicated on the drawings.

5. Wherever conduit may be affected by dissimilar movements of the supporting structures or medium, provide flexible or expansion devices.

E. **Damaged Conduit**

1. Replace conduit damaged during or after installation. Replace crushed or clogged conduit or any conduit whose inner surface is damaged or not smooth.

2. Repair cuts, nicks, or abrasions in the zinc coating of galvanized conduit with galvanizing repair stick, Enterprise Galvanizing "Galvabra", or equal.

3. Repair PVC coated steel conduits with Robroy "Plastibond" touch-up compound.

F. **Empty Conduit**

1. Cap spare conduits and provide #10 THHN Green wire below threaded cap.

2. Provide bonding bushing and bond wire.

G. **Sealing of Conduits**

1. After cable has been installed and connected, conduit ends shall be sealed by non-hardening duct sealing compound forced into conduits to a minimum depth equal to the conduit diameter. This shall apply for all conduits at handholes, manholes, and building entrance junction boxes, and for 1- inch and larger conduit connections to equipment.

2. Conduits entering hazardous (classified) areas and submersible or explosionproof enclosures shall have "EYS" sealing fittings with sealing compound.

H. Conduit Identification

1. Conduits shall be provided with identification tags in manholes, handholes, building entrances, junction boxes, and equipment. Identification tags shall be attached to conduits with nylon tie wraps and shall be positioned to be readily visible for inspection.

2. Identification tags shall be 19-gauge stainless steel, with 1/2-inch stamped letters and numbers as indicated on the drawings.
3. Identification tags shall be attached to conduits with nylon tie wraps and shall be positioned to be readily visible for inspection.

I. Schedules

1. Conduit Sizes: In accord with NEC, unless otherwise indicated on the Drawings or specified as follows:

    a) Exposed Conduit: Minimum 3/4-inches.

    b) Rigid Non-metallic PVC encased in concrete: Minimum 1 inch.

    c) Buried Conduit Size: Minimum 1-inch.

    d) Buried Conduit for Telemetry Cable: Minimum 2 inches.

    e) Duct Banks: Minimum 2 inches.

END OF SECTION

SECTION 16120 - WIRES AND CABLES

PART 1 - GENERAL

A. Description

1. This section describes materials and installation of wires and cables.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010
2. Telemetry Cable: 16650
3. General Instrumentation and Control Requirements: 17000

C. Submittals

1. Submit shop drawings in accord with the General Provisions and Section 16010
2. Submit material list for each conductor type. Indicate insulation material, conductor material, voltage rating, manufacturer and other data pertinent to the specific cable, such as type shielding, number of pairs, and applicable standards.

PART 2 - MATERIALS

A. Conductors

1. Conductor material for wire and cable shall be copper.

B. Low-Voltage Building Wire

1. Low-voltage building wire for use at 600 volts or less shall be 600-volt insulated, Type THHN/THWN, and rated for continuous operation at 90^{o} / 75º C. Conductors shall be copper.
2. Ground wires shall have 600-volt insulation, Type THWN.
3. No. 10 AWG minimum conductor size for power and lighting circuits.
4. No. 14 AWG minimum conductor size for control circuits.
5. Power conductors No. 10 AWG and smaller shall be stranded. Control wiring shall be stranded. Conductors No. 8 AWG and larger shall be stranded.

D. Wire in Light Fixtures

1. 600 volts, Type AVA No. 14 minimum.

E. Instrument Cable

1. Two or three 16 AWG stranded tinned-copper conductors individually insulated with fully color-coded PVC rated at 300 volts; insulated conductors twisted together and shielded with a spiral-wound metal foil tape overlapped for 100% shielding. Outer jacket shall be PVC.

F. Wire Color Requirements

1. Conductors No. 8 AWG and smaller shall have factory color coding with solid color insulation. Do not use onsite coloring of ends of conductors or apply colored plastic adhesives in lieu of factory color-coding.

2. Conductors No. 6 AWG and larger shall have factory color coding with solid color insulation or shall have black insulation with onsite application of colored plastic adhesives at ends of conductors and at each junction and splice box.

3. PLC input/output circuit wiring shall be Purple colored. PLC input/output circuit neutral wiring shall be white or purple w/white stripe.

4. Conductor color coding throughout the entire network of feeders and circuits (600 volts and below) shall be as follows:

480 / 277 Volt Circuits	
Circuit Designation	Color
Phase A	Brown
Phase B	Orange
Phase C	Yellow
Neutral	Gray
Ground	Green

120 / 240 Volt Circuits	
Circuit Designation	Color
Phase A	Black
Phase B	Red
Phase C	Blue
Neutral	White
Ground	Green
Control	Red
PLC Input / Output (Field)	Purple
PLC Output (neutral)	White or Purple w / White stripe
+ 24 VDC	Blue
- 24 VDC	Yellow

24 Volt DC Circuits	
Circuit Designation	Color
+ 24 VDC	Blue
- 24 VDC	Yellow
PLC Input / Output (Field)	Purple
PLC Input / Output (neutral)	Purple
Ground	Green

PART 3 - EXECUTION

A. Installation

1. Install wiring and cable in conduit unless otherwise noted.

2. To reduce pulling tension in long runs, coat cables with pulling compound recommended by the cable manufacturer before being pulled into conduits.

3. Remove debris and moisture from the conduits, boxes, and cabinets prior to cable installation.

B. Conductor Identification: General

1. Tagging of Conductors: Tag control wires and instrument cables in motor control centers, panels, pull boxes, wireways, and at control device with heat shrink type of marker: Brady, Thomas and Betts, or equal. Tag control wires and instrument cables with same wire numbers as on the shop drawing submittals. Self-laminating write on type or wrap around self-adhesive type Will Not Be Accepted.

2. Provide color coded conductors throughout the entire network of feeders and circuits (600 volts and below) as required by this Specification.

C. Conductor Identification: PLC Input/Output Circuits

3. Tagging of PLC Input/Output Circuit Conductors: Tagging of PLC circuit conductors shall include the PLC input/output register number. For example, PLC input 30001 shall have "30001" in the tag number scheme.

4. Provide purple color coded conductors for all PLC input/output circuits as required by this Specification.

   Purple colored wire for 120 Volt AC PLC input/output circuits is a worker safety precaution to identify foreign power sources in equipment. This requirement applies to –

   - internal wiring in the PLC enclosure cabinet.
   - interconnecting wiring to individual devices and equipment.
   - internal wiring at the equipment.

C. Low-Voltage Wire Splices

1. Solid Conductors: use 3M "Scotchlok", Ideal "Super Nut," Buchanan B-Cap, or equal.

2. Stranded Conductors No. 8 and Larger: Use T & B "Lock-Tie" connectors, Burndy Versitaps and heavy-duty connectors, O.Z. solderless connectors, or equal.

3. Control Wiring: Use crimp connectors with tools by same manufacturer and/or UL listed for connectors of all stranded conductors.

4. Retighten bolt-type connectors 24 to 48 hours after initial installation and before taping. Tape connections made with noninsulated-type connectors with rubber-type tape, one and one-half times the thickness of the conductor insulation, then cover with Scotch 33 tape.

END OF SECTION

SECTION 16135: CABINETS AND ENCLOSURES

PART 1 - GENERAL

A. Description

This section includes requirements for enclosures to house electrical controls, instruments, terminal blocks, and similar equipment.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900.

2. General Electrical Requirements: 16010.

3. Miscellaneous Electrical Devices: 16051

C. Submittals

1. Submit shop drawings in accordance with the General Provisions and Section 16010

PART 2 - MATERIALS

A. General Enclosure Design Requirements

1. Unless otherwise specified herein or indicated on the Drawings, enclosures to house electrical controls, instruments, terminal blocks, and similar equipment shall be NEMA 4X stainless steel and shall be compatible with the conduit system being used.

2. NEMA 4X Steel Enclosures:

   a) Make enclosures from 14-gauge steel with seams that are continuously welded. Doors shall have full-length piano hinges with the door removable by pulling the stainless steel hinge pin.

   b) Provide a rolled lip around 3 sides of the door and around all sides of the enclosure opening.

   c) Attach gasket with oil-resistant adhesive and hold it in place with steel retaining strips.

   d) Hardware, such as clamps, screws, and hinge pins, hasp and staple shall be provided for padlocking.

   e) Provide a print pocket for each enclosure.

   f) Do not paint NEMA 4X steel enclosures. Door fronts shall be ground smooth. Print pockets and interior panels shall be unfinished brushed stainless steel.

   g) NEMA 4X steel enclosures shall be Hoffman Products, or approved equal.

3. NEMA 4X Fiberglass Enclosures:

   a) Provide enclosures that consist of base and cover that shall be heavy-duty hot compression molded from fiberglass reinforced polyester compound containing not less than 25 percent fiberglass by weight. Transparent covers, when required, shall be polycarbonate. The enclosures shall be provided with cover hinges manufactured from nonmetallic materials. The cover latch system shall be nonmetallic.

   b) Provide the enclosures with gasket system of neoprene material cemented into a molded labyrinth on the cover.

   c) NEMA 4X fiberglass enclosures shall be Carlon Products, or approved equal

B. PLC Panels

1. The panels shall be floor-mounted NEMA 1 gasketed enclosure and shall be constructed from 14-gage formed steel throughout. Access door shall have continuous hinges with sealing clamps. All exposed edges and welds on the enclosure shall be ground smooth.

2. The exterior of the enclosure shall be painted with rust inhibiting primer and two coats of epoxy paint.

3. The interior shall be provided with a formed 12-gage subpanel for attaching surface-mounted components. The interior shall be painted with two coats of epoxy white paint.

4. PLC enclosures shall be Hoffman Products, or approved equal.

PART 3 - EXECUTION

A. Installation

1. Install panels and enclosures in accessible locations and provide working clearances that meet NEC requirements for electrical equipment.

B. Enclosure Air Conditioning Installation

1. Top mounted air conditioning units installed on enclosures shall not allow condensation to damage electrical equipment or enclosure.

C. Panel Device and Component Mounting

1. General: All components, except those on the front panels, shall be mounted behind on fixed or swing-out panels; terminal blocks for field connections shall be mounted on fixed channels located near the bottom of the sections but clear of the conduit entry area. Fixed panels shall be located so as not to prevent access within the cabinets to other components, wiring, and terminal blocks on fixed panels or front panels.

2. All components shall be attached with screws and the subpanel shall be threaded. Rivets or back of panel nuts shall not be allowed.

D. PLC Enclosures

1. Each interior shall be equipped with a 120-volt, 15-ampere duplex output and a single-pole, 15-ampere, 120-volt circuit breaker.

2. Provide a fluorescent lamp in the panel.

E. Terminal Requirements for Field Wires

1. Terminal Blocks: Provide terminal blocks in the panel for interconnecting panel mounted devices to field wires. Do not terminate field wires directly on panel mounted devices.

F. Terminal to Wireway Clearance Requirement

1. Provide a minimum of 2 inches of space between terminal blocks and any wireway.

END OF SECTION

SECTION 16140 - SWITCHES AND RECEPTACLES

PART 1 - GENERAL

A. Description

This section describes materials and installation of light switches and receptacles.

B. Related Work Specified Elsewhere

General Electrical Requirements: 16010

C. Submittals

1. Submit shop drawings in accordance with the General Provisions and Section 16010

2. Submit material list for each type of switch, receptacle, and cover plate. Indicate type, ratings, material, color, and manufacturer.

PART 2 - MATERIALS

A. Receptacles

1. Duplex Receptacles: Provide molded composition, ivory, specification grade receptacles. Duplex receptacles for 120-volt, single-phase, 3-wire service to be rated 20 amperes, 125 volts, back or side wired, NEMA Type 5-20R.

2. 480 Volt Receptacles: Provide a 480-volt, 30-ampere twist-lock receptacle and a spare plug, NEMA L16-30R and NEMA 16-30P.

B. Switches

Switches shall be molded composition, ivory, specification grade, single pole and three way as shown on the drawings.

120- or 277-Volt Lighting: Use switches rated 20 amperes, 120-277-volt AC.

C. Cover Plates

1. Provide weathertight gasketed stainless-steel cover plates for exterior and underground receptacles with hinged covers.

2. Provide Type 430 stainless-steel plates in all other locations.

PART 3 - EXECUTION

A. Grounding

Provide a bonding jumper between the grounded outlet box and the receptacle ground terminal. Feed power to 120 volt AC receptacles by a GFCI Type Circuit Breaker.

END OF SECTION

SECTION 16150 - ELECTRIC MOTORS

PART 1 - GENERAL

A. Description

1. This section describes materials, testing, and installation of electric motors that are provided as part of mechanical equipment described in other sections. When it applies, this section will be referenced in other equipment specifications.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900

2. General Electrical Requirements: 16010

C. Submittals

1. Submit shop drawings in accordance with the General Provisions and Section 16010.

2. Show ratings, characteristics, and mounting arrangement. For motors 40 horsepower and larger, submit efficiency and power factor at full, 3/4 and 1/2 load and locked rotor current.

3. Submit copies of certified test reports for factory no load current and speed, locked rotor current, and high potential tests.

4. Certification: When motors are supplied as part of a variable speed drive system, submit certification that selected motor:

   a. Is capable of satisfactory performance under the intended load.

   b. Is suitable for operation with the proposed variable speed drive unit.

PART 2 - MATERIALS

A. Electric Motors

1. General:

   a. Manufactured with cast iron frames in accordance with NEMA MG-1, and in accordance with requirements specified in this Section.

   b. Alternating Current Motors: Squirrel cage induction type suitable for 60-hertz power.

   c. Where not Otherwise Specified or Indicated on the Drawings:

      i. Motors 1/2 Horsepower and less: single phase, 120 volt.

      ii. Motors greater that 1/2 Horsepower to 300 Horsepower: three phase, 460 volt.

      iii. Motors greater than 300 Horsepower: three phase 4000 volt.

d. 2-speed motors: Dual winding design.

e. Temperature Rating and Altitude Requirements: Where not otherwise specified or indicated on the Drawings, provide motors that are rated suitable for continuous operation in 40 degree Celsius ambient temperature at project site altitude.

   i. Temperature rise under full load: Not to exceed that for Class B insulation (80 degrees Celsius).

f. Motor Data: Specific motor data including horsepower, speed, and enclosure type are indicated on the Drawings and specified under equipment for which motor is required.

g. Torque and Power of Motors:

   i. Provide motors that develop sufficient torque for required service throughout acceleration range at voltage 10 percent less than motor nameplate rating.

   ii. Provide motors that develop sufficient torque when started using reduced voltage starters.

h. Motor leads and insulating material: Insulated leads with non-wicking, non-hygroscopic material. Class F insulation.

i. Grounding lugs: Provide inside conduit boxes for motor frame grounding.

j. Hardware: Type 316 stainless steel.

k. Non-Reversing Ratchet: Pump motors shall be provided with a non-reversing ratchet.

2. Provide motors that are special premium efficiency type, except motors that are to be used on hoisting equipment heat pumps, unit heaters, sump pumps, and lubricating oil transfer pumps.

   a. Provide premium efficiency type motors having nominal full load efficiencies and power factors as specified in Schedule A appended to this Section.

   b. Actual full load efficiency of individual motors within the nominal efficiency band shall not be less than the minimum efficiency value specified in Schedule A.

3. Condensation Heaters:

   a. Use: Required in motors in outdoor applications.

   b. Type: Cartridge or flexible wrap-around type installed within motor enclosure adjacent to core iron.

   c. Rating, Phase and Wattage: Rated for 120 volt, single phase with wattage as required.

d. Bring power leads for heaters into conduit box.

4. Winding Temperature Detectors:

a. Switch Type:

i. When specified for individual equipment and on alternating current motors sized less than 150 horsepower, provide factory installed winding temperature detectors with leads terminating in conduit box.

ii. Provide detectors that protect motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts, or ventilation failure. Provide detector that has normally closed contacts.

iii. Auxiliary Relay and Controls: Provide relays and controls and mount them in controller enclosure that is suitable for the environment.

b. RTD Type:

i. On alternating current motors sized 150 horsepower and greater, provide factory installed RTD type winding temperature detectors with leads terminating in conduit box.

ii. RTD Type Temperature Detectors: Provide six- (6) 100-ohm platinum RTD's embedded in the motor windings, two per phase. Provide two each (2) 100-ohm platinum RTD's embedded in the motor bearings, one on each set of bearings.

iii. Provide detectors that protect motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts, or ventilation failure.

5. Internal Cooling of Motors: Design motors having speeds of 900 revolutions per minute and less, and motors that are connected to solid state motor controllers with special attention to internal cooling.

6. Coating: Coat motors per Section 09900, System No. 15. Apply prime coat at factory. Apply finish coat in field. Color of finish coat shall match the equipment to which the motor is attached. Motors housed within equipment enclosures, such as exhaust fans and air handling units may have factory's standard prime and finish coats in lieu of field painting.

B. <u>Single Phase Motors</u>

1. Capacitor start type rated for operation at 115 volts, 60 Hertz, unless otherwise specified or indicated on the Drawings.

2. Totally enclosed, fan cooled motors manufactured in accordance with NEMA MG 1-10.35.

3. Ball Bearings: Sealed.

4. 1/2 Horsepower or Less Fan Motors:

    a. Split-phase or shaded pole type when standard for the equipment.

    b. Open type when suitably protected from moisture, dripping water, and lint accumulation.

5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.

C. <u>Direct Current Motors</u>

1. Designed to operate from 90 volts direct current.

2. Sealed ball bearings having AFBMA B-10 life of 60,000 hours or more.

3. Insulation System: NEMA 1-1.65, Class F, resistant to attack by moisture, acids, alkalis, and mechanical or thermal shock.

4. Totally enclosed fan cooled enclosures.

D. <u>Three Phase Motors</u>

1. Suitable for 460 three-phase power or 4000 volt three phase power unless otherwise specified or indicated on the Drawings.

2. NEMA Design B except where driven load characteristics requires other than normal starting torque.

    a. Starting kilovolt ampere per horsepower (locked rotor) are not to exceed values specified in NEMA MG-1-10.37.

3. Motors over 50 HP shall be capable of reduced voltage starting with 50% to 80% of rated voltage applied.

4. Motor Bearings: Antifriction, re-greasable, and filled initially with grease suitable for ambient temperatures to 40 degrees Celsius.

    a. Suitable for intended application and have AFBMA B-10 rating life of 60,000 hours or more.

    b. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.

    c. Motors operated in a vertical position shall be designed for vertical operation. The thrust bearings shall be able to handle 150% of the maximum calculated down-thrust with a rated B-10 life of 5 years as defined by AFBMA standards.

    d. Provide two pole motors with ball type bearings.

5. Insulation Systems:

    a. Comply with NEMA 1-1.65.

b. Class F system with Class B temperature rise.

c. Resistant to attack by moisture, acids, alkalies, and mechanical or thermal shock.

6. Conduit Boxes:

a. Provide gaskets between following:

i. Frames and conduit boxes.

ii. Conduit boxes and box covers.

b. Provide oversized conduit box.

c. Motors rated for 4000 volts shall be provided with conduit boxes suitably sized to house all motor leads, power cables and stress cones.

7. Motor Enclosures: As specified herein or as indicated on the Drawings.

a. Open Drip Proof: Stamped steel conduit boxes; 1.15 service factor at 40 degrees Celsius. Motors 7 1/2 horsepower and larger shall have screens over openings.

b. Totally Enclosed Fan Cooled: Cast iron conduit box; 1.15 service factor at 40 degrees Celsius ambient; tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller, and automatic breather and drain devices for frames 324T and larger. Motors 7 1/2 horsepower and larger shall have screens over openings. The stator shall be vacuum-impregnated or vacuum pressure impregnated in an insulating polyester resin, and then baked to a cure for a minimum of 4-6 hours at 350 degrees F in accordance with procedures recommended from the resin manufacturer. The stator shall be impregnated with the polyester resin a minimum of two times.

c. Explosion-proof: 1.15 service factor at 40 degrees Celsius; tapped drain holes with corrosion resistant plugs for frames 286T and smaller, and automatic breather and drain devices for frames 324T and larger; UL label for Class I, Division I, Group D hazardous area.

d. Severe Duty: Corrosion resistant type conforming to motors designated by manufacturer as "Chemical Duty", "Mill and Chemical", "Custom Severe Duty", or similar applicable manufacturer's quality designation with 1.15 service factor at 40 degrees Celsius; tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller, and automatic breather and drain devices for frames 324T and larger; epoxy finish; and upgraded insulation using encapsulated or dip and bake windings.

e. Submersible: Water tight casing with insulated windings which are moisture resistant.

i. Pump Motors specified to be submersible: Provide motors having cooling characteristics suitable for continuous operation in totally, partially, or non-submerged condition without overheating or other damage.

ii. Moisture Detector: Provide complete moisture detection control with the moisture sensing probes in the motor.

iii. Electrical Cables: Provide cables of adequate length to allow unit to be wired without splices.

E. Motor Sizes

1. Motor sizes specified in the Specifications and indicated on the Drawings are minimum sizes.

2. Provide motors, electrical circuits, and equipment of ample horsepower capacity to operate equipment without exceeding rated nameplate horsepower, full-load current at rated nameplate voltage, or overheating at maximum load capacity.

F. Factory Tests

1. Factory Testing of three phase Motors:

   a. When specified in individual equipment specifications, factory test motors. Include testing of:

      i. No load current.

      ii. Locked rotor current.

      iii. Winding resistance.

      iv. High potential.

   b. Perform in accordance with NEMA Standards.

   c. Furnish copies of test reports.

   d. The insulating resin shall be tested by the resin manufacturer at regular intervals and records kept of condition and changes. The records shall be supplied to IRWD upon request.

PART 3 - EXECUTION

A. Installation

1. Install motors in accordance with manufacturer instructions.

B. Operating Tests

SCHEDULE A

FULL LOAD MOTOR EFFICIENCY AND POWER FACTOR RATING REQUIREMENTS FOR PREMIUM EFFICIENCY, 460 VOLT, 3 PHASE HORIZONTAL AND VERTICAL MOTORS

		Protected (open Drip Proof)(1)			Totally Enclosed Fan Cooled		
Nominal Horsepower (Horsepower)	Syn. (revolutions per minute)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)
1	1800	91.5	84	70.9	81.5	84	77.7
	1200	78.5	81.5	57	78.5	81.5	57
1 1/2	3600	81.5	84	86	81.5	84	86
	1800	81.5	84	73	81.5	84	77.4
	1200	81.5	84	67.8	84	86.5	67.8
2	3600	81.5	84	87.7	84	86.5	87.7
	1800	81.5	84	76.7	81.5	84	78.8
	1200	84	86.5	68.1	85.5	87.5	68.1
3	3600	80	82.5	90.4	84	86.5	82.8
	1800	86.5	88.5	78.9	86.5	88.5	79.2
	1200	87.5	89.5	71	87.5	89.5	71
5	3600	86.5	81.5	84.5	86.5	88.5	87
	1800	87.5	88.5	80.4	86.5	88.5	81
	1200	88.5	89.5	73	87.5	89.5	74.4
	900	87	87.5	70	87.5	89.5	70.5
7 1/2	3600	86.5	88.5	86.7	87.5	89.5	86.3
	1800	87.5	89.5	83.3	88.5	91.2	84.4
	1200	88.5	90.2	78.2	88.5	90.2	78.3
	900	87.5	89.5	72	87.5	89.5	72
10	3600	88.5	90.2	85.5	89.5	91	87.5
	1800	88.5	90.2	82.8	88.5	90.2	86
	1200	89.5	91	80.5	89.5	91	81
	900	89.5	91	75.8	88.5	90.2	76
15	3600	88.5	90.2	86.7	89.5	91	87.4
	1800	90.2	91.7	81.9	91	92.4	82.7
	1200	89.5	91	80.5	89.5	91	81
	900	89.5	91	76.8	88.5	91.2	77

SCHEDULE A FULL LOAD MOTOR EFFICIENCY AND POWER FACTOR RATING REQUIREMENTS FOR PREMIUM EFFICIENCY, 460 VOLT, 3 PHASE HORIZONTAL AND VERTICAL MOTORS							
		Protected (open Drip Proof)(1)			Totally Enclosed Fan Cooled		
Nominal Horsepower (Horsepower)	Syn. (revolutions per minute)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)
20	3600	90.2	91.7	87.1	90.2	91.37	88.7
	1800	91	92.4	73.1	97	92.4	84.2
	1200	90.2	91.7	83.7	90.2	91.7	79
	900	90.2	91.7	77.2	89.5	91	77.2
25	3600	90.2	91.7	88.1	91	92.4	85.5
	1800	91.7	93	82.7	92.4	93.6	84.3
	1200	91	92.4	79.2	91	92.4	83.5
	900	90.2	91.7	76.3	90.2	91.7	76.4
30	3600	91.7	93	88.3	91	92.4	73.9
	1800	91.7	93	83.3	92.4	93.6	83.1
	1200	91.7	93	82.1	91.7	93	83.5
	900	91.7	93	76	91	92.4	76.5
40	3600	92.4	93.6	89.2	92.4	93.6	87.5
	1800	93	94.1	80.8	93	94.1	82.3
	1200	92.4	93.6	82.2	92.4	93.6	80.5
	900	91.7	93	75	91.7	93	75.5
50	3600	91.7	93	86.3	94.7	93	87.7
	1800	93	94.1	83.3	93	94.1	84.2
	1200	92.4	93.6	83	95.4	93.6	80.6
	900	92.4	93.6	79.2	91.7	93	79.5
60	3600	92.4	93.6	88.8	92.4	93.6	88.9
	1800	94.1	95	84.5	94.1	95	84.2
	1200	93.6	94.5	84.4	93	94.1	85.4
	900	92.4	93.6	78.8	91.7	93	79.3
75	3600	93.6	94.5	87.5	93.6	94.5	89.7
	1800	94.1	95	85	94.1	95	85.5
	1200	94.1	95	85	94.1	95	85
	900	93.6	94.5	84.5	93	94.1	78.6
100	1800	94.5	95.4	85	94.5	95.4	85
	1200	94.1	95	85	94.1	95	81.3
	900	93.6	94.5	90.2	93	94.1	77.8

SCHEDULE A

FULL LOAD MOTOR EFFICIENCY AND POWER FACTOR RATING REQUIREMENTS FOR PREMIUM EFFICIENCY, 460 VOLT, 3 PHASE HORIZONTAL AND VERTICAL MOTORS

		Protected (open Drip Proof)[1]			Totally Enclosed Fan Cooled		
Nominal Horsepower (Horsepower)	Syn. (revolutions per minute)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)
125	1800	94.5	95.4	86.9	94.5	95.4	88.5
	1200	94.1	95	81.5	94.1	95	85.8
	900	94.1	95		93.6	94.5	80.4
150	1800	95	95.8	86.4	95	95.8	86.3
	1200	94.5	95.4	77.6	94.5	95.4	83.9
	900	94.1	95		93.6	94.5	79.7
200	1800	95	95.8	84.6	95	95.8	87.5
	1200	94.5	95.4	78.5	94.5	95.4	87.3
	900	94.5	95.4		94.1	95	80

NOTES:

(1) Motor data for continuous duty, NEMA Design B, 1.15 service factor, 40 degrees Celsius ambient, Class F insulation, 3 phase, 460 volt, at listed speed rating.

END OF SECTION

SECTION 16155 – LOW-VOLTAGE MOTOR CONTROL

PART 1 – GENERAL

A. Description

This section describes materials, testing, and installation of low-voltage motor control equipment.

B. Related Work Specified Elsewhere

1. One-year Guarantee: General Provisions
2. Permits and Licenses: General Provisions
4. Testing, Training and Facility Start-Up: 01510
5. General Electrical Requirements: 16010
6. Miscellaneous Electrical Devices: 16051
7. Electrical Testing: 16950

C. Submittals

1. Submit shop drawings in accord with the General Provisions and the following.
2. Submit material list for all conduits, fittings, boxes, conduit boxes, mounting hardware, and related accessories
3. Submit installation drawings including individual conduit numbers, routing, conduit sizes, circuit numbers contained in each conduit, and number and size of wires in each conduit.

D. Ratings

Motor horsepower ratings and enclosures shown are minimum expected. This does not limit the equipment size. When motors furnished differ from the minimum ratings indicated, make the necessary adjustments to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate the motors actually installed, at no additional cost to IRWD.

PART 2 – MATERIALS

A. Motor Control Centers

1. Motor control centers shall be dead front, dead rear, floor standing, and front accessible NEMA 1 gasketed construction. The voltage and ampere rating and physical dimensions shall be as indicated in the drawings.
2. Wiring shall be NEMA Class I, Type B, with wiring schematics showing field devices and connections.

3. Schematics shall show all terminal numbers and interior and field wire numbers. Obtain instrument wire numbers from instrument system supplier.

4. Provide wire markers on all wires control wires within the motor control center. Tag control wiring within 2 inches of termination at each device and terminal board.

5. Provide channel iron sills and removable lifting angles.

6. Provide a separate vertical-wiring compartment for each motor control center section. Provide cable supports and a hinged door separate from the unit starters.

7. Provide individual compartments separated by steel barriers and with separate hinged doors for each starter, circuit breaker, or other unit. Locate equipment to enable termination of field wiring from front without equipment removal.

8. Mechanically interlock starter and circuit breaker doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access while starter or circuit breaker is energized. Make provisions for padlocking external disconnect handles in the OFF position.

9. Bus bars shall be copper and braced to withstand the rms symmetrical short-circuit current ratings as shown in the drawings. Provide full horizontal bus rating for entire length of the motor control center. Do not taper the bus.

10. Provide a continuous, front accessible 200-ampere-minimum ground bus extended the full length of the motor control center.

11. Feeder circuit breakers shall be molded-case type. Provide quick-make and quick-break toggle mechanism, inverse-time trip characteristics, and trip-free operation on overload or short circuit. Automatic tripping shall be indicated by a handle position between the manual OFF and ON position. Provide trip ratings and number of poles as indicated in the drawings. Provide breakers with fault current interrupting ratings equal to or greater than the motor control center short-circuit current rating shown in the drawings.

12. Fusible switch feeder units shall have switch and fuse ratings as indicated in the drawings. Provide rejection feature to accept only Class R fuses. Provide 600-volt, time delay, Class RK-5 fuses. The short-circuit rating shall be at least 100,000 amperes symmetrical.

13. Combination starters shall be as described in "Combination Magnetic Motor Starters" in this section.

14. Motor control centers shall comply with applicable NEMA, UL, and ANSI standards for industrial control. Provide UL label on each motor control center section.

15. A single manufacturer shall supply the motor control centers. The MCC shall be completely assembled and wired in the manufacturer's factory. The manufacturer of the MCC shall also be the manufacturer of the motor starter equipment in the MCC.

16. A Manufacturer's authorized distributor within 25 miles of the project site shall supply motor control centers and provide warrenty service as required by the project documents.

17. Motor control centers shall be General Electric, Square D, Allen-Bradley, or equal.

B. Enclosed Combination Starters

1. Starters shall be wall mounted with NEMA 4 enclosures or as shown on the drawings.

2. Mechanically interlock door so it cannot be opened with unit energized. Provide defeater mechanism to allow intentional access while starter is energized. Provide provisions for padlocking external disconnect handle in the OFF position.

3. Starter shall be as described in "Combination Magnetic Motor Starters" in this section.

4. Starters shall comply with applicable NEMA, UL, and ANSI standards for industrial control. Provide UL label on starter.

5. Enclosed combination starters shall be General Electric, Square D, Allen-Bradley, or equal.

C. Combination Magnetic Motor Starters

1. Comply with NEMA ICS, Class A, and with NEC Article 430.

2. Combination motor starters shall be circuit-breaker type equipped with adjustable magnetic-trip circuit breakers (motor circuit protectors) as noted in the drawings. The short-circuit rating shall be at least 65,000 amperes symmetrical at 480 volts. Where a higher short-circuit rating is shown in the drawings, provide combination starters with higher short-circuit rating or provide current-limiting type breakers or circuit breakers with current limiters to achieve the short-circuit rating.

3. Solid-state controller shall be as described in the subsection on "Solid-State Controller."

4. Provide 120-volt control circuit transformer where indicated. Provide 100-volt-ampere spare capacity that is in addition to contactor load plus other loads specified. Fuse one side of secondary winding and ground other side. Provide primary winding fuses where shown in drawings. Transformer shall be NEMA ST1, machine tool grade with isolated secondary winding.

5. The manufacturer shall verify the motor ratings and coordinate the starter overloads with the actual horsepower ratings of the motors installed.

6. Provide indicating lights, control switches, elapsed time meters, ammeter, etc., as shown in the schematic wiring diagrams and single line diagrams. Mount on the front panel of the starter.

7. Provide externally operable overload relay reset buttons and disconnect operators.

8. Provide relays, etc., within the starter enclosure as shown in the schematic wiring diagrams.

D. Manual Motor Starters

1. Provide number of poles and size of thermal overload heaters for the motor being controlled. Provide NEMA 1 enclosure for starters located indoors and NEMA 4 for enclosure for starters located outdoors or as indicated.

2. Starters shall have provisions for padlocking in the off position and shall be UL listed.

3. Starters shall be the heavy-duty type with toggle or push-button operation. Arrow Hart Type LL, Allen-Bradley Bulletin 609, or equal.

E. Solid-State Controllers

1. The solid-state controller shall be a 6-SCR device fully rated for continuous operation for 50°C ambient. The control section shall be digital microprocessor based.

2. The controller shall comply with the following requirements:

3. Dielectric withstand per UL-508.

4. Noise and RF immunity per NEMA ICS-2-230 and IEEE STD 472.

5. Provide the following functions:

   a) Soft Start with Selectable Kickstart.

   b) Current Limit.

   c) Full Voltage Start.

   d) Soft Stop.

   e) Pump Control.

6. The acceleration ramp time shall be selectable from 2 to 30 seconds.

7. The initial torque shall be adjustable from 5% to 90% of locked rotor torque.

8. Kickstart function shall provide an adjustable time pulse of current prior to the normal start mode. The current shall be held at 500% plus or minus of full load for an adjustable time. This feature shall be field defeatable.

9. Provide the following protection during "starting" and "running" modes. When these conditions are detected, starting of the controller shall be inhibited or the controller shall be shut down if it is operating:

   a) Start Fault (faulty SCR firing).

b) Line Fault (phase loss, open motor lead, shorted SCR).

c) Temperature Fault (SCR rated temperature exceeded).

d) Stalled Motor.

10. Provide LED indicators for advisory status and fault annunciation. The LEDs shall be color coded for distinct annunciation and shall consist of:

    a) Control Voltage Present (green).

    b) Starting (amber).

    c) Running (green).

    d) Stopping (amber).

    e) Fault (red).

    f) Start Fault (amber).

    g) Stalled Motor (amber).

    h) Temperature Fault (amber).

    i) Line Fault (red).

11. Provide a latch circuit for three-wire control. It shall also be possible to wire it for two-wire control.

12. Include a Form C auxiliary contact for customer use. The contacts shall change state instantaneously on a start command and when the logic completes the ramp-down feature. It shall be possible to reconfigure the system via a switch such that the contacts change state when the controller has determined that the motor is "up-to-speed" and when the motor starts to decelerate.

13. Provide a Form C auxiliary dry contact for common fault signal.

14. Soft Stop: The deceleration ramp time shall be selectable with settings from 2 to 60 seconds. This feature shall be field defeatable.

15. Pump Control: This function shall reduce surges in a pumping system during starting or stopping of a centrifugal pump by smoothly accelerating and decelerating the motor by means of a closed loop control matching the specific torque requirements of the load. Pump starting shall also be accomplished via soft start, current limit, or full voltage. Starting and stopping time shall be adjustable.

16. Equip the controller with integral heatsink assemblies.

17. Provide grounding provisions for the controller mounting flange.

18. Incorporate integral fan(s) for forced air ventilation.

19. Provide metal oxide varistors for transient protection.

20. Equip controller with lugs to accept the wire sizes indicated in the drawings.

21. The controller shall be capable of:
    - 600% current rating, 10 seconds
    - 450% current rating, 30 seconds

22. The controller shall operate properly at the temperature, humidity, and altitude of the project.

23. Provide 3-phase motor thermal overload relay protection for both normal and bypass configurations.

24. Provide fully rated bypass and isolation contactors.

25. Provide a phase rebalance feature which would regulate the individual phase output voltages from the controller to maintain equal 3-phase current to the motor.

26. Provide a serial communication port for remote control, monitoring, and parameters settings downloading.

27. Provide a communications protocol interface module for connection to a Modicon PLC via MODBUS PLUS protocol. Control power shall be 120 volt AC. Converter shall be as manufactured by Prosoft Technology Inc., Model 1560-MBP -1.

28. Provide Allen-Bradley SMC Dialog Plus, or SMC Flex, Smart Motor Controller.

F. Control Relays

1. Provide relays with the number of contacts shown on the schematic diagrams. Utilize additional contact blocks or relays to satisfy the required number of contacts shown at no additional cost to the IRWD.

2. Control relays shall have 120-volt AC coils, except as noted; contacts shall be rated for the various circuit applications shown on the drawings. Control relays shall be 10-ampere, multiple-contact, 300-volt, plug-in type with dust cover and sockets. If additional contacts are required, they shall be ganged.

3. Control relays for 120 volt AC application shall be as follows:

   a) DPDT - Allen Bradley 700-HA32A1

   b) Relay Base: 700 HN 125, 10 amp, 300 volt

   c) TPDT - Allen Bradley 700-HA33A1

   d) Relay Base: 700-HN126, 10 amp, 300 volt

4. Timing Control relays for 120 volt AC application shall be as follows:

   a. DPDT – Allen Bradley 700-HR52TA17
   b. Relay Base: 700 HN 101, 10 amp, 300 volt
   c. Retainer Clip: 700-HN131

G. Miscellaneous Devices

1. Control switches shall be round, oiltight type, complete with legend plates and quantity of contact blocks required for the control function.

2. Indicating lights shall be oiltight type, complete with color of lens indicated in drawings and legend plate. Lamps shall be 120-volt AC, 6S6 screw base. Indicating lights shall be push-to-test type.

3. Reset timers shall be synchronous motor driven with a solenoid-operated clutch and suitable for semiflush, panel mounting. Utilize timers with time range indicated and 10-ampere, 120-volt contacts. Provide Eagle Signal Bulletin 125 timers, Automatic Timing and Controls Bulletin 305 timers, or equal.

4. Elapsed time meters shall be synchronous motor driven, 0- to 99,999.9-hour range, nonreset type, suitable for semiflush, panel mounting.

5. Phase failure or phase monitoring relays shall provide protection against loss of any phase, phase unbalance, and phase reversal. An adjustable trip delay shall be incorporated in the unit. A locking potentiometer undervoltage adjustment and an LED indicating "relay energized" shall be provided. Unit shall be Square D 8430 DASV or equal. Plug-in type units are not acceptable.

H. Motor Management and Protection Relays – Motors 100 HP and Above

1. Motor protection and management shall be provided by a digital relay.

2. Protective functions shall include:

   a) phase overload standard curves (51)

   b) overload by custom programmable curve (51)

   c) I2t modeling (49)

   d) unbalance/ single phase (46)

   e) phase reversal (47)

   f) starts per hour and time

   g) between starts (48)

   h) short circuit (50)

   i) ground fault (50G/50N 51G/51N)

   j) mechanical jam/stall

3. Management functions shall include:

   a) statistical data

b) pre-trip data (last 40 trips)

c) ability to learn, display, and integrate critical parameters to maximize motor protection

d) a keypad and 40 character display

e) flash memory

4. Optional functions include:

a) under/overvoltage

b) metering package

c) stator overtemperature/bearing overtemperature with 12 independent RTD inputs (49)

d) underpower & power factor (55)

e) backspin detection

f) Modbus TCP, ethernet communications port

5. The relay shall be capable of displaying important metering functions, including phase voltages, kilowatt, kilovar, power factor, frequency and MWhr. In addition, undervoltage (27) and low power factor alarm and trip levels shall be field programmable.

6. The communications interface includes one front RS-232 port and three independent RS-485 ports, and one ethernet port. The serial communicatoins protocol shall be Modbus RTU. The ethernet communications protocol shall be Modbus TCP.

7. Motor management protection relays shall be as manufactured by Multilin, Model 369-HI-R-M-O-E, no equal.

PART 3 – EXECUTION

A. Installation

1. Secure motor control centers rigidly to floors or mounting pads and wall with stainless steel anchor bolts or Phillips Drill Company Red Head edge anchors.

B. Motor Temperature Monitoring and Protective Relays

1. Motor starters for motors with resistance temperature detectors (RTDs) shall be supplied with a full motor management protective relay as specified in Part 2 of this section, which includes the temperature monitoring and protection function.

C. Tests

1. The operation of each interlock shall be tested to verify that the interlock performs its function.

2. Set adjustable trip circuit breakers to the minimum setting which will provide freedom from nuisance tripping in accord with the manufacturer's recommendations.

END OF SECTION

SECTION 16160 - PANELBOARDS

PART 1 - GENERAL

A. Description

This section describes materials, testing, and installation of panelboards.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010

2. Low Voltage Motor Control: 16155

C. Submittals

1. Submit shop drawings in accord with the General Provisions and Section 16010.

2. Show ratings and characteristics including voltage ratings, bussing arrangement, continuous current ratings, fault current withstand ratings, neutral bus rating, enclosure type, ratings and arrangement of overcurrent protective devices, and mounting provisions.

PART 2 - MATERIALS

A. General

Dead front, safety type, with 120 / 240 volt ratings as scheduled. Panelboards shall be circuit breaker type and suitable for the short circuit and duty ratings specified. Panelboards shall be as manufactured by Allen-Bradley, Square D, or Cutler Hammer.

B. Breakers

Molded-case. Provide quick-make and quick-break toggle mechanism, inverse-time trip characteristics, and trip-free operation on overload or short circuit. Automatic tripping shall be indicated by a handle position between the manual OFF and ON position. Provide trip ratings as indicated in the panelboard schedules. Provide lock-on or lock-off devices where indicated on the drawings.

Single-pole breakers shall be full module size; two poles shall not be installed in a single module. Multiple circuit breakers shall be of the common-trip type having a single operating handle.

Furnish ground fault interrupter (GFI), 5-ma trip, 10,000-ampere interrupting capacity circuit breakers where indicated and to all 120 volt AC receptacles circuits.

C. Bolted Type

Circuit breaker current-carrying connections to the bus shall be of the bolted type, factory assembled.

D. **Bus Bars**

Bus bars shall be tinned copper. Provide a copper ground bus bar installed on the panelboard frame, bonded to the box, and containing at least 10 terminal screws.

E. **Space Only**

Where "space only" is noted on the drawings, provide connectors, mounting brackets, etc., for the future insertion of an overcurrent device of the size indicated.

F. **Directories**

Provide typed circuit directories on the inside face of the door of each panel. Handwritten directories are unacceptable.

G. **Nameplates**

Provide nameplates as specified in Section 16010. Designate the identifying nomenclature, voltage, and phase of the panel as shown on the drawings; for example, "PANEL A, 120/240-volt, single-phase, 3-wire, 100-ampere bus".

H. **Gutter**

Provide flashing gutter along the entire length of the back of the outdoor metering switchboard. Slope to a downspout on one side. Flash between building and the metering switchboard.

PART 3 – EXECUTION

A. **General**

Install panelboards in accord with manufacturer's instructions.

B. **Circuit Schedule**

Provide circuit schedule listing permanently attached to the inside surface of the panelboard access door.

END OF SECTION

SECTION 16400 – SERVICE AND DISTRIBUTION

PART 1 - GENERAL

A. Description

Requirements specified in Conditions of the Contract and Division 1 form a part of this Section. This Section outlines the electrical work for underground power service, power distribution and grounding, and forms a part of all other Sections of Division 16 unless otherwise specified.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010.
2. Structure Earthwork: 02220
3. Concrete: 03300
4. Painting and Coating: 09900
5. Low Voltage Switchboards: 16443

C. Power Service

1. The power company shall supply alternating current at 60 Hertz and at the indicated voltage for the power service as shown on the Drawings.

2. Underground service shall be complete and as shown on the Drawings. The service installation shall conform to the power company service requirements.

3. Distribution: The power distribution system shall include equipment installations and underground wiring installations as shown on the Drawings.

4. Grounding: System, structural and equipment grounding installations shall be complete as indicated and required per governing codes.

   a. Equipment Grounding includes all non-current carrying metal parts of electrical equipment and wiring systems that shall be effectively grounded with a minimum of #1 cu. A.W.G. or as noted on the Drawings.

   b. Structural Grounding includes all structural steel that shall be effectively grounded with #4/0 cu. A.W.G. or as noted on the Drawings.

   c. System Grounding includes a solid ground connection to the neutral point of a system, transformer and rotating machine as indicated on plans and required by N.E.C.

C. Submittals

Submit for the Owner's approval material lists, shop drawings, reports, and technical data to the extent required in this Section and Section 16010.

1. Material Lists: The material lists shall be complete and include all products specified in this Section, including the equipment that shall have shop drawings. The list shall include only one manufacturer for each product.

2. Shop Drawings: The equipment shop drawings shall be complete and include the following for the primary service, transformers, switchboards and panelboards:

    a. Plans shall show the equipment location, space requirements, clearances, conduit and anchor bolt locations.

    b. Elevations shall show the vertical positions and arrangements of equipment and nameplates.

    c. Details shall show the requirement enlarged small parts.

    d. Dimensions shall be included on the Drawings.

    e. Weights for equipment and seismic anchoring requirement shall be included on the Drawings.

    f. Nameplate Data shall include the nameplate material, heights of letters and inscriptions.

3. Technical Data: Complete equipment descriptive, operation and installation data shall be submitted with the shop drawings.

4. Test Reports: Copies of the Factory Test Reports shall be certified by the manufacturer and submitted to the Owner as specified in Section 16010.

PART 2 - PRODUCTS

A. <u>General</u>

Provide all equipment and materials, including proper space, and complete all of the power service, power distribution and grounding installations as indicated, specified and required. Refer to Sections 16010, 16110, 16120 and 16433 for conduits, conductors, switchboards, circuit breakers, and nameplates.

B. <u>Handholes and Pull Boxes</u>

Below Ground: Precast concrete handholes and pull boxes shall be provided as shown on the Drawings. They shall be Brookes, Quikset or approved equal and shall be designed for H-20 bridge loading. Knockouts shall be provided for connection to underground conduits. Covers shall be steel, bolt down traffic type. Sump shall be provided in the bottom section. Inside dimensions shall not be less than 24" W x 48" L x 36" D.

C. <u>Service Equipment</u>

Provide the metal enclosed, service equipment as shown on the Drawings, specified and in accord with the Power Company service requirements. The low voltage service equipment shall be supplied with 100 percent rated copper bus and shall be Square D, GE or Cutler Hammer.

1. Provisions for Power Company metering, consisting of current transformers, demand meter, and kilowatt-hour meter and associated protective devices shall be made in switchboard as indicated on the Drawings and as required by the Power Company.

2. Pull Section shall be totally metal enclosed, full height, free standing and equipped with copper busses and connectors for the underground service conductors.

3. Main Service Switch shall be included in the service equipment as shown on the Drawings, and specified in Section 16443. Provide a shunt trip as indicated. Interrupting rating shall be as indicated on the Drawings.

4. Ground Fault Protection shall be provided. The system shall provide low-level ground fault protection, and shall be manufactured by Westinghouse, Square D, or Allen Bradley. The ground fault protection system shall be complete and consist of an adjustable relay, monitor panel, current sensor and a disconnect device that actuates a shunt trip on the circuit breaker. The ground fault relay shall be solid state with an adjustable pickup setting. The sensor shall be a specially constructed current transformer, which encompasses the phase and neutral conductors. A monitor panel shall include visual indication when the circuit interrupter has opened on a ground fault, and a push-to-test button. The circuit disconnecting device shall be actuated when the current output of the sensor exceeds the pickup setting of the static relay, which trips the shunt mechanism on the circuit breaker.

5. Nameplates shall be provided for the service equipment. Refer to Section 16010 for nameplates.

6. Power Company approval of the proposed service equipment shall be obtained before shop drawings are submitted for review.

PART 3 – EXECUTION

(Not Used)

END OF SECTION

SECTION 16418: VARIABLE FREQUENCY DRIVES BELOW 100 HP

PART 1 - GENERAL

A. The Requirement

The CONTRACTOR shall furnish all tools, equipment, material, and supplies and perform all labor required to install three variable frequency drive systems rated at less than 100 horsepower as indicated on the Drawings and specified herein.

B. Related Work Specified Elsewhere

1. The WORK of the following Sections and Divisions that applies to the WORK of this Section.

   a. Division 11 Vertical Turbine Pumps (11318), and applicable Sections.

   b. Division 16 Electrical, applicable Sections.

   c. Division 17 Instrumentation and Control, applicable Sections.

2. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

3. Materials and equipment furnished and installed under this specification with raceway and electrical conductors furnished, installed, and connected under Division 16, Electrical.

C. Reference Specifications, Codes and Standards

1. All work specified herein shall conform to or exceed the applicable requirements of the referenced portions of the following publications to the extent that the provisions thereof are not in conflict with other provisions of these specifications.

2. Comply with the current provisions of the following Codes and Standards.

   a. Codes and Standards

NEC	National Fire Protection Agency (NFPA) – 70 National Electrical Code (NEC), latest adopted edition.
CCR	National Electrical Code, Title 8, Industrial Relations, Subchapter 5, Electrical Safety Orders, California Code of Regulations.

   b. Commercial Standards

ANSI/UL 467	Safety Standard for Grounding and Bonding Equipment.

IEEE 519 — Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

NEMA MG-1998 — Standard for Motors and Generators.

NEMA 250-1997 — Standard for Enclosures for Electrical Equipment (1,000 volts maximum).

NEMA Standard ICS7.1 1995 — Safety Standards for Construction and Guide to Selection, Installation, and Operation of Adjustable Frequency Drives Systems.

UL 508A — Standard for Industrial Control Equipment.

D. System Description

A. Furnish and install 3 complete, solid-state variable frequency drive systems as specified herein and indicated on the Drawings. This Specification describes variable speed motor control which includes the design, fabrication, testing, installation and support requirements for variable frequency drive systems for 3-phase squirrel cage rotor, induction motors listed in the table below. Where noted on the drawings, in addition to the variable frequency drive, provide each system with a starter for bypass starting during variable frequency drive downtime.

VFD Driven Equipment Tag Number	VFD Number	Motor Rating (hp)	Motor Rating (Volts)	Motor Rating (Amperes)
P-001	VFD # 1	--	480, 3 phase	--
P-002	VFD # 2	--	480, 3 phase	--
P-003	VFD # 3	--	480, 3 phase	--

B. Point of Common Coupling: The point of common coupling shall be located at the secondary side of the transformer serving the VFD systems, as shown on the drawings.

1. The Available Short Circuit Current at the Point of Common Coupling is 42000 amperes.

E. Contractors Submittals

Submittals shall be made in accord with the Section 16010 Electrical General Provisions. The submittals shall include the following:

1. Shop Drawings

a. Layout Drawings

(1) Layout drawings of the variable frequency drive systems that include all cabinet or enclosure dimensions, access details, and weights.

(2) Layout drawings of panels or enclosures showing size, arrangement, color, and nameplates. Drawings shall include the physical arrangement of door-mounted devices located on the variable frequency drive enclosure. Sufficient detail shall be provided for locating conduit stub-ups. General "catalog data sheet" layout drawings that are not specific to the systems specified herein are not acceptable.

b. Single Line Diagrams: Complete single line diagrams indicating all devices comprising the variable frequency drive system including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system. Electrical ratings of all equipment and devices shall be clearly indicated on these single line diagrams.

c. Control Diagrams

(1) Schematic and interconnection wiring diagrams of all electrical work, including terminal blocks and identification numbers, wire numbers and wire colors. These drawings shall be circuit specific for each motor-load combination.

(2) Logic diagrams identifying system control logic.

(3) Indicate all devices, regardless of their physical location, on these diagrams. The specific device location symbols and their respective legend shall also appear on these diagrams.

(4) Specific equipment names consistent with the Drawings shall appear on each respective diagram.

(5) Functional diagrams that identify major system functional blocks and interfaces. The diagrams shall note any special requirements or restrictions of the motor-load combination and shall show all interface wiring and points of connection to the VFD enclosure (and bypass if included).

d. Manufacturers Drawings

(1) Drawings submitted by the manufacturer shall be complete and documented to provide the OWNER with operations and maintenance capabilities.

(2) Relay and timer coil and respective contact identification numbers shall match those indicated on the Drawings.

e. Bill of Material: Complete Bills of Material with catalog data sheets and manuals for all equipment and devices comprising the variable frequency drive system. Where catalog cuts and other brochures depicting product characteristics are supplied, annotate to show product to be used on this project.

f. List of Spare Parts: A complete list of recommended spare parts. Include item descriptions, recommended quantities, and unit costs. The recommended list should be based on a maintenance plan where the OWNER will remove and replace failed items to the lowest replaceable module/component level.

2. Test Reports

a. Submit certified copies of manufacturer's test reports.

b. Submit factory bench-test data to indicate that the manufacturer's proposed equipment has been tested in the specified arrangement and found to achieve specified accuracy.

3. Operation, Maintenance and Installation Instructions: Furnish with the equipment at delivery 8 copies each of manufacturer's operating and maintenance manuals, installation instructions, and other documentation necessary for the installation, start-up, operation and maintenance of the system.

4. Programming Guides and Manuals: If the variable frequency drive systems require computer software or configuration, provide 4 copies of all programming guides/manuals. Flow charts and listings of software developed shall be submitted to the ENGINEER. Submit final flow charts and program listings no later than 6 weeks prior to factory testing of the system.

5. Record Drawings: Drawings of each of the above types representing the as-built condition of the equipment and software shall be delivered with the equipment at the jobsite. Final or corrected as-built drawings shall be delivered 4 weeks after field system acceptance.

6. System Warranty

7. Test documentation shall be provided in a three-ring binder(s) within three weeks after the completion of the project. The binder(s) shall be clearly marked on the outside front cover and spine with the words "Test Results", the project name, and the date of completion (month and year). Scanner tests shall be printed on 8-1/2" x 11" paper. When repairs and re-tests are performed, the problem found and corrective action taken shall be noted, and both the failed and passed test data shall be collected in the binder.

F. Quality Assurance

1. System Warranty

a. The CONTRACTOR shall provide a system warranty covering the installed variable frequency drives against defects in workmanship, components, and performance, and follow-on support after project completion.

b. The CONTRACTOR shall warrant the variable frequency drives against defects in workmanship for a period of one year from the date of system final acceptance. The warranty shall cover all labor and materials necessary to correct a failed portion of the system and to demonstrate performance within the original installation specifications after repairs are accomplished. This warranty shall be provided at no additional cost to IRWD.

c. The CONTRACTOR shall facilitate a 2-year component warranty between the manufacturer and the District. An extended component warranty shall be provided which warrants functionality of all components used in the system for 2 years from the date of acceptance.

(1) The CONTRACTOR shall maintain current status with the warranting manufacturer, including all training requirements, for the duration of the Project.

(2) The CONTRACTOR shall staff each installation crew with the appropriate number of trained personnel, in accord with their manufacturer/warranty contract agreement, to support the 2-Year Performance Warranty requirements.

(3) After installation, the CONTRACTOR shall submit all documentation to support the warranty in accord with the manufacturer's warranty requirements, and to apply for said warranty on behalf of the IRWD.

(4) The warranty shall cover the components and labor associated with the repair/replacement of any failed link, within the warranty period, that is a valid warranty claim.

2. Manufacturer Qualifications

a. Variable frequency drive manufacturer shall have ISO 9001 certification.

b. Variable frequency drive manufacturer shall maintain, as part of a national network, engineering service facilities within 250 miles of the equipment installation to provide start-up service, 24 hour/day emergency service calls, repair work, service contracts, maintenance, and troubleshooting training of customer personnel.

c. Provide the following supporting information:

(1) The location of repair facilities where drive system components would be repaired.

(2) The location(s) nearest to Fountain Valley, California where spare parts are stocked.

(3) Variable frequency drive manufacturer information guaranteeing 72 hours turnaround time after receipt at the repair facility for the repair and return of a failed part.

3. Underwriter's Laboratory: Variable Frequency Drive shall have a visible UL mark.

G. Operating Conditions

The following operating conditions are applicable for all equipment of this Specification.

1. Humidity: 0-95 percent. Space heaters shall be provided to prevent condensation for outside equipment only. Space heaters shall be tubular type operated at half voltage for long life; 500 volt or 250 volt rated heaters shall be used at 240 volts or 120 volts, respectively. Power supplies to the space heaters shall be as indicated on the Drawings. Heaters to be wired to provide temporary heating during storage.

2. Ambient Temperature: Minus 20 degrees Celsius to plus 40 degrees Celsius.

3. Altitude: Sea level to 3,300 feet.

4. Power Supply: 480 volts, 3-phase, 60 Hertz.

5. Short circuit fault withstand 42000 Amps.

PART 2 - PRODUCTS

A. Manufacturer

1. The same manufacturer shall supply all variable frequency drive systems. The manufacturer shall be Allen Bradley or equal.

B. Variable Frequency Drive System

1. Each variable frequency drive shall be a complete alternating current electric drive system including hardware, software, technical data, and spare parts necessary to accomplish variable speed operation of an induction motor and load combination in accord with the requirements as indicated on the Drawings and as described in these Specifications. CONTRACTOR shall refer to the appropriate sections of these Specifications for the driven equipment control description for each variable frequency drive system.

2. Variable frequency drive system manufacturer shall either manufacture all items of component equipment or supply them using coordinated specifications furnished to the original equipment manufacturers to insure compatibility and performance in accord with this Specification.

3. Variable frequency drive manufacturer shall be responsible for the successful application and operation of the drive combined with the motor and driven equipment. This includes the responsibility for determining all load, torque, speed, and performance requirements from the respective sources and integrating these into a variable frequency drive system that fulfills the requirements of this Specification.

4. Variable frequency drive system shall be suitable for operation as part of a 480 volt alternating current, 3-phase, and 60-Hertz power distribution system. The complete variable frequency drive system shall withstand the mechanical forces exerted during short circuit conditions. In the event that the results of the CONTRACTOR'S short circuit fault analysis, as accepted by the ENGINEER, indicate that a higher short circuit duty rating of the variable frequency drive system is required, the CONTRACTOR shall furnish the variable frequency drive system with that higher rating.

5. The variable frequency drive system shall be suitable to operate, at times, on a limited power source engine-generator set. The system when operating on this source shall also conform to waveform distortion limits for normal operation as specified in Article 2.03 of this Specification.

6. All necessary motor and drive parameters together with specific control and protection functions shall be programmable via a keypad. Control and sequence logic shall be designed such that the motor-load combination can be operated in the manual mode upon control and sequence logic failure, and that all necessary personnel and equipment safety interlocks will remain effective.

7. The CONTRACTOR and variable frequency drive system manufacturer are cautioned regarding the review and compliance with the total Contract Documents. Typical examples are circuit breakers, motor circuit protectors, line and load reactors, magnetic starters, relays, timers, programmable logic controllers, pilot devices including pushbuttons, selector switches and pilot lights, enclosures, conduit, disconnect switches, terminal boxes, and other equipment.

C. Design Requirements

1. The variable frequency drive shall consist of an 18-pulse full wave diode bridge rectifier, a DC bus, a power transfer inverter and line and load reactors. The inverter shall invert the direct current voltage into an alternating current voltage and frequency proportional to the desired speed using isolated gate bipolar transistors (IGBTs) with pulse width modulation (PWM) technology. This alternating current voltage and frequency shall both vary simultaneously at a constant "Volts-Per-Hertz" ratio to operate the induction motor at the desired speed.

2. Provide each variable frequency drive with a main disconnects and protective device (motor circuit protector) as indicated on the Drawings, which shall be pad lockable. Provide line and load reactors having a minimum 2-1/2 percent reactance. Reactors shall be mounted in the VFD enclosure.

3. The drive shall operate the motor and produce full rated nameplate horsepower at the motor output shaft without exceeding rated total temperature including the additional temperature increment that constitutes the motor service factor. Motor service factor shall be 1.0 when operated from the VFD. The drive shall operate with a minimum 95 percent input power factor at speeds between 30 percent and 100 percent of rated speed.

4. Efficiency is the total 3-phase power delivered to the motor, measured at the output terminals of the drive system, including any output filters. Power $_{(Supply)}$ is the total electrical power delivered to the drive system, measured at the input terminals of the variable frequency drive including input filters, line reactors, isolation transformers, or other harmonic distortion attenuation equipment. Include power input required for auxiliary equipment (e.g., controls, fans, air conditioning, pumps) for complete system operation in this Power $_{(Supply)}$ total. The overall drive system efficiency shall be a minimum of 96 percent when operating the specified motor-load combination at rated voltage, frequency, and current. This efficiency shall be calculated as follows:

$$Efficiency\,(\%) = \frac{Power\,(Load)}{Power\,(Supply)}\,x\,100$$

5. The variable frequency drive system shall maintain a desired output frequency (setpoint) with a steady state accuracy of 0.5 percent of rated frequency of 60 Hertz for a 24-hour period. The drive system shall achieve a desired output frequency (setpoint) with a repeatability of 0.1 percent of rated frequency of 60 Hertz.

6. The variable frequency drive shall have an automatic current limit feature to control motor current during startup and provide a "soft start" torque profile for the motor-load combination. The current limit setting shall be field adjustable.

7. A door-mounted membrane keypad with integral two-line, 24 character LCD displays shall be provided, capable of controlling the VFD and setting drive and motor parameters. The keypad module shall contain a self-test software program that may be activated to verify proper keypad operation.

8. The system shall be capable of operating the specified load continuously at any speed within the operating speed range of 10 percent to 100 percent of rated speed. The minimum and maximum continuous operating speeds shall each be adjustable within this speed range. The variable frequency drive shall provide for field adjustment of these setpoints.

9. Drive system controls shall be microprocessor-based and have controlled linear acceleration capability to ramp up and down the speed (revolutions per minute) of the motor-load combination from the minimum selected operating speed to the maximum selected operating speed at individual adjustable rates. Provide 3 field-adjustable speed setpoints for the variable frequency drive to skip equipment resonant frequencies. Provide controlled linear deceleration capability. The acceleration and deceleration time limits shall be field adjustable to values up to 120 seconds.

10. Voltage unbalance between phases of the variable frequency drive output shall not exceed 3 percent of the instantaneous values with balanced input voltage. The variable frequency drive system shall continuously monitor the output voltages and generate an alarm condition when the unbalance exceeds 3 percent. The system shall detect and generate a separate alarm for loss of any output phase voltage (single phasing). Phase unbalance shall be as defined by NEMA Standard MG-1.

11. The variable frequency drive system shall operate continuously without interruption of service or damage to equipment during transient input voltage variations up to 110 percent for duration of 15 cycles. Output voltage regulation shall be plus or minus 2 percent.

12. The variable frequency drive shall be capable of supplying continuously an output motor load RMS current equal to 110 percent of the motor full load RMS current when operated from an undistorted sine wave source. This 110 percent RMS value shall include all harmonic content in the inverter output current while producing full nameplate horsepower from the motor. Motor over current protection shall be provided.

13. The audible noise (sound pressure) level of a motor when operated from no load to full load with the variable frequency drive described herein shall not increase more than 5 decibels (dbA) above its noise level when operated at constant rated speed from a utility power source without the variable frequency drive. Audible noise shall be measured in a free field at 3 feet in all directions from the motor.

14. Carrier Frequency for pulse width modulation shall be 3500 Hertz or less.

15. The driven motor shall operate in the forward direction regardless of input source phase sequence. The VFD shall be capable of energizing a spinning load of a motor "on-the-fly" if the motor is spinning in the forward direction

16. When a motor lockout stop pushbutton is indicated on the Drawings, activation of this device shall disable operation of the VFD including operation by the keypad in the manual mode and the bypass control mode.

17. The drive must fit within the space allocated on the drawings while meeting all code clearance requirements.

18. All operation, maintenance, and repair tasks shall be performed via front access to the enclosure. No side or rear access will be available.

D. System Features and Conditions

1. Controls and indicators to accomplish operation and maintenance functions shall be located on the variable frequency drive equipment assembly as specified herein and indicated on the Drawings. As a minimum, the required controls and indication shall consist of the following displayed in English units or narrative English. No display codes for these items shall be accepted.

    a. Digital Output Speed Indicator: Revolutions per minute.

    b. Variable Frequency Drive Mode: Red.

    c. Bypass Mode Indicator: Red.

    d. Input Voltage.

    e. Output Voltage.

    f. Output Current.

g. Output Frequency.

h. Drive Ready: White.

i. Run Indication: Green.

j. Stop Indication: Red.

k. Running Time.

l. Control Mode Selection.

m. Start and Stop.

n. Mushroom Head Emergency Stop Pushbutton.

o. Manual Speed Control.

p. Motor Winding Over temperature Shutdown and Indication.

q. Enclosure Over temperature Shutdown and Indication.

r. Alarm: Amber.

s. Alarm Read-out: Display.

t. Alarm Reset.

u. Event and Diagnostic Recorder.

v. Alarm, Auxiliary Contacts and Other Devices: As indicated on the Drawings and specified.

w. Programming keypad to input set points and mode and sequence programming data.

x. One spare keypad, cable, connectors, and other appurtenances shall be provided by the variable frequency drives system manufacturer as required for every 3 variable frequency drives of the same series/model number.

2. Variable frequency drive system shall provide a 4-20 mA direct current output signal that is proportional to the drive output frequency for use as speed feedback or control and remote speed indication. This signal shall not report until the motor is actually rotating.

3. Variable frequency drive system controls shall accept a 4-20 mA direct current input command signal to control the output frequency in the "remote" control mode as specified herein or indicated on the Drawings. The controls shall accept the input increase/decrease command with a resolution that permits incremental changes in speed, revolutions per minute, equal to or less than 0.1 percent of rated speed. In "Local" mode the VFD shall receive a resistance signal from a manual speed potentiometer.

4. When operating in the automatic mode, the variable frequency drive system shall shut down during a power outage. Upon restoration of normal or emergency power and after an adjustable time delay (0-30 seconds); the variable frequency drive system shall automatically restart and then ramp up to speed as required by the control system. Upon temporary power loss lasting more than 100 milliseconds, VFD shall immediately restart motor. With longer power outages VFD shall restart as programmed in the field. The plant operator shall not be required to reset the system manually after a shutdown caused by a power outage.

5. Provide each variable frequency drive with its respective drive controller and required output contactors for each drive.

6. Provide variable frequency drive system with RFI filters to reduce transmitted and received radio interference.

7. Variable frequency drive design shall include on-line diagnostics, with an automatic self-check feature that will detect a variable frequency drive failure that affects motor operation and generate an alarm with an output contact rated for 125 volts-direct current suitable for interfacing into a SCADA system. All keypad displays and diagnostics shall be in narrative English.

    a. Diagnostics shall illuminate an amber pilot light indicator that is visible on the variable frequency drive equipment cabinets without opening cabinet doors.

    b. Provide an RS 232 output for connection to a laptop computer. A keypad indication of the "First Out" failure is a minimum for fault sequence detection.

    c. Provide a normally closed dry contact for the alarm function and a normally closed contact for VFD failure out to enable remote indication. An RS232C communication port shall be provided for future link to a central computer.

E. Enclosures

1. Unless otherwise specified the variable frequency drive system enclosures shall be NEMA 1 gasketed, force ventilated dead front with front accessibility. Design enclosures for top entry of cables. Design variable frequency drive system so that rear or side cabinet access is not required for operations, maintenance, and repair tasks.

    a. Treat metal surfaces and structural parts by phosphatizing, or equal, prior to painting.

    b. Apply a gunmetal gray undercoat to enclosures, which is equal to zinc chromate.

    c. Finish exterior of the enclosures in ANSI-61 gray.

2. Furnish each variable frequency drive system with the control switches, alarm lights and indicators as specified herein and as indicated on the Drawings. Furnish main circuit breakers with an external operating handle interlocked with the door so that the door cannot be opened unless the disconnect is in the OFF position. Power supply to the motor from both the variable frequency drive and the bypass starter, if provided, shall be capable of being positively locked in the OFF position. The disconnect shall be interlocked so that equipment cannot be energized when the door is open.

3. Equipment to be of modular construction allowing normal maintenance and repair to be done with ordinary hand tools. Design and install semiconductor assemblies so that a single failed thyristor can be individually removed and replaced.

4. Comply with the seismic requirements of the Uniform Building Code. Design mechanical and electrical equipment, and their supports and connections, to prevent sliding or overturning. Brackets and anchors shall be of ductile material so that they can absorb energy and continue to carry load.

5. Each VFD enclosure size shall be a maximum of 90 inches high by 60 inches wide by 40 inches deep, with output and bypass motor starters.

6. Each VFD enclosure shall have positive forced air ventilation controlled by a thermostat with a temperature range of 85 – 104 Deg F. Supply fans shall be located approximately 18" above bottom with removable filter. A minimum of two individually fused fans shall be provided. Exhaust louvers shall be located near the top of the enclosure. Insect screens shall be provided on exhaust louvers. Supply fans and exhaust openings shall be on the front of the VFD enclosure.

F. Bypass Starters and Output Starters

1. Provide bypass and output starters with incoming line protective devices as specified for variable frequency drive proper, full capacity rated input and output magnetic contactors, each interlocked with the input and output contactor of the variable frequency drive. Provide soft-start starters where indicated on the drawings.

2. The VFD and the bypass compartment shall have separate doors and barriers to allow maintenance personnel to work in either portion.

G. Harmonic Distortion

1. The harmonic distortion values contributed by operation of all variable frequency drive motor-loads operating at full load shall be:

    a. Maximum Allowable Total Harmonic Voltage Distortion (THVD) Contribution: 3 percent of the fundamental.

    b. Maximum Allowable Total Harmonic Current Demand Distortion (THID) Contribution: 8 percent of the combined load current of the main feeder supplying all 480 volt loads.

2. The ENGINEER shall review the harmonic study before equipment manufacturing is begun.

PART 3 - EXECUTION

A. Harmonic Distortion

A. The variable frequency drive manufacturer shall perform a comprehensive pre-equipment-selection harmonic study to determine harmonic voltage and current distortion and the ratings and characteristics of individual tuned filters or other attenuation equipment if these are necessary to achieve the required distortion limits. In conducting the study, the manufacturer shall calculate the total harmonic voltage distortion at the point of common coupling which will be the 480 volt bus supplying the VFDs using an assumed source impedance of 3.5 percent unless stated otherwise in the specifications or drawings.

B. The harmonic distortion values contributed by operation of all variable frequency drive motor-loads operating at full load shall be:

1. Maximum Allowable Total Harmonic Voltage Distortion (THVD) Contribution: 3 percent of the fundamental.

2. Maximum Allowable Total Harmonic Current Demand Distortion (THID) Contribution: 8 percent of the combined load current of the main feeder supplying all 480 volt loads.

C. The ENGINEER shall review the harmonic study before equipment manufacturing is begun.

B. Source Quality Control

1. Factory Testing

a. Factory test the complete variable frequency drive system in accord with IEEE and NEMA standards and these Specifications. In addition, the variable frequency drive system shall be tested for efficiency and for operational integrity during output short circuit conditions. Short circuit tests shall demonstrate that the equipment will successfully protect against and survive a minimum of 3 successively repeated phase-to-phase short circuits at the drive output terminals.

b. Variable frequency drive system components, including power transistors, Gatos, Scars, and diodes shall be 100 percent inspected and tested, including temperature cycling and ambient high temperature of 65 degrees Celsius load testing. All integrated circuits shall be inspected, pass/fail tested, temperature cycled and ambient high temperature tested. Small components, including small signal semiconductors, resistors, capacitors, diodes, etc. shall be lot sampled and tested for functionality. Test printed circuit boards using a temperature cycled 20-hour load test and functionally bench test prior to unit installation. Inspect all final assemblies and test at full load with application of line-to-line and line-to-ground bolted faults. The variable frequency drive system shall electrically trip off line under these conditions without device failure.

c. After the specified inspections and tests have been successfully completed, the variable frequency drive system shall undergo a 10-hour burn-in test. Burn system in at 100 percent inductive or motor load for 10 hours without an unscheduled shutdown. After the burn-in cycle is complete, the variable frequency drive system shall be put through a 30 minute varying motor load test before final factory inspection and shipping.

d. Auxiliaries, including fans, that are required for rated load operation at maximum ambient temperature, shall be 100 percent redundant. A new and unused spare replacement fan(s) or air conditioning unit(s), shipped in original carton, may be an acceptable alternate.

e. Circuit boards and electrical components shall have corrosion protection suitable for an industrial environment.

f. Authorized representatives of the OWNER shall be allowed free access to the shops at all times while work is in progress for the purpose of inspection, observe tests, and obtaining information on the progress of the work. The OWNER shall give the CONTRACTOR 72 hours prior notice.

g. Acceptance of a shop test does not relieve CONTRACTOR from requirements to meet field installation tests under specified operating conditions, nor does the inspection relieve the CONTRACTOR of responsibilities.

h. The CONTRACTOR shall successfully complete Acceptance Test Procedures on the assembled drive system that demonstrate compliance with the requirements of this Specification. The test plan shall be submitted for acceptance at least 30 days prior to the planned test date.

i. Drive system shall not be shipped from the manufacturing and assembly facility until the acceptance tests are completed and the results approved by the ENGINEER.

2. Verification of Performance

a. A representative of the ENGINEER may witness tests. Variable frequency drive manufacturer shall notify the ENGINEER 2 weeks in advance and shall provide testing procedures to the ENGINEER 4 weeks prior to actual testing. Failure of a test shall result in rejection of the equipment until performance is in compliance with these specifications.

b. Certification on materials and records of shop tests necessary for the inspector to verify that the requirements of the specifications are met shall be made available to the inspector.

c. Submit signed and dated certification that all of the factory inspection and testing procedures described herein have been successfully performed by the CONTRACTOR prior to shipment.

F. Field Quality Control

1. Provide the services of an experienced, factory trained technician or service engineer of the variable frequency drive manufacturer at the jobsite for minimum of 2 days for startup of each VFD beginning at a date mutually agreeable to the CONTRACTOR and the OWNER. One additional day shall be provided for training. The technician shall be on duty at the site for at least 8 hours per day and shall be available 24 hours per day when required to advise concerning special problems with equipment and systems.

2. Include in the bid an allowance for factory-trained service personnel to supervise field installation, inspect, make final adjustments and operational checks, make functional checks of spare parts, and prepare a final report for record purposes. Adjust control and the ENGINEER has accepted instrument equipment until this equipment has been field tested by the CONTRACTOR and the results of these tests.

3. Include in the bid the training of personnel in the operation and maintenance of each furnished variable frequency drive control system. For the purposes of this training section of the Specifications, a system is by definition a group of driven equipment which all serve a common function (e.g., filter influent pumps, chlorine mixers, flocculators).

G. Maintenance

1. Spare Parts: As a minimum, furnish and list the following spare parts in the Bill of Material:

   a. One set of all power and control fuses and indicating lamps for each variable frequency drive.

   b. One fully functional main control circuit board.

   c. One of each inverter power semiconductor for each rating supplied for each variable frequency drive.

2. Tools and Equipment: Variable frequency drive manufacturer shall identify and supply special tools or test equipment necessary to perform maintenance or repair tasks.

3. Field Services: Manufacturer shall describe the field service system available to support the proposed variable frequency drive system. As a minimum describe:

   a. Type of technical support available (e.g. system engineering and technician).

   b. Location of field service personnel (maximum 100 miles.)

   c. Field service daily rates in dollars per hour and dollars per day.

   d. Guaranteed response times to service requests.

H. Acceptance Testing

1. Final Inspection: The CONTRACTOR to perform and submit the results of a final comprehensive field performance survey after equipment installation.

2. Performance Verification

   a. The CONTRACTOR shall field measure actual harmonic distortion and verify with tests acceptable to the OWNER after satisfactory full-load operation. Test methods shall be acceptable to the ENGINEER.

   b. As part of the specified harmonic studies and measurements for this project, use frequency scan analysis to identify and correct resonance conditions in the electrical distribution system at no additional cost to the OWNER.

      (1) Measurements shall include harmonic voltage and current spectra and individual and total harmonic distortions.

3. System Performance

   a. During the three-week period between final inspection and delivery of the test and as-built documentation, IRWD shall validate operation of the variable frequency drive system by regular inspection during workdays.

   b. Completion of the installation, final inspection, receipt of the test and as-built documentation, and successful performance of the system for a three-week period shall constitute acceptance of the system.

END OF SECTION

SECTION 16443 - LOW-VOLTAGE SWITCHBOARDS

PART 1 - GENERAL

A. Description

This section includes materials and installation of low-voltage switchboards.

B. Utility Approval

Shop drawings of service sections shall be approved by the serving utility and reviewed by IRWD prior to fabrication.

C. Manufacturers

Switchboards shall be manufactured by General Electric, Square D, or equal.

PART 2 - MATERIALS

A. General

1. Main service and distribution switchboards shall be floor standing, dead front and rear enclosure with front removable devices and load connections, front and rear accessible.

2. Construct sections with a minimum thickness of 12-USSG formed sheet steel and of overall dimensions that will fit within the space limitation indicated in the drawings.

3. Provide service switchboards with metering and current transformer space, pull sections, and fully removable front covers of the widths, depths, and heights required by the service utility and as necessitated by the physical requirements of the conduits and cables entering the sections.

4. Provide distribution switchboards with individually mounted circuit breakers, power monitor, and other equipment as indicated.

5. Switchboard shall consist of required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on louvers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

6. The switchboard shall be provided with adequate lifting means.

7. Provide circuit breakers with fault current ratings equal to or larger than the switchboard rating shown in the drawings.

8. Switchboards shall comply with NEMA PB-2 and UL-891 standards. Provide UL label on each switchboard section.

B. Busing

1. Provide switchboards with rectangular copper busing. Cross busing shall be full capacity. Vertical busing shall be full height and rated for the load to be carried, but in no case less than one-third the capacity of the main bus. Horizontal and vertical busing shall be braced to withstand 50,000 amperes symmetrical fault current. A copper ground bus with a cross section meeting code requirement but not less than 1/4 by 2 inches shall extend the entire length of the distribution sections of the switchboards.

2. Connections shall be silver plated. Provide conical spring-type washers at each bolted joint.

3. Provide heavy-duty pressure-type terminal lugs for connections of incoming and outgoing cables. Support cables and internal wiring with bolted cleats.

C. Main Disconnect

1. Main disconnect device shall be as indicated in the drawings. Device shall be capable of being padlocked in the off position.

2. The disconnect shall be permanently marked to identify it as a service disconnecting means, in accord with NEC Article 230, Part F.

B. Distribution Circuit Breakers

Circuit breakers shall be molded-case type. Provide quick-make and quick-break toggle mechanism, inverse time trip characteristics, and trip-free operation on overload or short circuit. Automatic tripping shall be indicated by a handle position between the manual OFF and ON position. Provide trip ratings and number of poles as indicated in the drawings. Provide provisions for padlocking external disconnect handles in the OFF position.

C. Molded Case Power Main Circuit Breakers

Provide power circuit breakers of the molded or insulated case type with the frame size and trip rating shown, fixed mounting, manually operated with a solid-state trip device having an adjustable long time delay, adjustable short time delay, adjustable instantaneous trip, fixed, high-set instantaneous (15X), and a stored-energy close and trip mechanism. Provide integral ground fault protection with adjustable time delay and trip settings.

D. Nameplates

Provide nameplates as specified in Section 16010. Provide a nameplate for each circuit breaker or fusible switch to indicate load served. The main nameplate shall give the switchboard designation in 1/2-inch-high letters. A second line in 1/4-inch-high letters shall indicate the voltage and phases.

F. Power Monitor

1. Provide a microprocessor-based monitoring and protective device where shown in the drawings providing electrical metering. Device shall have the following features:

    a. Continuous metering of the three phases of the electrical system.

    b. It shall be possible to view on the LCD module display the current, voltage, active power, reactive power, power factor, watt-hours, frequency, and demand values.

    c. Multiposition keypad shall give full front panel programmability.

    d. All set points shall be stored in EEPROM for permanent storage.

    e. A minimum 32-character liquid crystal display shall provide English language description of all set points and metered values.

    f. The module shall provide a minimum of four isolated analog current outputs (4 to 20 ma).

    g. The module shall provide alarm indication via a front panel LED indicator and the change in state of a dedicated on-board alarm output relay, with a Form C contact.

2. Device shall be Multilin PQM, model PQM-T20-C-A, no equal.

G. Factory Finish

1. Provide a factory-applied, corrosion-resistant finish which shall withstand 3,000 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the scribed test mark.

2. Alternatively, provide 304 stainless-steel enclosure.

END OF SECTION

SECTION 16450: GROUNDING

PART 1 - GENERAL

A. Description

This section includes materials, testing, and installation of electrical grounding.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010
2. Electrical testing: 16950

C. References

1. National Electrical Code Article 250

D. Submittals

1. Submit shop drawings in accord with the General Provisions and Section 16010
2. Submit material list for all grounding materials and equipment. Indicate size, material, and manufacturer.

PART 2 - MATERIALS

A. Ground Conductors

All ground conductors shall be at least 12 AWG soft drawn copper cable or bar, bare or green-insulated in accord with the NEC Table 250-94 and Table 250-95.

B. Ground Rods

Ground rods shall be copper-clad steel, minimum ¾ -inch diameter, and minimum 10 feet long, with hardened steel points.

C. Ground Clamps

Ground clamps for connection of ground wire to ground rod shall be bronze.

D. Ground Resistance Tester

The ground resistance tester shall be an instrument specifically design for ground resistance testing.

E. Ground Well

Provide a ground rod well as shown on the drawings.

PART 3 - EXECUTION

A. Ground Electrode

1. Install a bare copper ground loop in the concrete footing for new buildings as shown on the drawings. Bring both ends of the loop to the ground bus within the motor control center.

2. At well pump sites, install a bare copper ground wire from the MCC ground bus to the well casing as shown on the drawings.

3. Install concrete encased bare ground conductor in each duct bank.

4. Run grounding electrode system conductors continuously in duct banks, through manholes, handholes, through raceway boxes, and cable tray exteriors. Connect conductors to structure ground ring or grounding system to provide a continuous grounding electrode system.

5. Bond electrical enclosures, including metallic raceways, panels, switchboards and other similar metallic panels, cases and devices associated with power, instrumentation, and control systems to the grounding electrode system.

6. Drive ground rods and install grounding conductors prior to construction of concrete slabs and ductbanks. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels or other electrical equipment are installed.

7. Buried or concealed joints or terminations are not permitted.

8. Protect wires with a rigid steel conduit where wires stub up through slab at motor control center.

9. Provide either exothermic welded or mechanical connections for grounding cable to rods or cable.

B. Equipment Grounding

1. Connect the ground bus of the lighting panel to the ground bus within the motor control center.

2. Ground raceways and noncurrent carrying parts of electrical equipment in accord with NEC Article 250. Use the rigid steel conduit system for equipment and enclosure grounding. Grounding through the conduit system shall be in excess of any ground conductors shown on the drawings. Circuits in nonmetallic conduit shall carry one ground conductor for equipment grounding.

3. Ground antenna mast to ground well (bus).

4. Install ground bushings at both ends of rigid conduit runs bond ground bushings to the grounding system.

C. **<u>Ground Test Well</u>**

Provide a handhole and ground rod as detailed on the drawings to aid in performing ground testing and connecting additional ground rods if required by the test results. Connect ground wire from ground rod to motor control center ground bus as detailed on the drawings.

D. **<u>Tests</u>**

1. Notify IRWD a minimum of 48 hours prior to ground testing to allow for witness of all ground resistance testing.

2. Before making connections to the ground electrode, measure the resistance of the electrode to ground using a ground resistance tester. Perform the test not less than 14 days after the most recent rainfall and in the afternoon after any ground condensation (dew) has evaporated. A representative of the District shall witness test. If a resistance of 5 ohms or less is not obtained, provide a ground rod driven 6 inches below grade and connect to ground test well with No. 4 AWG bare copper wire and repeat the test. If the resistance is still above 5 ohms, inform the District.

END OF SECTION

SECTION 16460: TRANSFORMERS

PART 1 - GENERAL

A. Description

This section included materials and installation of transformers.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010.

2. Low and Medium Voltage Motor Control: 16155.

C. Submittals

1. Submit shop drawings in accordance with the General Provisions and Section 16010.

2. Submit ratings and characteristics including voltage, phases, connection, enclosure type and dimensions, and conduit entry restrictions.

PART 2 - MATERIALS

A. General

1. Kva size, voltage, and phase of the transformers are indicated on the drawings.

2. Transformers to be UL listed and labeled where listing applies.

B. Dry-Type Transformers (150 kva and Below)

1. Construct transformers in accordance with ANSI C898.2, NEMA ST-20, and UL listed under the requirements of Standard 506.

2. Transformers rated 2 kva and below shall have Class B, 80 C rise insulation system.

3. Transformers rated 3 through 25 kva shall have Class F, 115 C rise insulation system and shall have copper windings.

4. Transformers 5 kva and larger shall have two 2-1/2% FCBN and two 2½% FCAN taps on the primary side and shall have copper windings.

5. Transformers 25 kva through 300 kva shall have Class F, 115 C rise insulation system.

6. Core and coil shall be encapsulated in an insulating resin of the class equal to the temperature rise and shall be embedded in a resin and filler system to attenuate the sound level.

7. Transformers shall be Square D Company electro-magnetically shielded type or equal.

PART 3 - EXECUTION

A. General

1. Set taps under load conditions for correct voltage.

END OF SECTION

SECTION 16500: LIGHTING

PART 1 - GENERAL

A. **Description**

This Section includes materials and installation of lighting fixtures.

B. **Related Work Specified Elsewhere**

General Electrical Requirements: 16010

C. **Submittals**

1. Submit shop drawings in accord with the General Provisions and Section 16010

2. Submit manufacturer's catalog data including complete catalog number, photometric data, and descriptive literature.

PART 2 - MATERIALS

A. **General**

1. Furnish lighting fixtures of the type indicated on the drawings, complete with lamps, sockets, wiring, and mounting hardware.

2. The use of a manufacturer's name and model or catalog number in the drawings is for the purpose of establishing the standard of quality and general appearance desired only. Products of other manufacturers will be considered in accord with the General Provisions.

B. **Fixtures**

1. Fluorescent: Lithonia DMW232-120

2. Wall lights: Lumark Wal Eye HPWP70HMTU

C. **Lamps**

1. Fluorescent: 32 watt - T8, 41K, rapid start lamps.

2. Incandescent: Rough service type, 125 volts, of the type and wattage shown on the drawings.

3. H.I.D. - mogul base 70 watt high pressure sodium, glass is to be clear.

4. Manufacturers: Guaranteed Service Brand extended service.

D. Ballasts

1. Fluorescent: UL listed for lamp wattage specified for the fixture, high power factor with Electrical Testing Laboratories (ETL) certification for compliance with Certified Ballast Manufacturers (CBM) specifications. Provide Class P protected ballasts with an "A" sound rating.

2. Manufacturers: Advance, Universal, or equal.

PART 3 - EXECUTION

A. Installation

1. Install lighting fixtures as close as possible to the locations shown on the drawings, making adjustments only for the purpose of avoiding interferences.

2. Install lighting fixtures plumb and level, with fixture surfaces parallel and perpendicular to walls and other major structures.

3. Support lighting fixtures at two points minimum from structural elements which are capable of carrying the total weight. Mount fixtures rigidly with no rocking action.

4. Ballast, which is judged by the Owner's Representative to be excessively noisy, shall be removed and replaced at no cost to the Owner.

END OF SECTION

SECTION 16620 – MANUAL TRANSFER SWITCH

PART 1 - GENERAL

A. Description

This Section outlines the material and installation requirements for manual transfer switches.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010.
2. Structure Earthwork: 02220
3. Concrete: 03300
4. Painting and Coating: 09900
5. Low Voltage Switchboards: 16443

C. Submittals

Submit for the Owner's approval material lists, shop drawings, reports, and technical data to the extent required in this Section and Section 16010.

1. Material Lists: The material lists shall be complete and include all products specified in this Section, including the equipment that shall have shop drawings. The list shall include only one manufacturer for each product.

2. Shop Drawings: The equipment shop drawings shall be complete and include the following for the manual transfer switches:

   a. Plans shall show the equipment location, space requirements, clearances, conduit and anchor bolt locations.

   b. Elevations shall show the vertical positions and arrangements of equipment and nameplates.

   c. Details shall show the requirement enlarged small parts.

   d. Dimensions shall be included on the Drawings.

   e. Weights for equipment and seismic anchoring requirement shall be included on the Drawings.
   f. Nameplate Data shall include the nameplate material, heights of letters and inscriptions.

3. Technical Data: Complete equipment descriptive, operation and installation data shall be submitted with the shop drawings.

4. Test Reports: Copies of the Factory Test Reports shall be certified by the manufacturer and submitted to the Owner as specified in Section 16010.

PART 2 - PRODUCTS

A. **General**

Provide all equipment and materials, including proper space, as indicated, specified and required. Refer to Sections 16010, 16110, 16120 and 16433 for conduits, conductors, and nameplates.

B. **Manual Transfer Switch**

1. Furnish and install manual transfer switch with number of poles, amperage, voltage and withstand rating as shown on the Plans. Switch shall be listed per U.L. Standard 1008 for all classes of loads.

2. Operation shall be accomplished by a manually operated handle. Mechanical locking in each position shall be accomplished without the aid of springs, latching solenoids, gear mechanisms or motor operators.

3. Operation shall be inherently double-throw where all contacts move simultaneously and with no delay in the mid position. Electrical spacings shall not be less than those listed in Table 15.1 of U.L. Standard 1008. Main contact structures not originally manufactured for transfer switch service are not acceptable. An overload or short circuit shall not cause the switch to go to a neutral position.

4. Inspection and replacement of all main and arcing contacts (movable and stationary) shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors for switches 260 amperes or greater. A U.L. listed manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to stop the contacts at any point throughout the entire travel including points of contact make and break.

4. All switches for solid neutral systems (shown as 3 pole on the drawings) shall have fully rated insulated neutral plates. All switches for systems with switched neutrals (shown as 4 pole on the drawings) shall have fully rated neutral transfer contacts which momentarily (100 milliseconds, max.) interconnect the neutrals of the sources during the transfer/retransfer operation. The Neutrals shall remain interconnected through the main contacts until the phase contacts close on the alternate source. Phase and neutral contacts shall be driven by one single main operator.

5. Electrical and Mechanical Performance

   The switch must comply with U.L. Standard 1008 and NEMA Standard ICS 2-447. In addition, the switch must meet or exceed the following requirements and if so requested, be verified by certified independent laboratory test data:

   a. Temperature Rise: Measurements shall be made after the overload and endurance tests.

   b. Withstand: U.L. listed to withstand the magnitude of fault current available at the switch terminals when coordinated with respective protective devices as shown on the plans.

c. Dielectric: Tested after the withstand test at 1960 vac R.M.S. minimum.

d. Voltage Surge: Control panel voltage surge withstand test per IEEE Standard 472-1974 and voltage impulse withstand test per ICS-1-109.

   The manufacturer shall certify that the complete unit meets or exceeds the seismic requirements of the California Administrative Code Title 24 and Uniform Building Code.

e. Service: The manufacturer shall have a local factory certified service center which stocks spare parts and which employs full time factory trained field service technicians/engineers. Replacement parts shall be of the same make as provided by the original manufacturer. Service shall be available on a 24 hour per day, seven-day week basis. Normal response time for emergency service shall not exceed 8 hours between receipt of a request for service and arrival of service personnel at the job site.

f. Operator's Manual: Each transfer switch shall be furnished with an operator's manual providing installation, operating and service instructions.

g. Enclosure: Transfer switch shall be furnished with NEMA 3R enclosure suitable for outdoor installation. Provide strip heater, thermostat and terminal blocks for external 120 VAC power supply.

h. Acceptable Manufacturers: Manual transfer switches shall meet all of the requirements of the specification and shall be ASCO or Zenith, or equal.

PART 3 – EXECUTION

(Not Used)

END OF SECTION

SECTION 16625 – AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

A. Description

1. This section describes materials, testing, and automatic transfer switches

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900.

2. General Electrical Requirements: 16010.

C. Codes and Standards

1. The automatic transfer switches and controls shall conform to the requirements of:

    a. UL 1008 - Standard for Transfer Switch Equipment

    b. IEC 947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment

    c. NFPA 70 - National Electrical Code

    d. NFPA 99 - Essential Electrical Systems for Health Care Facilities

    e. NFPA 110 - Emergency and Standby Power Systems

    f. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

    g. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches

    h. UL 508 Industrial Control Equipment

PART 2 – PRODUCTS

A. General

1. Furnish and install automatic transfer switches (ATS) with number of poles, amperage, voltage, withstand and close-on ratings as shown on the plans. Each ATS shall consist of a power transfer switch mechanism and a microprocessor controller to provide automatic operation. All transfer switches and controllers shall be the products of the same manufacturer.

2. The ATS shall operate as a conventional break-before-make (open transition) switch when the power source serving the load fails.

3. The ATS shall be UL listed in accord with UL 1008 and be labeled in accord with that standard's 1½ and 3 cycle, long-time ratings. ATSs which are not tested and labeled with 1½ and 3 cycle (any breaker) ratings and have series, or specific breaker ratings only, are not acceptable.

B. Acceptable Manufacturers

1. Closed transition transfer switches shall be ASCO 7000 Series. Any alternate shall be submitted for approval to the consulting engineer at least 10 days prior to bid. Alternate bids must list any deviations from this specification.

C. Mechanically Held Transfer Switch

1. The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, solenoid mechanism. Main operators which include overcurrent disconnect devices, linear motors or gears shall not be acceptable.

2. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.

3. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.

4. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

5. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

6. Designs utilizing circuit breakers are not acceptable.

7. Where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.

D. Microprocessor Controller

1. The controller's sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, and the ability to communicate serially through an optional serial communication module.

2. A single controller shall provide twelve selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to ± 1% of nominal voltage. Frequency sensing shall be accurate to ± 0.2%. The panel shall be capable of operating over a temperature range of -20 to +60 degrees C and storage from -55 to +85 degrees C.

3. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator's manuals.

4. All customer connections shall be wired to a common terminal block to simplify field-wiring connections.

5. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

a.	EN 55011:1991	Emission standard Group 1, Class A
b.	EN 50082-2:1995	Generic immunity standard, from which:
c.	EN 61000-4-2:1995	Electrostatic discharge (ESD) immunity
d.	ENV 50140:1993	Radiated Electro-Magnetic field immunity
e.	EN 61000-4-4:1995	Electric fast transient (EFT) immunity
f.	EN 61000-4-5:1995	Surge transient immunity
g.	EN 61000-4-6:1996	Conducted Radio Frequency field immunity
h.	IEEE472 (ANSI C37.90A) Ring Wave Test	

E. <u>Enclosure</u>

1. The ATS shall be furnished in a Type 3R enclosure unless otherwise shown on the plans.

2. All standard and optional door-mounted switches and pilot lights shall be 16-mm industrial grade type or equivalent for easy viewing & replacement. Door controls shall be provided on a separate removable plate, which can be supplied loose for open type units.

F. <u>Controller Display and Keypad</u>

1. A four line, 20 character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller:

    a. Nominal line voltage and frequency
    b. Single or three phase sensing
    c. Operating parameter protection
    d. Transfer operating mode configuration
    (Open transition, Closed transition or Delayed transition)
    e. All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

G. <u>Voltage, Frequency and Phase Rotation Sensing</u>

1. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout and trip setting capabilities (values shown as % of nominal unless otherwise specified):

Parameter	Sources	Dropout / Trip	Pickup / Reset
Under-voltage	N&E, 3ϕ	70 to 98%	85 to 100%
Over-voltage	N&E, 3ϕ	102 to 115%	2% below trip
Under-frequency	N&E	85 to 98%	90 to 100%
Over-frequency	N&E	102 to 110%	2% below trip
Voltage un-balance	N&E	5 to 20%	1% below dropout

2. Repetitive accuracy of all settings shall be within ± 0.5% over an operating temperature range of -20°C to 60°C.

3. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.

4. Open transition transfer shall be accomplished with no power interruption and without altering or actively controlling standby generator set.

5. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).

6. Source status screens shall be provided for both normal & emergency to pro-vide digital readout of voltage on all 3 phases, frequency, and phase rotation.

H. **Time Delays**

1. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 volt DC power supply.

2. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

3. An adjustable time delay of 0 to 6 seconds to override momentary emergency source outage to delay all retransfer signals during initial loading of engine generator set.

4. Two time delay modes (which are independently adjustable) shall be provided on re-transfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.

5. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.

6. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:

   a. Prior to transfer only.
   b. Prior to and after transfer.
   c. Normal to emergency only.
   d. Emergency to normal only.
   e. Normal to emergency and emergency to normal.
   f. All transfer conditions or only when both sources are available.

7. The controller shall also include the following built-in time delays for Open Transition operation:

a. 1 to 5 minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.

b. 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.

8. All time delays shall be adjustable in 1 second increments, except the extended parallel time, which shall be adjustable in .01 second increments.

9. All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port. The time delay value displayed on the LCD or remote device shall be the remaining time until the next event occurs.

I. <u>Additional Features</u>

1. A three position momentary-type test switch shall be provided for the test / automatic / reset modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal. Switches which require utilizing the keypad and display function or have no manual time delay bypass means are not acceptable.

2. A set of DPDT gold-flashed contacts rated 10 amps, 32 volts DC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

3. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact closed, when the ATS is connected to the emergency source.

4. LED indicating lights (16 mm industrial grade, type 12) shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

5. LED indicating lights (16 mm industrial grade, type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset settings for each source.

6. Engine Exerciser - The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to seven different exercise routines. For each routine, the user shall be able to:

   a. Enable or disable the routine.
   b. Enable or disable transfer of the load during routine.
   c. Set the start time, .
      time of day
      day of week
      week of month (1st, 2nd, 3rd, 4th, alternate or every)
   d. Set the duration of the run.

e. At the end of the specified duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. A 10-year life battery that supplies power to the real time clock in the event of a power loss will maintain all time and date information.

J. <u>Tests and Certification</u>

1. The complete ATS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

2. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

3. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accord with ISO 9001.

K. <u>Service Representation</u>

1. The ATS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

2. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

PART 3 – EXECUTION

A. <u>Training</u>

1. Provide on-site training by manufacturer’s instructors and provide appropriate training documents of 8 hours per location to District personnel.

END OF SECTION

SECTION 16640: CATHODIC PROTECTION AND JOINT BONDING

PART 1 - GENERAL

A. Description

This section describes materials and installation of cathodic protection and testing equipment including wiring, zinc anodes, joint bonding, test stations, reference cells, alumino-thermic welds, and flange insulation kits.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, & Compacting: 02223
2. Concrete: 03300
3. Painting & Coating: 09900
4. Facilities Identification: 15151

C. Submittals (For Contracts Between District and Contractor)

1. Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.
2. Submit manufacturer's catalog data on wire and cables, test stations, reference cells, thermic welds, insulation kits, dielectric coatings, and anodes.
3. Submit qualifications of company performing required testing and record keeping. The testing shall be performed under the direction and oversight of a registered corrosion engineer or certified NACE Cathodic Protection (CP) specialist.

PART 2 - MATERIALS

A. Alumino-Thermic Weld Materials

Cartridges and sleeves for welding test lead wires, joint bonding wires and anode lead wires to the pipe, shall be "Cadweld," "Thermoweld," or for contracts between District and Contractor, approved equal. Based on the type of pipe (steel, ductile iron, or cast iron) to which the wire is to be welded, the cartridge type, size and weight shall be as recommended by the manufacturer.

B. Alumino-Thermic Weld Caps

Alumino-thermic weld caps shall incorporate a high-density polyethylene plastic sheet, 10 mils (minimum) thick with a protective adhesive, 165 mils (minimum) thickness, as manufactured by Farwest Corrosion Control Company, Chase Corporation’s Royston Products, or for contracts between District and Contractor, approved equal. Design shall incorporate an elastomeric or a mastic-filled dome and a tunnel portion to contain lead wire from the alumino-thermic weld connection. The mastic coating shall be Carboline Bitumastic 50, Tnemec 46-465, Tnemec 46H-413 or for contracts between District and

Contractor, approved equal. Prior to application of the mastic coating, the manufacturer's recommended primer shall be applied to exposed metal.

Weld caps shall be Royston Handy Cap IP, Royston Handy Cap XL IP or for contracts between District and Contractor, approved equal.

C. Test Station Boxes

Test station boxes shall be a minimum 10-inch diameter, 12-inch deep, precast concrete with a cast iron lid designed for H-20 traffic loading. “CPTS” shall be cast on the lid. Test boxes shall be Brooks Products 3-RT, Christy G05T, or for contracts between District and Contractor, approved equal. Test box lids shall be painted in accordance with Section 09900, Painting and Coating.

D. Pipe Leads

Unless noted otherwise, pipe leads shall be stranded copper wire with high molecular weight polyethylene (HMW/PE) insulation specifically designed for cathodic protection service and suitable for direct burial in corrosive soil or water. Wire gauge shall be as shown on IRWD Standard Drawings CP-1, CP-2, and CP-3. Polyethylene insulation shall conform to ASTM D-1248, Type 1, Class C, Grades E-4 and E-5. Each pipe lead shall be of sufficient length to extend from the attachment to the pipe to the test box or anode test box without a splice. Wires with cut or damaged insulation shall be rejected. Insulation color shall be as shown on the plans or IRWD Standard Drawings.

E. Joint Bonding Wires

Pipe joint bonding wires shall be AWG No. 4 stranded copper wire with minimum 7/64-inch thick high molecular weight polyethylene (HMW/PE) insulation rated for 600 volts. The number of conductors shall be as shown on the plans and/or IRWD Standard Drawings. Polyethylene insulation shall conform to ASTM D-1248, Type 3, Class C, Grade 5. Each bond wire shall be 18 inches in length for 18-inch pipes or less and 24 inches for pipes larger than 18-inch.

F. Flange Insulation Kits

Insulating material shall be of the type designated by the manufacturer as suitable for the operating temperature and pressure of the service. Flange insulation kits shall consist of:

1. Insulating Gaskets: Gaskets shall be Type E full-faced, 1/8-inch minimum thickness, dielectric neoprene faced phenolic. Gaskets shall be Pipeline Seal & Insulator, Inc. (PSI), George Fischer Central Plastics, Advance Products & Systems, Inc. (APS), or for contracts between District and Contractor, approved equal.

2. Insulating Sleeves and Washers: Insulating stud sleeves and washers shall be one-piece and full-length, made of Minlon or Mylar. One 1/8-inch thick gasket shall be attached to the sleeve, while the other shall be loose. Single insulating washers and sleeves shall be used on buried insulating flanges. Double insulating washers and sleeves shall be used on insulating flanges above ground, in structures, or in vaults.

3. Insulating Washers for Bolts: Insulating washers shall be 1/8-inch thick glass-clad phenolic. Single insulating washers shall be used on buried insulating

flanges. Double insulating washers and full length sleeves shall be used on insulating flanges above ground, in structures, or in vaults.

4. Steel Washers Over Insulating Washer: Steel backing washers shall be 1/8-inch thick Type 316 stainless steel.

5. Compatibility with Valves: Insulating flange kits are not compatible with most valve flanges. Where cathodic isolation is required near a valve, a flanged spool shall be installed adjacent to the valve; and the required insulating joint shall be installed at the opposite end of the spool from the valve. Refer to the project plans for specific details.

6. Manufacturers: Flange insulation kits shall be as manufactured by Pipeline Seal & Insulator, Inc. (PSI), George Fischer Central Plastics, Advance Products & Systems, Inc. (APS), or for contracts between District and Contractor, approved equal.

G. Buried Insulating Flange External Coating

1. Primer: Primer shall be a blend of microcrystalline waxes, plasticizers and corrosion inhibitors having a paste-like consistency. The material shall have the following properties:

Pour Point	100°F -115°F
Flash Point	350°F min
Coverage (approx.)	1 gallon/100 sq. ft.
Color	Brown

The primer shall be Trenton Wax-Tape Primer, or for contracts between District and Contractor, approved equal.

2. Wax-Tape: Flange covering material shall be a plastic-fiber felt tape, saturated with a blend of microcrystalline waxes, plasticizers and corrosion inhibitors that is easily formable over irregular surfaces. The tape shall have the following properties:

Tape Width	6-inches
Saturant Pour Point	115°F - 125°F
Thickness	70 - 90 mils
Dielectric Strength	170 Volts/mil
Weight	4 lbs/sq yd
Color	Brown

The Wax-Tape shall be Trenton #1 Wax-Tape, or for contracts between District and Contractor, approved equal.

3. Outer Covering: The primed and wax-tape wrapped flange shall be covered with a plastic wrapper consisting of three each of 50 gauge, clear, polyvinylidene chloride, high cling membranes wound together as a single sheet. The material shall have the following properties:

Width	6-inches
Thickness	1 1/2 mils
Dielectric Strength	2000 Volts/mil

Water Absorption	negligible
Color	Clear

The outer covering shall be Trenton Poly-Ply, or for contracts between District and Contractor, approved equal.

H. Above Ground Insulating Flange External Coating

Above ground insulating flange coating shall consist of self-fusing elastic putty tape and vinyl plastic electrical tape. The self-fusing elastic putty tape shall be Scotchfil™ Electrical Insulation Putty and there is no equal. The vinyl plastic electrical tape shall be 7 mil thick premium grade vinyl adhesive electrical tape, brand Scotch® Super 33+ Vinyl Electrical Tape and there is no equal.

I. Internal Insulating Flange Coating

Coating for the interior lining of the pipeline at the insulating flange shall be a two-part smooth white, thixotropic liquid epoxy consisting of 100 percent solids. Coating shall be Aquatapoxy Paint as manufactured by American Chemical Corporation, or for contracts between District and Contractor, approved equal.

J. Zinc Anodes

1. Zinc Anode: Anode shall conform to ASTM B-418, Type II and shall be a prepackaged zinc alloy ingot having a chemical composition not exceeding the following limits:

Lead	0.003% Max.
Aluminum	0.005% Max.
Cadmium	0.003% Max.
Iron	0.0014% Max.
Copper	0.002% Max.
Zinc	Remainder

2. Anode Weight and Dimensions: Ingot weight and dimensions of the pre-packaged zinc anode shall be as listed in the table below. Weights are minimum.

ZINC ANODE SIZES FOR 1-INCH & 2-INCH BARE COPPER PIPE SERVICES			
Copper Pipe Size (inches)	**Copper Pipe Length (feet)**	**Zinc (Bare) Anode Size (inches)**	**Zinc (Bare) Anode Weight (lbs.)**
1	0 to 45	1.4x1.4x30	15
1	45 to 90	2.0x2.0x30	30
2	0 to 22	1.4x1.4x30	15
2	22 to 45	2.0x2.0x30	30
2	45 to 70	2.0x2.0x48	45
2	70 to 90	2.0x2.0x60	60

Note: For copper pipe length greater than that listed above, additional Zinc Anodes of appropriate size shall be added as approved by the District.

3. Anode Backfill: Each zinc anode shall either be prepackaged in a permeable cloth bag with backfill of the following composition or installed bare and backfilled with material having the following composition:

Gypsum	5%
Powdered Bentonite	20%
Anhydrous Sodium Sulfate	5%

Backfill grains shall be capable of 100% passing through a 20 mesh screen and 50% passing through a 100 mesh screen.

The backfill shall be firmly packed around the anode by mechanical vibration, which will maintain the zinc ingot in the center of the cloth bag and surrounded by at least 1-inch of backfill. The packaged weight of the zinc anode and backfill shall be approximately twice the weight of the zinc anode ingot weight.

4. Steel Core: Anode shall be cast full length with an electro-galvanized 1/4-inch diameter steel core, which shall be exposed at one end for connection of the anode lead wire.

5. Anode Lead Wire: Anode lead wire shall be AWG No. 8 stranded copper wire with high-molecular weight polyethylene (HMW/PE) insulation suitable for direct burial use. HMW/PE insulation shall conform to ASTM D-1248, Type 1, Class "C", Category 5, Grades E4 and E5 with tensile strengths J1, J3.

Wire shall be attached to the steel core with silver solder by the anode manufacturer. The connection shall be encapsulated in a heat-shrinkable sleeve. Anode lead wire shall be a minimum of 15 feet long and shall be of sufficient length to extend from the anode to the designated termination point without a splice and 3-feet of coiled wire shall be provided in the test box. Wires with cut or damaged insulation shall be rejected and replacement of the entire lead shall be required at the Contractor's expense.

6. Anode Manufacturer's: Pre-packaged anodes, with lead wire and bagged backfill shall be supplied by Northtown Company, Far West Corrosion Control Company or Galvotech Alloys, Inc. or for contracts between District and Contractor, approved equal.

K. Identification Tags

The identification tag shall be rotary engraved with identifying letters and numbers. The circular plastic tag shall be 1/16-inch thick, 2-inch diameter, and the exterior shall be UV resistant 3 ply (color on both sides) lamicoid plastic by Rowmark, Gravoply or approved equal. Color shall be Blue with a white core for potable, Purple with a white core for recycled, Light-Blue with white core for untreated, or Green with white core for sewer. IRWD shall provide the un-engraved plastic tags to the Contractor for engraving. See IRWD Standard Drawing CP-6 for details.

L. Warning Tape

Warning tape shall comply with Section 15151, Facilities Identification and per the IRWD Standard Drawings.

M. Mortar

Mortar used to repair concrete coated pipe after attachment of the various bond or test wires shall be fast drying, non-shrinkable type. Refer to Section 03300, Concrete.

N. Marker Paddles – Utility Marker

Brown colored polycarbonate marker paddles shall be installed adjacent to the location of each test station, anode bed, shunt box, and reference cell location. Marker paddles shall be as manufactured by Carsonite Composites, a Phillips Group Brand. Marker paddles shall have an IRWD logo and 1-inch high yellow letters affixed, indicating the particular cathodic appurtenance. Both logos and decal letters are available from the District upon request. Refer to the IRWD Standard Drawing G-2.

O. Pipe Clamps

Pipe clamps used to attach the zinc anode lead wire to the above ground copper riser portion of the copper water tubing shall be brass or copper and of a size to fit the tubing. The pipe clamp shall have a screw terminal suitable for an AWG No. 8 copper stranded wire.

P. Insulating Blanket

The insulating blanket shall be a 1/8-inch thick neoprene or butyl insulating material. The width and length of the blanket will vary due to diameter of the pipelines to be insulated. The width and length shall be 12-inches larger than the diameter of the largest pipeline to be insulated.

Q. Casing Seal

The casing seal shall be composed of an irradiated, semi-rigid polyolefin sleeve which when exposed to temperatures in excess of 250°F will shrink from its original diameter to a predetermined recovered diameter. Casing seal shall be as manufactured by Pipeline Seal & Insulator, Inc. (PSI), Advance Products & Systems, Inc. (APS), or for contracts between District and Contractor, approved equal.

R. Reference Electrodes

Reference electrodes shall be copper-copper sulfate type, suitable for direct burial, and shall remain stable for at least ten years. The reference cell shall be capable of maintaining a potential within 15 millivolts of a freshly made cell while drawing 2 microamperes. Reference cells shall contain a barrier to inhibit migration of chloride ions from the soil into the reference cell.

Reference cell lead wires shall be AWG No. 8, stranded copper wire with high-molecular weight polyethylene (HMW/PE) insulation suitable for direct burial use. HMW/PE insulation shall conform to ASTM D-1248, Type 1, Class "C", Category 5, Grades E4 and E5 with tensile strengths J1, J3.

The lead wire shall be silver soldered to the copper core of the reference cell with the connection epoxy sealed according to the manufacturer's recommendations. Copper-copper sulfate reference cells shall be located next to the pipe in "native soil" near the "spring line" of the pipe.

The reference cells shall be EDI Model UI-CUG manufactured by Electrochemical Devices, Inc.; IonX40 Catalogue No. 14669 by M. C. Miller Company; Model CU1-UG by GMC Electrical, Inc.; Stelth Model SRE-002-CFY by Borin Manufacturing, Inc. or for contracts between District and Contractor, approved equal.

PART 3 - EXECUTION

A. General

Cathodic protection installation shall conform to NACE Publication RP0169 (Latest Revision) – *"Recommended Practice, Control of External Corrosion on Underground and Submerged Metallic Piping Systems"* and to NACE Publication RP0286 (Latest Revision) – "*Recommended Practice, Electrical Insulation of Cathodically Protected Pipelines"*.

B. Wire Attachments

Wire leads shall be attached to the pipe and shall terminate at the test box without a splice. A minimum of 3-feet of slack wire from each lead shall be coiled and remain in each test box.

C. Attachment of Wire to Pipe

1. Surface Preparation for Alumino-Thermic Welding: Any existing coating on the pipe shall be removed by making a 3-inch square window in the coating. The exposed metal surface shall be cleaned to produce a bright metal finish, equivalent to SSPC SP-10, "near-white".

2. Alumino-Thermic Weld: The attachment of copper wire shall be made using an alumino-thermic weld as shown on IRWD Standard Drawing CP-9. Remove only enough insulation from the wire to allow the weld connection to be made. The wire shall be held at a 30°- 45° angle to the surface when welding. One wire only shall be attached to each weld.

3. Weld Test: As soon as the weld is cool, the weld shall be tested by striking a sharp blow with a 3-pound hammer while pulling firmly on the wire. All unsound welds shall be rewelded and retested.

4. Wire Locations: Wires shall be attached to the top (horizontal) surface of the pipe. Where two or more wires are required, welds shall be at least 6-inches apart.

5. Alternative Attachment Methods: The weld mold may not fit between the pretension bars of concrete cylinder pipe, depending on the diameter and pressure class of the pipe. Alternate methods of attachment may include:

   a. thermite welding the test wire to the bell ring at a joint; or

   b. arc welding a 1/4-inch diameter steel bar, with test wire pre-attached, to the steel cylinder between pretension bars.

D. Dielectric Coating Over Thermic Weld Connection

After completing the thermic weld connection between the wire and the pipe, the connection shall be coated in accordance with the following table:

Pipe Material	Connection Coating
Cement-mortar coated steel	Carboline Bitumastic 50, Tnemec Series 46H-413 or for contracts between District and Contractor, approved equal and cement mortar
Carbon steel, Ductile iron	Thermic weld cap, Royston Handy Cap XL IP or Royston Handy Cap IP

Repairs to the cement mortar coating shall be of the same material and thickness as specified for the pipe.

E. Backfill Over Wire

Buried wires shall be installed at a minimum depth of cover of 36-inches below the street section, or 36-inches below finished grade for un-paved areas. The trench bottom shall be level and free of exposed rocks. The first 12-inches of backfill above and the first 12-inches below the cable shall be sand per District bedding requirements. The remainder of the trench zone shall be backfilled in accordance with Section 02223, Trenching, Backfilling and Compaction. Plastic warning tape shall be installed 12-inches above the wire.

F. Test Stations

1. Test Station Boxes: Test boxes shall be located as shown on the plans or IRWD Standard Drawings, and shall be positioned in the parkway or raised median, as close to above the pipeline as practical. Boxes shall be installed in accordance with the IRWD Standard Drawings.

2. Two-Wire Test Station Spacing: Two-wire test stations with boxes shall be placed at intervals not to exceed 500 feet and at the end-points of all metallic pipelines and casings.

G. Joint Bonding Wires

Joint bonding wires shall be installed on ferrous metal pipelines at all unwelded joints, fittings, valves, and flanges (excluding insulated flanges) as shown on IRWD Standard Drawing CP-10. Two bond wires shall be welded across each joint for pipe diameters less than 18-inches. Three bond wires shall be welded across joint for pipe diameters 18-inches and larger. Bond wires shall be attached using the alumino-thermic weld process. Bond wires shall not be attached to valve bodies, but instead to the valve flanges.

H. Flange Insulation Kits

Flange insulation kits shall be installed as follows:

1. Cleaning: Faces of flange pairs shall be cleaned of all dirt, rust or fouling materials which would interfere with a watertight joint and insulating properties of the flange kit.

2. Alignment: Alignment pins shall be used to properly align the flange and gasket. The manufacturer's recommended bolt tightening sequence shall be followed. Bolt insulation sleeves shall be centered within the insulation washers so that the insulating sleeve is not compressed and damaged.

3. Locations: A bonding test station shall be installed at each buried flange insulation. Two test wires shall be installed on each side of the buried insulator according to the details of the plans, these specifications, and IRWD Standard Drawings.

4. Insulation Kits at Valves: Flange insulation kits shall not be installed directly against valve flanges. A 24-inch long spool shall be installed adjacent to the valve so that the insulating flange kit may be installed on a standard pair of flanges.

I. External Insulating Flange Coating

1. Buried Insulating Flange Coating:

   a. Primer: Surface shall be cleaned of all dirt, dust, and loose rust or mill scale by wire brush and by wiping with a clean cloth. The surface shall be dry. Apply primer by hand or brush. A thick coating of primer shall be worked into all crevices, around bolts and in threads, and shall completely cover all exposed metal surfaces. The primer should overlap the pipe coating by 3inches minimum.

   b. Wax-Tape: The wax-tape can be applied immediately after primer application. Short lengths of tape shall be cut and formed completely around each individual bolt and stud-end. After all bolts are covered, the tape shall be applied circumferentially and formed by hand into all voids and spaces. There shall be no gaps or air spaces under the tape. The tape shall be applied with at least 55% overlap.

   c. Outer Covering: The clear plastic outer covering shall be applied by hand such that the material conforms and adheres to the wax-tape surface. Two layers of plastic outer wrapping shall be applied.

2. Above Ground Insulating Flange Tape Coating: All flange and pipe surfaces shall be clean and free of all dirt, grease, water, and other foreign material prior to installation of tape coating. The two separate tapes shall be half-lapped twice over the outer surface of the flange.

J. Internal Coating at Insulating Flange

The interior of the pipeline shall be coated for a distance of two pipe diameters in each direction away from the insulating flange. At an insulated valve flange, interior of pipeline shall be coated away from the valve for a distance of two pipe diameters. Coating shall be in accordance with Section 09900, Painting and Coating, System No. B-1 or B-2 as appropriate.

1. <u>Surface Preparation</u>: The surface preparation of the mortar lining shall consist of wire brushing to remove all loose mortar to provide a suitable surface for adhesion of the coating.

2. <u>Application</u>: Coating shall be applied by brushing until a minimum coating thickness of 20 mils is achieved. Each ensuing coat shall be applied before subsequent coat cures, usually within 3 to 6 hours after subsequent coat has been applied.

K. Zinc Anodes

Where called for on the drawings, prepackaged zinc anodes shall be installed in excavated, drilled, or punched holes a minimum of 3-inches larger in diameter than the prepackaged anode diameter. Anodes shall be installed below the level of the service main, with a minimum separation of 2-feet between the copper water tubing and the zinc anode maintained at all times. Anodes shall not be lowered, transported, handled, or lifted by the lead wire.

1. <u>Backfilling</u>: After the prepackaged anode is placed in the hole, water shall be poured into the hole so that the anode is completely covered with water. Stone-free native soil shall then be used to backfill the anode hole in accordance with Section 02223, Trenching, Backfilling and Compacting. Imported sand shall not be used for backfilling. The anode hole shall be backfilled in stages and carefully compacted to ensure that no voids exist around the bag and that the bag and anode wire are not damaged. After backfill is level with the top of the anode, a minimum of 15 gallons of water shall be poured into the hole to completely saturate the soil backfill. More water shall be added if it is suspected that the backfill is not completely saturated. Care shall be taken to avoid damage to the anode and anode lead wires.

2. <u>Anode Lead Wire</u>: The anode lead wire shall run to the point of connection at the end of the pipe run in the meter box. The anode lead wire shall be clamped to the copper-tubing riser. Sufficient slack shall be provided in the wire, and it shall be coiled in the meter box for attachment to a future point of connection at the water meter. At combination air release and vacuum relief valves the anode lead wire shall run through the concrete pad and shall be clamped to the riser as shown in the IRWD Standard Drawings. At blow-offs and manual air releases, anode lead wire shall be coiled in the valve box and clamped to the riser.

L. Identification Tags

Identification tags shall be securely attached to each of the wires in the test box using UV rated zip ties rated to hold 50 pounds.

M. Marker Paddles – Utility Markers

Utility markers shall be installed per IRWD Standard Drawing G-2 at locations shown on IRWD Standard Drawing CP-7 or as directed by the District Representative.

N. Insulating Blanket

Install an insulating blanket as shown in the Project Plans between any metallic pipelines that cross or parallel each other when the distance between the two pipelines is less than 18-inches.

O. Earthwork

Trenching, backfilling, and compacting shall be in accordance with Section 02223, Trenching, Backfilling, & Compacting.

P. Required Test and Record Keeping

The Contractor shall furnish all necessary equipment, material and qualified personnel required to perform all tests described herein.

1. Continuity Tests: The Contractor shall notify the District Representative when continuity bonding has been completed and all test boxes have been completed. A registered corrosion engineer or certified NACE CP specialist retained by the Contractor shall oversee and certify the testing and measuring of the electrical continuity of metallic pipelines. The pipeline shall be considered electrically continuous when the measured longitudinal resistance of the pipeline between each pair of adjacent test stations is no greater than 20 percent higher than the theoretical resistance of that section of pipeline.

   If tests indicate that adequate electrical continuity has not been achieved, the Contractor shall excavate to investigate and locate improperly bonded joints and shall make repairs until electrical continuity is achieved to the satisfaction of the District.

2. Test Stations: The Contractor shall notify the District Representative when test station wires are ready for testing. The wires shall remain disconnected to facilitate testing. A registered corrosion engineer or certified NACE CP specialist retained by the Contractor shall oversee and certify the tests to certify that none of the wires were damaged during the installation. If the test indicates damage, the entire wire shall be replaced and retested at the Contractor's expense.

   Records shall be made of all test stations and reference electrodes tested and submitted to the District.

3. Insulation Joints: The Contractor shall test each insulated joint with the insulator tester in accordance with the manufacturer's written instructions. All damaged or defective insulation parts shall be replaced and retested. Records shall be kept of all insulated joint tests and shall be submitted to the District.

4. Anode and Pipe Lead Wire Integrity Tests: After the pipe and anodes are buried, the pipe lead wire and anode lead wire trenches are backfilled, and the test boxes are installed, the Contractor shall notify the District Representative that the anode and pipe lead wires are ready for testing. The wires shall remain disconnected to facilitate testing. A registered corrosion engineer or certified NACE CP specialist retained by the Contractor shall oversee and certify the tests to confirm that none of the anode wires or pipe lead wires were damaged during the installation. Each anode lead wire will be tested for electrical continuity to the anode by measuring the anode's potential with respect to a copper copper-sulfate reference electrode. The measured open circuit potential of the anode shall be as specified in the table below or as specified by the manufacturer and approved by the District Representative.

Measured Open Circuit Potential for Anodes	
Anode Type	**Minimum Measured Open Circuit Potential (Volts)**
High Potential Magnesium Anode	1.7
Standard Magnesium Anode	1.4
Zinc Anodes	1.0

5. Acceptance: The Contractor shall submit a certified report by the corrosion engineer stating that the facilities are performing satisfactorily. All tests made must be reviewed and approved by the District before the corrosion control work is accepted. The District reserves the right to spot check any or all tests performed by the Contractor. All construction defects must be repaired and retested before the final acceptance is made. All unacceptable tests must be re-performed by the Contractor at no additional cost to the District. Contractor shall hook up all lead wires after testing is completed.

END OF SECTION

SECTION 16650: TELEMETRY CABLE SYSTEM

PART 1 - GENERAL

A. Description

This section includes materials, installation and testing of the telemetry cable system which is typically buried along pipelines for communications between facilities.

B. Related Work Specified Elsewhere

1. Trenching, Backfilling, and Compacting: 02223
2. General Electrical Requirements: 16010
3. Conduit, Pull Boxes, Fittings: 16110
4. Grounding: 16450

C. Submittals

1. Submit shop drawings in accord with the General Provisions and Section 16010.

2. Submit certification of compliance with the specification and test report of installed cable. Include test reports from both factory testing and both field pre-installation and post-installationinstalled testing of the cable.

PART 2 - MATERIALS

A. General Requirements

1. This specification covers the overall requirements for the IRWD owned telemetry cable system that is typically installed under pipelines for telemetry communications between District facilities.

B. Telemetry Cable

1. Cable comply with specification REA PE-89 as manufactured by Essex Sealpic-FSF 12/19, AT&T Comcode #105185565, or approved equal.

2. Physical Characteristics:

   Conductors shall be AWG No. 19 insulated conductors twisted into 12 pairs of specific color combinations to provide pair identification and to provide low susceptibility to noise pick-up, and with varying lay lengths to minimize crosstalk.

   Core fill shall be gel filling of cable core space between insulated conductors and between the core and the core wrap, including core wrap tape overlay, to prevent moisture or water entry and migration transversely and longitudinally in the cable core.

Core wrap shall be non-hygroscopic polymeric tape applied with overlay over the cable core to ensure high dielectric strength from cable core to shield, to enhance mechanical properties of the cables, and to provide thermal barrier for cable jacket extrusion operation.

Shield shall be metallic armored cover consisting of aluminum tape laminate of thick, ethylene-acrylic acid copolymer on each side. Coated tape shall be corrugated and applied longitudinally with overlap. It shall be designed with corrugations to enhance cable flexibility and to minimize shield metal fatigue.

Outer jacket shall be black, high molecular weight polyethylene copolymer jacket extruded overall for high resistance to abrasion, weathering, temperature extremes, environmental stress cracking, and mechanical stresses encountered during installation and servicing.

3. <u>Electrical Characteristics:</u>

Attenuation/mile at 1 kHz:	Nominal 1.29 dB
Average mutual capacitance at 1 kHz, pair-to-pair:	Nominal 83 pF/mile
Maximum capacitance unbalance at 1 kHz, Pair-to-pair:	25 pF/kf
Maximum capacitance unbalance at 1 kHz, Pair-to-ground:	800 pF/kf
Maximum conductor resistance at 68°F:	45.9 ohms/mile
Maximum conductor resistance unbalance of individual pairs:	0.60 ohm/kf
Insulation resistance:	1,000megohms/mile
Maximum far-end crosstalk loss at 150 kHz:	63.0 dB/kf
Dielectric strength, conductor-to-conductor:	Minimum 5,000 VDC for 3 sec.
Dielectric strength, conductor-to-shield:	Minimum 15,000 VDC for 3 sec.

C. <u>Flush Mounted (In-Ground) Pull Boxes</u>

1. Flush pullboxes, shall be standard 17"x30" concrete pullboxes, pull boxes (Brooks #66 or approved equal.

2.1. equivalent). Use bolt-down metallic lids marked as follows, "IRWD TELEMETRY".

D. **Pedestal Mounted (Above-Ground) Pull Boxes**

1. Pedestal mounted above-ground pullboxes, shall be as Manufactured by APX, Large Single Door Enclosure, Model #LSD301815, 30"Hx18W"x15"D, NEMA 4X, stainless steel, Brushed Stainless Finish, no solid bottom, delete all vents and main door lock, door handle shall have provisions for a No. 5 padlock, provide a back panel, no switch compartment, or approved equal.

E. **Terminal Boxes**

1. Pedestal mounted above-ground terminal boxes – as Manufactured by APX, Large Single Door Enclosure, Model #LSD301815, 30"Hx18W"x15"D, NEMA 4X, stainless steel, Brushed Stainless Finish, no solid bottom, delete all vents and main door lock, door handle shall have provisions for a padlock, provide a back panel with terminal blocks, no switch compartment, or approved equal.

F. **Terminal Blocks**

1. Terminal blocks shall be Phoenix USK-4 terminal blocks. No substitutions will be allowed.

G. **Conduit**

1. Refer to Standard Construction Manual, specification 16110 for material requirements for PVC conduit systems and for PVC coated rigid steel conduit systems.

H. **Cable Splices**

1. Above- ground In-line cable splices (see execution section) shall be Scotchcast model 78-R1, reenterable splice kit only, no substitutions will be allowed.

2. Inside of splice kit, join cable ends together using 3M Wire Connectors; Model 557 IDC only, no substitutions will be allowed.

PART 3 - EXECUTION

A. **General Telemetry Cable System Installation Requirements**

1. Cable shall be installed in the protection zone of the pipeline, direct buried or in conduit as shown on the plans.

2. Conduit installed with pipelines over long distances shall include pull boxes every 500 feet to facilitate cable installation. Pull Boxes shall be either flush mounted pullboxes or pedestal mounted free standing pullbox cabinets per this specification and IRWD Standard Electrical Construction Drawings E-1 "Telemetry Cable Terminal Box" and E-2 "Telemetry Cable Pullbox / Splice Box, In-Ground".

3. Pullboxes and terminal boxes shall be located behind the sidewalk. A minimum of two loops of cable shall be made in each box. Minimum slack length shall be 3 feet.

4. Cable Access for Future Continuation: When the plans require a cable end to be brought above ground to be made available for future connection, install an above- ground terminal box per this specification and Standard Construction DrawingsDrawing E1 "Telemetry Cable Terminal Box".

5. Any cable installed outside the protection zone of a pipeline shall be in 2" PVC coated rigid steel conduit.

6. Conduit bends shall be long radius sweeps only.

B. <u>Telemetry Cable Splice Installation</u>

1. Direct Buried Splices: In-line non-reenterable splices shall be used in direct buried applications only when it is necessary to intercept existing direct buried cable to bring two ends above ground, or to repair broken cable. Use non-reenterable splices with two-way wire connectors for direct buried in-line splices. Direct buried splices shall not be allowed for new installations.

2. Splices in Pullboxes: In-line reenterable splices and wire connectors are allowed in accessible pullboxes only. Use flush pullboxes or pedestal mounted pullboxes.

3. Only two cable ends may be spliced. Three way splices shall not be permitted. Refer to the Telemetry Cable Termination section of this specification for instructions for connecting 3 cables together.

4. Mark cables with permanent labels in all splice boxes. Indicate the street name and direction of travel of the cable leaving the box (ex. Spliced connection on Harvard, the cables will be labeled (1.) Harvard -North, (2.) Harvard -South).

C. <u>Telemetry Cable Termination Installation</u>

1. Telemetry cable shall be terminated in above- ground pedestal mounted terminal boxes, or facility (pump station, pressure reducing station, etc.) telemetry cabinets only.

2. Terminate cable as shown on to Standard Construction DrawingsDrawing E-1, "Telemetry Cable Terminal Box".

3. Install telemetry cable three-way connection points at locations shown on the plans. Three-way connections (three cables) shall be made on terminal strips only, no three-way splices are allowed. Refer to Standard Construction DrawingsDrawing E-1, "Telemetry Cable Terminal Box" for three-way cable termination details.

4. Mark cables with permanent labels in all splice/connection boxes. Indicate the street name and direction of travel of the cable leaving the box (ex. for a 3-way connection at Harvard and Main, three cables will be labeled (1.) Harvard -North, (2.) Harvard -South, (3.) Main St. -East).

D. Cable Installation

1. The entire length of cable for installation between specified locations shall be provided as a continuous element from a single reel. Cable shall be tested at the factory to verify that the electrical characteristics meet the requirements stated herein. Cable shall be wound on the reel in such a way that both ends are accessible for testing at the job site.

2. The jacket shall be free from holes, splits, blisters, or other imperfections.

3. The end of cable shall be sealed to prevent the entrance of moisture during shipment, installation, and before termination.

4. Prior to placing cable in the trench or conduit, the reel of cable shall be tested for continuity of each cable pair with an ohm meter. Test results shall be recorded and submitted to the District Representative.

5. Direct Buried Cable shall not come in contact with any sharp rock or object. Direct Buried Cable shall be installed in the bedding zone of pipelines only.

6. The intent of these specifications is that the cable shall be installed between facilities without splices. The exception shall be where initial cable is stubbed-out and additional cable is to be installed and connected at a later date, as shown on the plans.

7. Adequate precautions shall be taken to ensure protection of the cable during and after installation. Cables that are stubbed-out for an indeterminate period of time shall be adequately sealed to prevent entry of moisture or water.

E. Cable Post-Installation Testing

1. After installing the cable, an acceptance test shall be conducted to verify that the cable performs to specifications. The test shall be for the entire length of cable. The District Representative shall be notified a minimum of three days prior to the scheduled tests.

2. Each cable pair shall be tested for continuity and attenuation. Loop back tests values shall be within 10% of the specifications.

3. In the event that the cable fails to pass the test, the location of defects shall be ascertained and the cable repaired. The acceptance test shall then be repeated until successful results are obtained.

F. Conduit Installation

1. Conduit in the protection zone of a pipeline shall be PVC schedule 4080 conduit only.

2. Conduit outside the protection zone of the pipeline shall be PVC coated rigid steel conduit only.

3. Install conduit sweeps as necessary, no 45° or 90° bends are allowed.

4. Seal conduit openings within flush mounted pull boxes to prevent water entry into conduit system.

5. Refer to Standard Construction Manual specification 16110 for additional installation requirements for PVC conduit and PVC coated rigid steel conduit systems.

G. Flush Pull Boxes Installation

1. Provide a minimum of 6”" of crushed rock base for pull boxes.

H. Pedestal Mounted Boxes and Cabinet Installation

1. Provide a 10-foot solid copper ground rod and ground each pedestal-mounted box. Refer to section 16450 for ground rod and ground wire installation requirements.

2. All above- ground boxes and cabinets shall be permanently sealed at the base, and all openings into equipment shall be screened or sealed as required to prevent the entrance of rodents and insects the size of wasps and mud daubers. Sealing material at the base shall be concrete grout. Small cracks and openings shall be sealed from the inside with silicone sealant, Dow-Corning "795" or General Electric "SCS 1200".

END OF SECTION

SECTION 16700 – TELEPHONE UTILITY EQUIPMENT

PART 1 - GENERAL

A. Description

This Section outlines the electrical work for telephone company communication equipment and wiring installations.

B. Related Work Specified Elsewhere

1. General Electric Requirements: 16010

2. Earthwork, Division 12

3. Concrete, Division 3

C. Submittals.

Submit for Owner's approval material lists, shop drawings and technical data to the extent required in this Section and Section 16010.

PART 2 - MATERIAL

A. General

Provide all the equipment and materials, including proper space, and complete all the installations as shown on the Drawings, specified and required. All outdoor equipment shall be weatherproof and gasketed.

1. Telephone. Provide the earthwork, concrete, manholes, handholes, pull boxes, terminal cabinets, wood backboards, outlets, conduits, fittings, supports and grounding as indicated, specified and required, and in accord with the requirements of the telephone company.

   a. Telephone Company will provide the instruments, terminals, relays and cables, and complete the installations and connections.

   b. Pay the telephone company for all charges that are required for the complete installations.

PART 3 - EXECUTION

A. Installation-General

Provide all the communication equipment installations and wiring installations, and tests as indicated, specified and required. Assure proper fits for all equipment and materials in the locations on the Drawings.

B. Telephone and Telemetering Installations

Provide the entire required concrete, earthwork, manholes, handholes and pullboxes. Install the terminal cabinets, wood backboards, telephone outlets, conduits, cables, supports, pull wires and grounding as indicated and required. The telephone and telemetering installations shall conform to the requirements of the telephone company.

C. Test

All the equipment and cables shall be checked for proper installations and connections.

1. Test Plan. Prepare the demonstration and final operation test plan as specified in Section 16010.

2. Operational Tests. Demonstrate that performance of the installed communication equipment and materials complies with the requirements of the Project Documents, and to the satisfaction of the Owner.

END OF SECTION

SECTION 16950: ELECTRICAL TESTING

PART 1 - GENERAL

A. Description

This section includes requirements for acceptance testing of the electrical system, wiring, equipment, and grounding.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010

2. Testing, Training, and Facility Startup: 01756

C. References

1. National Electric Testing Association (NETA):

    a) ATS-1995 – Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems.

D. Submittals

1. Pre-Test Submittals:

    a) Testing service qualifications.
    b) Test personnel qualifications (resumes).
    c) Equipment testing schedule.
    d) Test data forms.

2. Post -Test Submittals:

    a) Summary of testing for the project.
    b) Description of the equipment tested.
    c) Description of the test and test procedures.
    d) Test results.
    e) Conclusions and recommendations.
    f) Completed test forms, including witness's signatures.
    g) List of test equipment and calibration documents.
    h) Date and time.
    i) Include the following data tabulated for each piece of equipment:
        i) Circuit number.
        ii) Equipment or motor name and tag number (where applicable).
        iii) Nameplate full-load-ampere rating.
        iv) Motor service factor.
        v) Motor ambient temperature rating.
        vi) Overload relay rating.
        vii) Measured full load current.
        viii) Measured discharge pressures (where applicable).

3. Submit equipment test schedule no later than 7 days prior to scheduled date of testing.

4. Project Record Documents: Note or indicate wiring deviations from Contract Documents on Project Record Documents.

E. <u>Quality Assurance</u>

1. The Contractor shall retain a qualified Engineering appraisal and testing organization to provide inspections, tests, and evaluation to determine that the equipment designated herein is furnished in accord with specifications and is installed and adjusted for successful energization and operation.

2. Testing Firm:

   a) Obtain services of an independent testing service firm that meets the Federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1910.7 and has a work history and qualifications acceptable to the Engineer.

   b) The appraisal and testing organization shall have two or more years of experience related to the appraisal and testing of equipment designated herein.

   c) The managing or supervising representatives of the appraisal and testing organization shall have extensive knowledge of the products involved and at least two years experience conducting appraisals and tests. All testing shall be conducted under the supervision of the managing or supervising representatives.

   d) Testing technicians shall be trained and experienced in the testing they perform.

   e) The engineering appraisal and testing organization shall utilize comprehensive report forms to document engineering appraisal and test results on all equipment's and products. Upon completion of the work, the report forms shall be signed by the managing or supervising engineering representative and included in the final report.

   f) Testing shall be done in accord with the manufacturer's instructions, these specifications, and applicable ANSI, ASTM and NEMA standards. Applicable product instructions shall be furnished to the Engineer for review.

   g) Prequalified Testing Services and Manufacturing Firms:

      i) Electro-Test Inc.

      ii) Square D Company Technical Services Divisions.

      iii) General Electric Company.

   h) Qualifications of other testing services firms may be submitted.

i) Testing service or testing personnel may be accepted or rejected based upon, but not limited to, the testing equipment intended to be used, the qualifications of the firm, and personnel.

F. Measurement and Payment

Payment for the work in this section shall be included as part of the lump-sum bid amount stated in the proposal.

PART 2 - MATERIALS

Not Applicable.

PART 3 - EXECUTION

A. Examination

1. Verify that electrical work is free from improper grounds, short circuits, and overloads.

2. Verify correctness of wiring first by visual comparison of the conductor connections with connection diagrams.

3. Make individual circuit continuity checks by using electrical circuit testers.

B. Acceptance Testing

1. Perform testing and allow Owner and Engineer to witness testing. Notify the Owner's representative three days or more in advance when any test is to take place.

2. Perform electrical acceptance testing in accord with NETA Standards.

3. Perform tests to assure that electrical equipment specified to be tested will operate within industry and manufacturers published tolerances, and will perform safely. Record test result data, to be used as a baseline for future tests.

4. Testing of installed equipment shall result in acceptable test data. Equipment for which acceptable test data has not been submitted, or has been submitted but rejected, shall be deemed as not meeting Contract requirements.

5. Conduct 3 point fall of potential ground test by using equipment of one of the following manufacturer, or equal:

   a) Biddle Company.

   b) Associated Research.

7. Test insulation resistance of circuits. Test each complete circuit prior to energizing. Insulation resistance between conductors and between each conductor and ground shall not be less than 25 megohms. Repair or replace wires or cables in circuits that do not pass this test, and repeat the test.

8. Test project electrical equipment, including 4KV and 600 volt electrical distribution equipment, motor control centers, and grounding. Complete test reports for each individual piece of equipment. The following types of electrical equipment shall be tested according to the requirements of this specification section. Refer to the project documents to identify the equipment related to a specific project:

   a) Power Distribution Switch

   b) Molded Case Circuit Breaker.

   c) Motor Circuit Protector, 200 HP and above.

   d) Motors, 200 HP and above.

   e) Grounding Electrode Systems and Equipment Grounding System (refer to section 16450 for additional requirements).

   f) Protective Relays (relay settings shall be as documented in the project coordination study, see section 16010).

   g) Three Phase Power Transformers.

9. Ground Fault Protective Equipment: The ground-fault protection system shall be performance tested after installation in accord with NEC 230-95C. Submit a written record of the test to the Owner's representative. Label on panel above the device with certification and values. Record current pickup level and time delay settings to which the equipment was finally adjusted. Measure and record relay pickup current and the relay time delay at two values above pickup. Test for correct system operation at 57% rated voltage. If relay pickup current is not within 5% of the manufacturer's calibration marks or fixed setting or relay timing does not conform with manufacturer's published time-current characteristic curves, repair or replace equipment and repeat test.

10. Motor Operating Test: Run each motor as nearly as possible to rated operating conditions. Record current in each phase of each motor 1/2 hp and larger and submit to the Owner's representative. Repair or replace motor or driven equipment if current exceeds motor nameplate current.

11. Power Company Voltage Test: When the installation is essentially complete and the facility is in operation, check the voltage at the point of termination of the power company supply system to the project. Check voltage amplitude and balance between phases for loaded and unloaded conditions. If the unbalance (as defined by NEMA) exceeds 1%, or if the voltage varies throughout the day and from loaded to unloaded conditions more than $\pm$5% of nominal, make a written request to the Power Company that the condition be corrected. If corrections are not made, request that the Power Company official provide a written statement that the voltage variations and/or unbalance are within their normal standards.

B. <u>Summary Test Report</u>

1. Upon completion of testing in every area, submit summary test report.

END OF SECTION

SECTION 17000: GENERAL INSTRUMENTATION CONTROL REQUIREMENTS

PART 1 - GENERAL

A. Description

1. This section of the specifications includes materials, testing, and installation of instrumentation and programmable logic control system as specified herein and indicated on the drawings.

2. These specifications shall not be interpreted as permission or direction to violate any governing code or ordinance. Equipment, materials, and workmanship shall comply with the latest revisions of the following codes and standards:

    a. Instrumentation: Instrument Society of America (ISA).

    b. Wiring: National Electrical Code (NEC), ISA S5.3 and S5.4, 1976.

    c. Control Panels and Equipment: NEMA, UL, and ANSI.

    d. Control Logic: Joint Industrial Council (JIC).

    e. Piping: ANSI B-31.3 (instrumentation piping).

B. Related Work Specified Elsewhere

1. One-year Guarantee: General Provisions

2. Permits and Licenses: General Provisions

3. Testing, Training, and Facility Start-up: General Requirements 01510

4. General Electrical Requirements: 16010

C. Submittals

1. Detailed Systems Drawings and Data: The submittal shall consist of six sets of detailed drawings and data prepared and organized by the Contractor who was designated at the time of bidding. These drawings and data shall be submitted as a complete package at one time.

    a. Submittals shall be in three-ring hardcover binders and arranged for convenient use including tab sheets, all indexed, and cross-referenced.

    b. Detailed JIC-style schematic diagrams of each discrete input/output (I/O) point.

    c. Detailed instrumentation diagrams of each analog I/O instrumentation and control loop, per ISA S5.3 and S5.4 standards.

    d. Detailed programmable logic controller (PLC) loop diagrams.

e. Data sheets for each component, together with a technical product brochure or bulletin. The data sheets shall show:

i. Component name.

ii. Manufacturer's model number.

iii. Project tag number.

iv. Project location.

v. Input and output characteristics.

vi. Scale range and units (if any) and multiplier (if any).

vii. Requirements for electric supply (if any).

2. The data sheets shall be grouped together in the submittal by systems or loops as a separate group for each system or loop. If within a single system or loop, a single component is employed more than once, one data sheet with one brochure or bulletin may cover all identical uses of that component in that system.

3. Component interconnect drawings showing the interconnecting wiring between each component including equipment supplied under other sections requiring interfacing with the control system.

4. Arrangement and construction drawings for consoles, control panels, and for other special enclosed assemblies for field installation. These drawings shall include dimensions, identification of all components, preparation and finish data, nameplates, and the like. These drawings shall also include enough details to define the style and overall appearance of the assembly.

5. Installation, mounting, and anchoring detail for all components or entry details.

6. ELECTRONIC FILES OF SHOP DRAWINGS: Submit electronic files of all shop drawings in AutoCAD 2008 format.

7. Complete detailed bills of material.

D. <u>Qualifications of Contractor</u>

1. Evidence of such qualification, as well as notification of the assuming unit responsibility, shall be furnished to the District in writing prior to commencement of the work. The qualification evidence shall include the following:

a. The Contractor shall have had a minimum of five years experience with the installation of industrial control systems similar in type to those to be installed in this project.

b. A complete list of similar installations including names and address of District, name of project, and date of completion.

c. The name and qualifications of supervisory personnel to be directly responsible for the installation of the control system.

2. The Contractor shall be experienced in the design, programming, and service of this type of equipment. In the event of a dispute as to the acceptability of the work, the District's Representative shall make the final determination.

3. Instrumentation systems and control panels, with the exception of Pressure Reducing Valve Vault Instrumentation Systems and control panels, shall be supplied, installed, calibrated, and tested by the following pre-qualified suppliers:

Mr. Greg Beebe **Brithinee Electric** 620 South Rancho Avenue Colton, CA 92324 Phone- 909-825-7971 FAX- 909-825-2044 greg_beebe@mail.brithinee.com	Dave Stone **Control Technologies** 6780 Katella Ave. Cyprus, CA 90630 Phone- 714-901-3500 FAX- 714-527-3335 davids@control-technologies.com	Mr. Brian Downing **Delta System Eng., Inc**. 3550 North Central Avenue, Suite 1900 Phoenix, AZ 85012 Phone 602-266-4658 FAX 602-266-4953 bdowning@deltaseinc.com
Mr. Peter Matthews **Morrow-Meadows Corp.** 665 Brea Canyon Walnut, CA 91789 Phone- 909-772-5428 FAX- 909-468-0593 pmatthews@morrow-meadows.com	Mr. Joe Engle **Neal Electric** 13250 Kirkham Way Poway, CA 92604 Phone- 858-513-2525 FAX- 858-513-9499 jengle@nealelectric.com	Mr. Salib Mansour **Soffa Electric** 5901 Corvette Street Commerce, CA 90040 Phone- 323-728-0230 FAX- 323-887-8076 salib.mansour@soffaelectric.com
Mr. Jerry Horst **TESCO Controls, Inc.** 3434 52nd Avenue Sacramento, CA 95823 Phone- 916-395-8800 FAX- 916-429-2817 rmartinez@tescocontrols.com	Mr. Dean McLaughlin **Trimax Systems** 565 Explorer Brea, CA 92821 Phone- 714-255-8590 FAX- 714-255-1922 deanm@trimaxsystems.com	

E. Responsibilities of Contractor

1. The Contractor shall furnish and install all proposed hardware as shown on the drawings and as specified herein. One contractor shall have the unit responsibility of all the hardware for all the systems. The programmable logic control system installation and wiring connections to peripheral equipment and instruments shall be the responsibility of the qualified personnel possessing the necessary equipment and having experience in making similar installations.

2. Under this section, the Contractor shall furnish the following:

   a. Instrumentation equipment, programmable logic control system, and control panels and shall include the following.

      i. Spare parts.

      ii. Special tools and test equipment required by the supplier.

iii. Installation, integration and testing.

iv. Documentation.

v. Operator training.

vi. Warranty (one year).

vii. Shipping and receiving.

3. All calibration and final checkout of the instrumentation and programmable logic control system shall be witnessed by the District's Representative to determine if the system complies with the contract documents.

4. The Contractor shall be responsible for coordinating and interfacing with equipment supplied under these contract documents which are an integral part of the system. Interfacing shall be incorporated in the detailed systems drawings and data section of the contract documents.

5. The District will provide PLC programs for PLC hardware shown on the contract documents, unless otherwise noted in the contract documents.

6. The District will provide Local HMI programs for HMI hardware shown on the contract documents, unless otherwise noted in the contract documents.

7. Descriptions of the system operation and PLC functions are provided in the contract documents to help the Contractor and System Supplier to understand the complete system and its operation. The following requirements shall apply to the contract:

   a. The Contractor shall be responsible for all aspects of the hardware installation.

   b. The Contractor shall be responsible for all aspects of testing in accordance with General Provision Section 01510, Testing, Training, and Facility Start-up

   c. The District will support the work of the System Supplier, as defined below, with the following aspects of the testing and start-up process identified General Requirements, Section 01510. During testing and start-up, the District is strictly a support service and it is the Contractor’s responsibility to perform the necessary tests to prove the functionality of the instruments and equipment. The Contractor shall provide the District with a minimum of one week notice prior to the date of needed District assistance.

      i. <u>Section 01510, 1.07, C.3., Instrumentation Systems.</u> The District will provide assistance to the System Supplier with PLC input/output tests as follows:

         1. The District will observe and report the I/O state, for both discrete and analog I/O, as observed in the PLC monitoring program when hardwired I/O signals are initiated and the state condition is requested by the System Supplier.

2. The District will initiate output commands from the PLC, for both discrete and analog I/O, when hardwired I/O signal outputs are requested to be initiated by the System Supplier.

ii. Section 01510, 1.08, Equipment/System Operational Testing. The District will provide assistance to the System Supplier as follows:

1. The Contractor and District shall jointly develop and coordinate equipment system operational testing.
2. The District will observe and report the I/O state, for both discrete and analog I/O, as seen in the PLC monitoring program when hardwired I/O signals are initiated and the state condition is requested by the System Supplier.
3. The District will initiate output commands from the PLC, for both discrete and analog I/O, when hardwired I/O signal outputs are requested to be initiated by the System Supplier.
4. The District will initiate automatic control sequences (equipment start/stop sequence, etc.) to demonstrate equipment operation when requested by the System Supplier.

iii. Section 01510, 1.11, Equipment/System Operational Testing. The District will provide assistance to the System Supplier as follows:

1. The Contractor and District shall jointly develop and coordinate equipment system operational testing.
2. The District will observe and report the I/O state, for both discrete and analog I/O, as seen in the PLC monitoring program when hardwired I/O signals are initiated and the state condition is requested by the System Supplier.
3. The District will initiate output commands from the PLC, for both discrete and analog I/O, when hardwired I/O signal outputs are requested to be initiated by the System Supplier.
4. The District will initiate automatic control sequences (equipment start/stop sequence, etc.) to demonstrate equipment operation when requested by the System Supplier.
5. The District will respond to reasonable requests to troubleshoot system operational failures to resolve cause of malfunctions or deficiencies which (a) cause shutdown or partial operation of the facility or (b) result in performance that is less than specified.

7. The Contractor shall provide a PLC system whose input and output configuration complies with the requirements of the contract documents, including specific I/O register assignments when applicable. This requirement is applicable when the District supplies the PLC program. The Contractor is required to provide a hardware configuration that properly interfaces with the PLC program provided by the District. The Contractor shall notify the District of any changes to the input/output configurations described by the contract documents at the time of the submittal of shop drawings. After submittal review, the Contractor shall continue to be responsible for notifying the District immediately if any changes that impact the PLC input/output configuration as defined in the contract documents.

F. Guarantee

The Contractor shall repair or replace defective components, rectify malfunctions, correct software problems (for any software supplied by the Contractor), and correct faulty workmanship, at no additional cost to the District during the guarantee period. To fulfill this obligation, he shall utilize technical service personnel designated by the Contractor who was originally assigned project responsibility. Corrections shall be made within five calendar days after notification by the District's Representative.

PART 2 - MATERIALS

A. Designation of Components

In these specifications and on the plans, all systems, and other elements are represented schematically and are designated by numbers, as derived from criteria in Instrument Society of America Standards. The nomenclature and numbers designated herein and on the plans shall be employed exclusively throughout shop drawings, data sheets, and the like. Any other symbols, designations, and nomenclature unique to a manufacturer's standard methods shall not replace those prescribed above, as used herein, and on the plans.

B. Instrument Tagging

1. Attach a stainless-steel tag to the instrument at the factory or in the field. Permanently mark the stainless-steel tag with the instrument tag number.

2. The manufacturer's standard metal nameplate as a minimum shall denote model number, serial number, operating electrical voltage and amperage (when applicable), and date of manufacturer.

C. Instrument System Power

1. Power provided for the instrument system shall be 120-volt AC, single phase from a single source. This system will supply 100% of the control power for the PLC and instruments. Provide battery backup and/or UPS systems as required by the contract documents.

2. Where DC power supplies are not furnished integral with any one instrument system loop, then provide separate solid-state power supplies.

D. Matching Style, Appearance and Type

All display instruments of each type shall represent the same outward appearance, having the same physical size and shape and the same size and style of numbers and pointers.

PART 3 - EXECUTION

A. Installation

1. The drawings indicate connections for typical equipment only. If the equipment furnished is different from what is shown, provide the modifications necessary for a safe and properly operating installation in accordance with the equipment manufacturer's recommendations.

2. The drawings indicate diagrammatically the desired location and arrangement of equipment. Field determine exact location based on physical size and arrangement of equipment, finished elevations, and obstructions.

3. Work or equipment not indicated or specified which is necessary for the complete and proper operation of the instrumentation and control systems shall be accomplished without additional cost to the DISTRICT.

B. Uniformity of Components

1. Components that perform the same or similar functions shall, to the greatest degree possible, be of the same or similar type, the same manufacturer, the same grade of construction, the same size, and the same appearance.

C. Mounting of Equipment and Accessories

1. Mount equipment in accordance with the installation detail drawings as prepared by the Contractor and reviewed by the Engineer. Mount equipment so that they are rigidly supported, level and plumb, and in such a manner as to provide accessibility; protection from damage; isolation from heat, shock, and vibration; and free from interference with other equipment, piping, and electrical work. Do not install consoles, cabinets, and panels until heavy construction work adjacent to computer and telemetry equipment has been completed to the extent that there shall be no damage to the equipment.

2. Locate devices, including accessories, where they shall be accessible from grade, except as shown otherwise.

3. Mount local equipment in cabinets or existing panels as specified. Mount associated I/O terminals on a common panel or rack; mounting panels and rack shall be baked enamel.

4. Coordinate the installation of the electrical service to components related to the system to assure a compatible and functionally correct system. All accessories shall be coordinated and installation supervised by the Contractor.

5. Test the complete system after installation to assure that all components are operating with the specified range and all interlocks are functioning properly.

D. Testing

1. The Contractor shall perform testing and start-up of the instrumentation and control equipment in accordance with General Provisions Section 01510, Testing, Training, and Facility Start-up.

E. Maintenance and Repair Manuals

1. Maintenance manuals shall be prepared and submitted to the District's Representative for preliminary review in six copies. When the District's Representative is satisfied that these are complete and properly prepared, six final sets shall be delivered to the District's Representative.

2. The complete Maintenance manual shall contain all the information included in the preliminary equipment submittal, the detailed installation submittal, programming instructions, and the additional information required herein, all bound in hard-cover binders and arranged for convenient use including tab sheets, all indexed and cross referenced, and all final as-built drawings.

3. The maintenance manuals shall contain:

    a. calibration and maintenance instructions,

    b. trouble-shooting instructions, and

    c. instructions for ordering replacement parts.

4. At the time of submittal of the Maintenance Manuals, the Contractor shall provide as-built versions of submittal drawings, and equipment manufacturers shop drawings.

5. ELECTRONIC FILES OF SHOP DRAWINGS: Provide electronic files of all "As-Built" shop drawings in AutoCAD (latest version) format with the Maintenance Manuals.

END OF SECTION

SECTION 17110 – IDENTIFICATION TAGS

A. **<u>Description</u>**

This section includes requirements for materials and installation of identification tags for instrumentation and control systems.

B. **<u>Related Work Specified Elsewhere</u>**

1. General Electrical requirements: 16010

2. General Instrumentation Requirements: 17000

C. **<u>Submittals</u>**

Submit shop drawing in accord with the General Provisions and
Sections 16010 and 17000

PART 2 - MATERIALS

I. **<u>Designations of Components</u>**

A. **Metal Tags and Backplates**

Style S1

Material: Stainless steel, type 316
Thickness: 0.040"
Size: 2⅜" x ¾" (± 0.1")
Holes: 2 each, diameter = 0.12" . See Figure 1 below, for location.

FIG. 1 (not to scale)

Letter size: 3/16" high, 1/8" wide (no more than 12 characters in one line)

Characters shall be engraved in the center of the tag with a minimum depth of 0.009" or more and filled with Black enamel paint.

Manufacturer for S1: Dreiling Manufacturing (Pocoima, CA) or
Nu-Way (La Mirada, CA.) or equal.

B. **Backplate**

Material: Stainless steel, type 316
Thickness: 0.040"
Size: **Style B1**: 8½" x 5½" ($^{+}_{-}$ 0.1")

Style B2: 8½" x 11" ($^{+}_{-}$ 0.1")

Style B3: To be cut to fit.

Holes: 2 each, diameter = 0.12" . See Figure 2, below, for location.

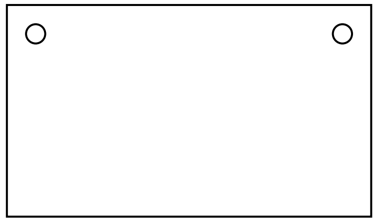

FIG. 2 (not to scale)

C. Plastic Tags

1. Style L1

Material: Laminated Plastic with UV inhibitor
Thickness: 1/16"
Color: Black plastic behind and Light blue on front.
Size: 2⅜" x ¾"   (± 0.1")
Letter size: 3/16" high, ⅛" wide and 0.010" deep
(one line with 12 characters maximum)

2. Style L2

Material: Laminated Plastic with UV inhibitor
Thickness: 1/16"
Color: Black plastic behind and Light blue on front.
Size: 2" x ⅜"   (± 0.1")
Letter size: 5/32" high, ⅛" wide and 0.010" deep
(one line with 12 characters maximum)

3. Style L3 Plastic

Material: Laminated Plastic with UV inhibitor
Thickness: 1/16"
Color: Black plastic behind and Light blue on front.
Size: 3" x ¾"   (± 0.1")
Holes: one each, diameter = 3/16" . See Figure 3, below, for location.

Manufacturer for L1, L2 & L3: Nu-Way (La Mirada, CA) or
Dreiling Manufacturing (Pocoima, CA) or equal.

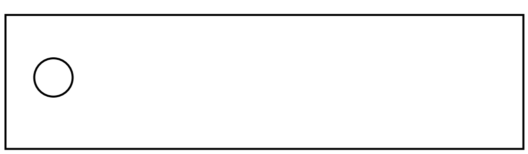

Fig. 3 (not to scale)

D. Plastic Backplate

Material: Laminated Plastic with UV inhibitor
Thickness: 1/16"
Color: Black plastic behind and light blue on front.
Size: **Style B1**: 8½" x 5½" ($\pm$ 0.1")

Style B2: 8½" x 11" ($\pm$ 0.1")

Style B3: To be cut to fit.

Holes: 2 each, diameter = 3/16" . See Figure 4 below, for location.

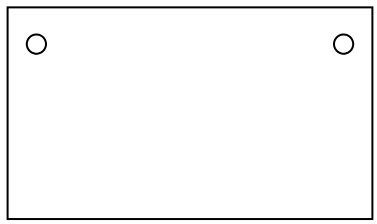

Fig. 4 (not to scale)

E. Aluminum Foil Tags

Material: Aluminum
Thickness: 0.003"
Size: 1.375" x 0.437". Corners = 3/32" 1/8" serialization.
Color: #31 Dark Green Background with # 10 Aluminum Text.
Characters: 1/8". Variable number printed on each label.
Adhesive: 3M 467
Manufacturer: Lustre-Cal (Lodi, CA) or Express (La Jolla, CA) or equal.

PART 3 – EXECUTION

A. ADHESIVE

Use Silicone II from GE (General Electric)

B. SST WIRE

Lead seal and 12" Monel wire from BRADY Signmark Division. Catalog number: 23302. Use the hand sealing press Catalog number: 23300 for this wire.

Nylon Coated stranded stainless steel wire alloy 316 from BRADY Signmark Division. Catalog number: 23310. Use Brass wire clamp – double ferrule design Catalog number 23312. Use clamping tool Catalog number 23311 for this wire.

END OF SECTION

SECTION 17200 – MISCELLANEOUS INSTRUMENTATION EQUIPMENT

PART 1 - GENERAL

A. Description

This section includes requirements for materials and installation of field mounted instrumentation.

B. Related Work Specified Elsewhere

1. General Electrical requirements: 16010

2. Miscellaneous Electrical Devices: 16051

3. General Instrumentation Requirements: 17000

4. Testing, Training, and Facility Startup: 01510

C. Submittals

1. Submit shop drawing in accord with the General Provisions and Sections 16010 and 17000.

2. Provide start up calibration data sheets as required.

PART 2 - MATERIALS

A. Designations of Components

1. In these specifications and on the plans, all systems, meters, instruments, and other elements are represented schematically and are designated by numbers, as derived from criteria in ISA standards. The nomenclature and numbers designated herein and on the plans shall be employed exclusively throughout shop drawings, data sheets, and the like. Any other symbols, designations, and nomenclature unique to a manufacturer's standard methods shall not replace those prescribed above, as used herein, and on the plans.

B. Signal Characteristics

1. Wherever possible and feasible, components shall be of electronic solid-state design and systems shall utilize the same signal characteristics throughout each and all of the several systems; transmission signals shall be 4 to 20 ma.

2. The combined power supply and transmitter loops shall, when tested with appropriate precision resistors, present a voltage signal of 1- to 5-volt d-cDC.

3. Signal isolators shall provide input/output of 4-20 ma DC.

4. Signal isolators shall be provided where required.

5. Signal isolators shall be manufactured by Phoenix Contact, no equal.

C. <u>Submersible Type Pressure/Level Transmitter</u>

1. Pressure/level transmitter shall be a sealed stainless-steel diffused silicon transducer that shall generate an electronic analog signal proportional to pressure/level and shall transmit the analog signal via a shielded cable.

2. The pressure/level transmitter output shall be a true 2-wire device with 24-volt DC power being derived from the control panel. No separate power supply shall be required at the transmitter.

3. The transmitter output shall be 4 to 20 ma DC into a load of 0 to 450 ohms maximum.

4. The submersible transmitter's stainless steel or titanium housing shall be waterproof.

5. Overall accuracy shall be within 0.25% of span.

6. Ambient temperature limits shall be -40º C to 60º C.

7. Provide all necessary mounting hardware, conduit adapter, remote transducer cable, and shutoff valves.

8. Suspended transmitters shall be provided with a kevlar reinforced cable or separate stainless steel support cable. The sensor cable shall be of sufficient length so no splice or connector is required in the wet or inaccessible area, and the vent tube termination point is located in an area protected from dirt and moisture.

9. Submersible level transmitter cable shall be without splices and marked off every foot with a permanent marker indicating the length of actual cable that is submersed.

10. Submersible cable for contact with chlorinated water shall be tefzel, no equal.

11. The pressure/level transmitter shall be ranged in engineering units as shown on drawings.

12. Submersible transmitters, mounted non-submersed in water, mounted on the pipeline, shall be manufactured by Amtek model number 575S, or Druck model number PTX530-8839, or Keller model number 210S, no equal.

13. Submersible transmitters, mounted submersed in water, i.e. wells, reservoir, tanks, provide Druck PTX1230, no equal.

D. <u>Pressure/Level Transmitter (Non-Submersible)</u>

1. Pressure/level transmitters shall be a sealed stainless-steel diffused silicon transducer that shall generate an electronic analog signal proportional to pressure/level and shall transmit the analog signal via a shielded cable.

2. The pressure/level transmitter output shall be a true 2-wire device with 24-volt DC power being derived from the control panel. No separate power supply shall be required at the transmitter.

3. The transmitter output shall be 4 to 20 ma DC into a load of 0 to 450 ohms maximum.

4. The transmitter's electronic housing shall be injected aluminum with polyester coating or 316 stainless steel to meet (NEMA 4X, IP67). It shall be of Explosion Proof and Weather Proof construction. The electronic circuit boards shall be "tropicallized" and be "intrinsically safe" for use in hazardous areas

5. Overall accuracy shall be within 0.25% of span.

6. Ambient temperature limits shall be -40º C to 60º C.

7. Provide all necessary mounting hardware, conduit adapter, remote transducer cable, and shutoff valves.

8. The pressure/level transmitter shall be ranged in engineering units as shown on drawings.

E. <u>Pressure Switches– Mechanical Type</u>

1. The unit shall be a two-stage pressure-actuated switch. The power element shall be either a stainless-steel bellows or a bourdon tube actuating two enclosed, snap-action metal contact switches. Switch connections are to be clearly and permanently identified. The unit shall have an indicator showing the trip set point of each switch. Adjustment of the switch trip points and viewing the trip point indicator shall be accomplished without having to gain access to the interior of the unit. All pressure switches shall be provided with stainless-steel gage valves and pulsation dampeners. The switch shall be United Electric, Mercoid, or equal.

2. "High" contacts closeopen on increasing pressure. "Low" contacts closeopen on decreasing pressure.

F. <u>Pressure Switches – Digital Type</u>

1. The unit shall be a two-stage electronic pressure-actuated switch. The connections are to be clearly and permanently identified. The unit shall have an indicator showing the trip set point of each switch. Adjustment and viewing of the switch trip points shall be accomplished without having to gain access to the interior of the unit. All pressure switches shall be provided with stainless-steel gage valves and pulsation dampeners.

2. Pump Suction Pressure switch applications shall be 120 volt AC powered, output contacts shall be relay type rated 120 volt AC, scaled readout option, as Manufactured by Neo-Dyn Smart Switch, Model 801P505ARQZ, no equal.

3. Pump Discharge Pressure switch applications shall be 120 volt AC powered, output contacts shall be relay type rated 120 volt AC, scaled readout option, as Manufactured by Neo-Dyn Smart Switch, Model 801P511ARQZ, no equal.

4. "High" contacts closeopen on increasing pressure. "Low" contacts closeopen on decreasing pressure.

G. Pressure Gages

1. Pressure gages shall be liquid filled 4.5 inches in diameter in a stainless steel weatherproof case. The dial shall be plastic coated with black figures on a white face. The scale shall have a 270-degree-minimum arc. The movement shall be stainless steel and nylon or all stainless steel, whichever is the manufacturer's standard. An over-range pressure of up to 130% of maximum scale reading shall not affect calibration of the gage. Accuracy shall be within 1.0% of scale range. All pressure gages shall be provided with stainless-steel gage cocks and pulsation dampeners rated for at least 200 psi (discharge). The pressure gages shall be Ashcroft Duragage or Noshok.

H. Flow Switch

1. Flow switches shall be pipeline mounted, providing SPDT 10-ampere dry contact switch closure at the actuating minimum flow rate. The flow switch shall be provided with a stainless-steel activating disc. With an increase in flow, a magnetic sleeve shall be raised into the field of a permanent magnet activating the attached switch. The process media shall be isolated from the NEMA 4 switch body.

2. Flow switches shall be that manufactured by Magnetrol International Model F503 or equal.

I. Differential Pressure Transmitter

1. The transmitter shall provide an electrical 2-wire DC current signal proportional to pressure differential applied across the unit's high and low diaphragm sensing elements. Flow transmitters shall include an integral square root extractor to linerizelinearize the DC current output signal. The differential pressure-sensing element shall be silicone oil filled with a process media operating temperature range of -40^{o} F to 220^{o} F. The calibrated range of the differential transmitter shall be compatible with the operating range of the primary measuring element. Provide the differential pressure transmitter with the following features:

   a. Independent external zero and span adjustments.

   b. Over-range protection.

   c. Vent/drain valve.

   d. Integral digital signal indicator.

   e. Two-inch pipe mounting bracket.

   f. Stainless-steel three-valve manifold with ¼-inch FIPT connections.

   g. Two electrical conduit connections ½-inch FIPT connections.

2. Accuracy of the differential pressure transmitter shall be +/-0.25% of calibrated span.

3. The differential pressure transmitter shall be manufactured by SMAR, model number LD301DP, no equal.

J. Digital Panel Indicators

1. Digital indicators shall be designed for semi-flush mounting in a panel.

2. The indicator shall be a 3-½ digit LED or gas-discharge type display, with digits at least ½-inch high.

3. The indicator shall be easily read at a distance of 10 feet in varying control room lighting.

4. Accuracy shall be $\pm$0.1 percent, operating temperature range shall be 0° to 60° C.

5. The indicator shall be scaled in engineering units, matching the device for which it provides indication, with units engraved on the display face or on the associated nameplate.

6. Digital indicators shall be manufactured by Action Instruments, model VP508-1-1, or Newport Electronics, model 202A-P part number 57SN006 B2S.

K. Power Supplies

DC power supplies shall be 28 volt DC, 4 amp, computer grade manufactured by: Phoenix Contact, Quint model, no equal.

L. Chart Recorders

1. Chart recorders shall be circular, 100mm calibrated width, with digital display and integral keypad. Configure inputs, output, and other options as shown on the project plans and/or as indicated on the approved submittal.

2. Calibrate chart recorder and display in engineering units to match the instrumentation that is being recorded.

3. Provide an engraved nameplate with Device name, Engineering Units, and Tag Number.

4. Supply 1 year of ink and charts ranged to match engineering units.

5. The recorders shall be Chessell Series "392", no equal.

M. Analytical Instrumentation

1. Gas Detection

Chlorine:	GasTech Safe-t-Net w/ defusion sensors
Combustible:	Infrared sensor, E.I.T., MSA, DRAGER
O2:	GasTech, MSA
H2S:	GasTech, MSA
CO2:	GasTech, MSA

2. PH: Great Lakes model P63 AIN1A1A1ENS with differential probe.

3. Conductivity: Great Lakes E63 FIN1A1A1ENS w/ 3700E series probe.

4. D.O.: Great Lakes w/ Zullig Series 504100 probe Z63G1N1A1A1ENS.

5. O.R.P.: Great Lakes R63CIN1A1A1ENS w/ differential probe.

6. Turbidity Analyzers: Hach 1820C.

7. Chlorine Analyzers: Prominent D1C w/ CTE 1-XX-MA probe.

8. Samplers: Sigma 900 MAX all weather-refrigerated.

N. <u>Ambient Room Temperature Transmitter</u>

1. Ambient Room Temperature Transmitter shall be RTD type with range equal to 0 to 200 degrees F.

2. Transmitter output signal shall be 4-20 ma.

3. Temperature transmitter shall be as manufactured by Omega, Model number PRTX-2, or equal.

O. <u>Level Switch – Float Type, Mercury Switch</u>

1. Float shall contains a single pole mercury switch which actuates when the longitudinal axis of the float is horizontal, and de-actuates when the liquid level falls one inch below the actuation elevation.

2. The float shall have a chemical resistant polypropylene casing with a firmly bonded electrical cable protruding. One end of the cable shall be permanently connected to the enclosed mercury switch and the entire assembly shall be encapsulated to form a completely water tight and impact resistant unit.

3. Suspended type float shall have a built in weight.

4. Pipe supported floats shall include hardware for mounting to a pump discharge or support pipe.

5. Floats shall be as manufactured by Anchor Scientific, ROTO-FLOAT model, Type P for support pipe applications, Type S for suspended applications.

P. <u>Level Switch – Float Type, Non-Mercury Switch</u>

1. Float shall contains a non-mercury snap action single pole switch which actuates when the longitudinal axis of the float is horizontal, and de-actuates when the liquid level falls one inch below the actuation elevation.

2. The float shall be encapsulated to form a completely water tight and impact resistant unit. The float shall contain a snap-action switch activated by a steel ball rolling back and forth within a switching tube in a plastic float housing.

3. Suspended type float shall be externally weighted.

4. Pipe supported floats shall include hardware for mounting to a pump discharge or support pipe.

5. Floats shall be as manufactured by Anchor Scientific, ECO-FLOAT model, Type SE for suspended applications.

PART 3 – EXECUTION

A. Ambient Room Temperature Transmitter

1. Install ambient room temperature transmitter in an area of the room that is not subject to direct radiated heat from equipment.

B. Pressure/Level Transmitter

1. Below ground or wet location, level or pressure transmitter, mounted not submersed in water, mounted on pipeline, provide submersible type transmitters.

2. Above ground, dry locations, indoors, provide non-submersible transmitter.

3. Submersed transmitters, i.e. wells, reservoir, tanks, provide submersible transmitter.

C. Spare Parts

1. Furnish all necessary spare parts of components required to maintain the instrumentation system. Prior to final acceptance of the work, the Contractor shall provide a spare parts listing of all necessary spare parts and quantities for review by the Owner's Representative. The spare parts shall be specified by the contract documents.

END OF SECTION

SECTION 17300: PLC's and PROGRAMMABLE OPERATOR INTERFACES

PART 1 - GENERAL

A. Description

This section includes materials, installation and testing of programmable logic controllers and programmable operator interface equipment.

B. Related Work Specified Elsewhere

1. General Electrical Requirements: 16010
2. General Instrumentation and Control Requirements: 17000
3. Telemetry and Control Systems – Communications Equipment: 17350

C. Submittals

1. Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.

PART 2 - MATERIALS

A. General Requirements

1. Provide Programmable Logic Controllers (PLC) systems as specified herein and as shown on drawings. Provide all I/O (analog and discrete), interface modules, and other cabling and hardware as needed to provide a fully functioning system.

B. Modicon Backplane Mounted Programmable Logic Control System

1. A fully integrated programmable logic control system shall be furnished as specified in this section and on the drawings. The PLC system shall come complete with central processor, memory, enhanced executive cartridge, power supply, interconnecting cables, and discrete and analog I/O interfaces.

2. The A-C power of the control system will be 120-volt +/-10% AC, 60 hertz, single phase derived from line power. The system shall be designed to operate satisfactorily from 0 C to 60 C ambient temperature for the PLC.

3. The D-C power of the control system will be 24 VDC.

4. Input/Output: At the PLC locations, analog transmitters and receivers have 4- to 20-ma signals. Discrete (on/off) inputs originate from dry relay contacts. For discrete control output, provide relays with dry contacts. Refer to instrumentation diagrams, schematics and I/O lists for I/O requirements.

5. Discrete PLC I/O modules shall have individual LED status lights for each I/O point. All discrete and analog modules shall have terminal blocks for termination

of the I/O wires. Individual I/O points shall be capable of withstanding low energy common mode transients to 1,500 volts.

6. Provide the following minimum spare I/O:

   a. Analog Inputs: Two
   b. Discrete Inputs: Six
   c. Discrete Outputs with Interposing Relay: Four
   d. Two Empty Rack Slots

C. PLC Component Manufacturer

1. The PLC components including I/O modules, shall be manufactured by Modicon, no equal.

D. Modicon Quantum PLC Backplane Mounting Rack

1. The PLC backplane mounting rack shall be a Modicon Quantum Series, Model Number 140 XBP 006 00, six slot rack, minimum. Refer to the minimum spare rack slot requirements above, and increase the size of the backplane mounting rack to a ten slot (140 XBP 010 00) or sixteen slot (140 XBP 016 00) rack as required to meet the requirement.

E. Modicon Quantum PLC Power Supply Module

1. The PLC rack power supply shall be a Modicon Quantum Series, Model Number 140 CPS 114 20, 11 amp power supply.

F. Modicon Quantum PLC Controller Module

1. The logic and variable memory shall be read/write RAM. All RAM shall have integral battery backup that will maintain the memory for a minimum of six months upon a utility power failure. The logic and variable memory shall be sufficient for programming all specified functions plus 25% spare memory.

2. The PLC Controller module shall be Modicon Quantum Series: Model 140 CPU 434 12U, or as shown on the drawings. This controller is considered a minimum requirement and shall be larger as required by the specific application.

G. Modicon Quantum PLC Discrete Input Modules

1. The PLC discrete input modules shall be 120-volt AC and have noise filters or use other techniques to reject short-time constant noise and 60-Hz pickup.

2. The discrete input modules shall be Modicon Quantum Series: Model Number DAI 553 00, 32 inputs per module, 120 volt AC.

H. Modicon Quantum PLC Discrete Output Modules

1. The PLC discrete output modules shall be 120-volt AC or 24-volt DC solid-state drivers suitable for operating control relays. Each discrete output module shall include fuses and fuse blown indicators.

2. The discrete output modules shall be Modicon Quantum Series: Model Number DAO 842 10, 16 outputs per module, 120 volt AC.

I. Modicon Quantum PLC Analog Input Modules

1. The PLC analog inputs shall be suitable for accepting 4- to 20-ma from either 2- or 4-wire transmitters. The input power shall be from an external 24-volt DC power supply. The analog to digital converter shall have a 10-bit minimum resolution with an overall accuracy of +/-1% at 60º C.

2. The analog input modules shall be Modicon Quantum Series: Model Number ACI 030 00, 8 inputs per module.

J. Modicon Quantum PLC Analog Output Modules

1. The PLC analog outputs shall be 4- to 20-ma signals suitable for driving into a 0- to 600-ohm load without load adjustments. The digital to analog converter shall have a 10-bit minimum resolution with an overall accuracy of +/-2% at 60º C. The output power shall be from an external, 24-volt DC power supply. If the PLC fails, the analog outputs shall retain their present value.

2. The analog output modules shall be Modicon Quantum Series: Model Number ACO 020 00, 4 outputs per module.

K. Modicon Quantum PLC Module to Terminal Block Field Wiring Interface

1. For discrete input module interface to field wiring, the Contractor shall provide the following:

   a. Modicon Cable Fast Terminal Block Model # 140 CFC 032 00.

   b. Interface Cable Model # 140 XTS 002 xx (where xx is the length of the cable, 3, 6, 9, or 12 feet).

2. For discrete output module interface to field wiring, the Contractor shall provide the following:

   a. Modicon Cable Fast Terminal Block Model # 140 CFG 016 00.

   b. Interface Cable Model # 140 XTS 002 xx (where xx is the length of the cable, 3, 6, 9, or 12 feet).

3. For analog input module interface to field wiring, the Contractor shall provide the following:

   a. Modicon Cable Fast Terminal Block Model # 140 CFH 008 00.

   b. Interface Cable Model # 140 XTS 002 xx (where xx is the length of the cable, 3, 6, 9, or 12 feet).

4. For analog output module interface to field wiring, the Contractor shall provide the following:

   a. Modicon Cable Fast Terminal Block Model # 140 CFJ 004 00.

b. Interface Cable Model # 140 XTS 002 xx (where xx is the length of the cable, 3, 6, 9, or 12 feet).

L. Modicon M340 PLC Backplane Mounting Rack

1. The PLC backplane mounting rack shall be a Modicon M340 Series, Model Number BMX XBP 0400, four slot rack minimum. Refer to the minimum spare rack slot requirements above, and increase the size of the backplane mounting rack to a six slot (BMX XBP 0600), an eight slot (BMX XBP 0800) or twelve slot (BMX XBP 1200) rack as required.

M. Modicon M340 PLC Power Supply Module

1. For 120 VAC powered PLC, the PLC rack power supply shall be a Modicon M340 Series, Model Number BMX CPS 3500, 115/230 VAC, 36 watt power supply.

2. For 24 VDC powered PLC, the PLC rack power supply shall be a Modicon M340 Series, Model Number BMX CPS 3020, 24-48 VDC, 31 watt power supply.

N. Modicon M340 PLC Controller Module

1. The logic and variable memory shall be read/write RAM. All RAM shall have integral battery backup that will maintain the memory for a minimum of six months upon a utility power failure. The logic and variable memory shall be sufficient for programming all specified functions plus 25% spare memory.

2. The PLC Controller module shall be Modicon M340 Series: Model BMX P342020, or as shown on the drawings. This controller is considered a minimum requirement and shall be larger as required by the specific application.

O. Modicon M340 PLC Discrete Input Modules, 120 VAC

1. The PLC discrete input modules shall be 120-volt AC and have noise filters or use other techniques to reject short-time constant noise and 60-Hz pickup.

2. The 120 VAC discrete input modules shall be Modicon M340 Series: Model Number BMX DAI 1604, 16 inputs per module, 120 volt AC, requires 20 points terminal block or prefab cable.

3. Terminal block for 16 input, 120 VAC DI module, 20 point terminal block, screw clamp type shall be Modicon M340 Series: Model Number BMX FTB 2000.

4. Terminal block for 16 input, 120 VAC DI module, 20 point terminal block, push spring type shall be Modicon M340 Series: Model Number BMX FTB 2020.

5. Cable accessory, for 120 VAC, 16 point discrete input module, (1) FTB terminal block, with 20 wire cable prefabricated cable with color coded flying leads, shall be Modicon M340 Series: Model Number BMX FTW 301 (3 meters length), Model Number BMX FTW 501 (5 meters length), or Model Number BMX FTW 1001 (10 meters length).

P. Modicon M340 PLC Discrete Input Modules, 32 point, 24 VDC

1. The 24 VDC PLC discrete input modules shall have noise filters or use other techniques to reject short-time constant noise and 60-Hz pickup.

2. The 24 VDC discrete input modules shall be Modicon M340 Series: Model Number BMX DDI 3202K, 32 inputs per module, 24 VDC.

3. Cable accessory for 32 point 24 VDC discrete input module with connectors to field termination module accessory, (1) FCN connector to (2) HE10 connectors, for direct connection to Telefast wiring system shall be Modicon M340 Series: Model Number BMX FCC 053 (0.5 meters), Model Number BMX FCC103 (1 meters), Model Number BMX FCC 203 (2 meters), or Model Number BMX FCC 303 (3 meters).

4. Termination module accessories, for 32 point, 24 VDC Discrete Input Modules, shall be Modicon M340 Series: Quantity (2) 16 point, Telemechanique Telefast Model Number ABE 7H16S21.

Q. Modicon M340 PLC Discrete Output Modules, 120 VAC

1. The PLC discrete output modules shall be 120-volt AC and have noise filters or use other techniques to reject short-time constant noise and 60-Hz pickup.

2. The 120 VAC discrete output modules shall be Modicon M340 Series: Model Number BMX DRA 1605, 16 outputs per module, 120 volt AC, requires 20 points terminal block or prefab cable.

3. Terminal block for 16 output, 120 VAC DO module, 20 point terminal block, screw clamp type shall be Modicon M340 Series: Model Number BMX FTB 2000.

4. Terminal block for 16 input, 120 VAC DO module, 20 point terminal block, push spring type shall be Modicon M340 Series: Model Number BMX FTB 2020.

5. Cable accessory, for 120 VAC, 16 point discrete output module, (1) FTB terminal block, with 20 wire cable prefabricated cable with color coded flying leads, shall be Modicon M340 Series: Model Number BMX FTW 301 (3 meters length), Model Number BMX FTW 501 (5 meters length), or Model Number BMX FTW 1001 (10 meters length).

R. Modicon M340 PLC Discrete Output Modules, 16 point, 24 VDC

1. The 24 VDC PLC discrete output modules shall have noise filters or use other techniques to reject short-time constant noise and 60-Hz pickup.

2. The 24 VDC discrete output modules shall be Modicon M340 Series: Model Number BMX DDO 3202K, 32 outputs per module but only 16 outputs to be used, 24 VDC, prefab cable.

3. Cable accessory for 32 point 24 VDC discrete output module with connectors for direct connect to Telefast field termination module accessory with only 16 outputs to be used, (1) FCN connector to (1) HE10 connector, shall be Modicon M340

Series: Model Number BMX FCC 051 (0.5 meters), Model Number BMX FCC 101 (1 meters), Model Number BMX FCC 201 (2 meters), or Model Number BMX FCC 301 (3 meters).

4. Termination module accessory, for 32 point, 24 VDC Discrete Output Module with only 16 outputs to be used, shall be Modicon M340 Series: Quantity (1) 16 point, Telemechanique Telefast Model Number ABE 7H16S21.

S. Modicon M340 PLC Discrete Output Modules, 32 point, 24 VDC

1. The 24 VDC PLC discrete output modules shall have noise filters or use other techniques to reject short-time constant noise and 60-Hz pickup.

2. The 24 VDC discrete output modules shall be Modicon M340 Series: Model Number BMX DDO 3202K, 32 outputs per module, 24 VDC, requires prefab cable.

3. Cable accessory for 32 point 24 VDC discrete output module with connectors for direct connect to Telefast field termination module accessory, (1) FCN connector to (2) HE10 connector, shall be Modicon M340 Series: Model Number BMX FCC 053 (0.5 meters), Model Number BMX FCC 103 (1 meters), Model Number BMX FCC 203 (2 meters), or Model Number BMX FCC 303 (3 meters).

4. Termination module accessories, for 32 point, 24 VDC Discrete Output Module, shall be Modicon M340 Series: Quantity (2) 16 point, Telemechanique Telefast Model Number ABE 7H16S21.

T. Modicon M340 PLC Analog Input Modules

1. The PLC analog inputs shall be suitable for accepting 4- to 20-ma from either 2- or 4-wire transmitters. The input power shall be from an external 24-volt DC power supply. The analog to digital converter shall have a 10-bit minimum resolution with an overall accuracy of +/-1% at 60º C.

2. The analog input modules shall be Modicon Modicon M340 Series: Model Number BMX AMI 0410, 4 inputs per module, 20 points terminal block.

3. Cable accessory, for 24 VDC, analog input module, (1) FTB terminal block, with 20 wire cable prefabricated cable with color coded flying leads, shall be Modicon M340 Series: Model Number BMX FTW 301S (3 meters length), or Model Number BMX FTW 501S (5 meters length).

4. Cable accessory for 4 point analog input module with connectors for direct connect to Telefast field termination module accessory shall be Modicon M340 Series: Model Number BMX FCA 150 (1.5 meters length), Model Number BMX FCA 300 (3 meters length), or Model Number BMX FCA 500 (5 meters length).

5. Termination module accessory, for 4 point, 24 VDC Analog Input Module, shall be Modicon M340 Series: Quantity (1) Telemechanique Telefast Model Number ABE 7CPA410.

U. Modicon M340 PLC Analog Output Modules

1. The PLC analog outputs shall be 4- to 20-ma signals suitable for driving into a 0- to 600-ohm load without load adjustments. The digital to analog converter shall have a 10-bit minimum resolution with an overall accuracy of +/-2% at 60º C. The output power shall be from an external, 24-volt DC power supply. If the PLC fails, the analog outputs shall retain their present value.

2. The analog output modules shall be Modicon M340 Series: Model Number BMX AMO 0210, 2 outputs per module, 20 points terminal block.

3. Cable accessory, for 24 VDC, analog output module, (1) FTB terminal block, with 20 wire cable prefabricated cable with color coded flying leads, shall be Modicon M340 Series: Model Number BMX FTW 301S (3 meters length), or Model Number BMX FTW 501S (5 meters length).

4. Cable accessory for 2 point analog output module with connectors for direct connect to Telefast field termination module accessory shall be Modicon M340 Series: Model Number BMX FCA 150 (1.5 meters length), Model Number BMX FCA 300 (3 meters length), or Model Number BMX FCA 500 (5 meters length).

5. Termination module accessory, for 2 point, 24 VDC Analog Output Module, shall be Modicon M340 Series: Quantity (1) Telemechanique Telefast Model Number ABE 7CPA21.

V. Modicon M340 PLC Network Module

Modicon M340 Ethernet Network Module (NOE): (1) RJ45 10/100 Ethernet port, includes memory card with 2 Mb space. Modicon M340 Series: Model Number BMX NOE 0100.

W. Modicon Momentum Fixed I/O PLC

1. A fully integrated programmable logic control system shall be furnished as specified in this section and on the drawings. The fixed I/O PLC system shall come complete with central processor, memory, power supply, interconnecting cables, and discrete and analog I/O interfaces.

2. The D-C power of the control system will be 24 volts dc. The system shall be designed to operate satisfactorily form 0º C to 60º C ambient temperature for the PLC.

3. Input/Output: At the PLC locations, analog transmitters and receivers have 4- to 20-ma signals. Discrete (on/off) inputs originate from dry relay contacts. For discrete control output, provide relays with dry contacts. Refer to instrumentation diagrams for I/O requirements.

4. The fixed I/O Controller shall be Modicon Momentum Series.

5. Provide Modicon Momentum I/O bases as required by the application, or as shown on the drawings. The following I/O bases are typically used and should be implemented unless otherwise specified or directed by IRWD:

a. Discrete Input Module Base, 24 volts DC, 32 points input, part number 170 ADI 350 10.

b. Discrete Input/Output Module Base, 24 volts DC, 16 points input, 16 points output, 0.5 Amp outputs, part number 170 ADM 350 10.

c. Analog Input Module Base, 8 channel differential input module, part number 170 AAI 030 00.

d. Mixed I/O Module Base, 4 channel analog input, 2 channel analog output, 4 channel 24 volt DC discrete inputs, 2 channel 24 volt DC discrete output, part number 170 AMM 090 00.

6. Provide CPU and Option adapter for the main PLC base as follows:

a. Provide CPU: Part number 171 CCC 960 30, M1E processor adaptor, 512K RAM, Ethernet and I/O bus ports, web page enabled, IEC programming compatible.

b. Provide Modbus Option Adapter, with Time of Day Clock and Battery Backup, part number 172 JNN 210 32.

7. Provide additional I/O bases with a communications option adapter as follows:

a. Provide I/O base communications adapter, part number 170 INT 110 00, Interbus communications adapter, with SUPI 2.

X. <u>Programmable Operator Interface Advanced</u>

1. The Programmable Operator Interface shall use the Windows CE operating system, and shall run operator interface HMI software as manufactured by Indusoft.

2. The Programmable Operator Interface shall be Maple Systems HMI612X-CE, no equal.

3. Provide (1) Compact Flash Card, 128 MB.

4. Provide (1) software runtime license as manufactured by Indusoft, part number IND-920CE-RT.

5. The HMI shall have Ethernet connectivity.

6. Provide all cables, connectors and Ethernet converter as needed to connect the unit to an Ethernet switch.

Y. <u>Industrial Panel Mounted Computer Monitor</u>

1. The Industrial Computer Monitor shall be panel mounted.

2. Industrial Computer Monitor shall be 17-inch diagonal.

3. The Industrial Computer Monitor shall be rated to 45º C.

4. The Industrial Computer Monitor shall have a resolution of 1280x1024, native mode.

5. The Industrial Computer Monitor shall have an aluminum bezel.

6. The Industrial Computer Monitor shall include a resistive touch screen.

7. Provide cables and power supply as required.

8. The Programmable Operator Interface shall be Allen Bradley, Model 1750M, Catalog Number, 6167M-17PT, no equal.

PART 3 - EXECUTION

A. <u>General Requirements</u>

Contact the District prior to installing I/O modules into existing PLC racks.

B. <u>PLC Controller Programming Requirements</u>

1. The District will perform programming of the PLC Controller unless otherwise stated in the project documents or on the drawings.

2. The District will perform upgrades of existing PLC Controller programs to integrate new hardware into existing control systems.

C. <u>Power Source</u>

1. The power source for the PLC system shall be an Uninterruptible Power Supply for 120-volt AC powered systems.

2. The power source for the PLC system shall be from a battery backed or UPS backed power supply for 24 volt DC powered systems.

    a. Industrial waste monitoring station telemetry.

    b. Flow control valve vault telemetry.

D. <u>Testing</u>

Test shall be performed in accordance with Section 17000, General Instrumentation Control Requirements.

E. **<u>Input/Output Wiring</u>**

1. All field wiring shall connect to field terminals. Do not connect field wires directly to the PLC Input/Output Modules.

2. Install wiring from the PLC Input/Output modules to field terminals for all spare module inputs and outputs.

END OF SECTION

SECTION 17330: SCADA SYSTEM HARDWARE AND SOFTWARE

PART 1 - GENERAL

1.01 DESCRIPTION

This section includes requirements for materials, testing, and installation of a control system.

A fully integrated control system shall be furnished as specified in this section. The control system hardware shall be intelligent process control units with analog and discrete I/O for process interface.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. PCIS General Requirements: 17000.

B. PLC Hardware and Software: 17300.

C. Fiber-Optic Data Transmission System: 17360.

1.03 DESIGNATIONS OF COMPONENTS

In these specifications and on the plans, all systems and other elements designated by numbers, as derived from criteria in ISA standards. The nomenclature and numbers designated herein and on the plans shall be employed exclusively throughout shop drawings, data sheets, and the like. Any other symbols, designations, and nomenclature unique to a manufacturer's standard methods shall not replace those prescribed above, as used herein, and on the plans.

PART 2 – MATERIALS

2.01 SCS HARDWARE

A. The Design Build Team shall deliver to the IRWD two (2) servers to be installed and integrated at the existing Operations Center by the IRWD. Two (2) complete sets of software, including SCADA software, shall be provided.

B. Control Unit: The CPU shall be, at a minimum, a Gateway 2000, Inc. ("Gateway") E-5400 system with a Pentium III Processor, minimum 733MHz clock, minimum 256k cache, 2 minimum 64 Mb PC600 memory modules (expandable to 1 Gb), 5 full length 32-bit PCI slots plus 1 AGP slot, an integrated Ultra ATA 66 Controller, and a Matrox G400 32Mb 4X AGP Graphics Accelerator.

C. Monitor: The monitor shall be a VX920 19" color monitor with an 18" diagonal viewing area. Substitutes shall be meet or exceed the performance and features of the named monitor and be approved by IRWD.

D. The system will also include a 3.5 floppy drive, minimum 48X CD-ROM, Philips Recordable/ReWriteable 8x/4x/32x CD-ROM, two minimum 30GB 7200 RPM SMART II Ultra ATA hard drives, a 104 key keyboard, and a Microsoft Intellimouse.

E. Substitutes: Provide only equipment provided by Gateway. Submit Gateway's specifications for any proposed substitute. Any proposed substitute shall meet or exceed the performance and features of the named item.

F. Log Printer, Type RO (Receive Only): The SCS log printer shall be used to produce hard copy output for files, event logs, or any other data required. The bi-directional impact type printer shall produce up to 300 characters per second in the draft mode and 100 characters per second in the letter mode. The printer shall have tractor drive feed adjustable for 3- to 15-inch paper width. Other features shall include jam detection, and out of paper alarm.

G. Color Printer: The high quality color inkjet-type printer shall be dedicated to producing screen hard copy, color charts, graphs, and graphical information generated by the applications software programs and functions. The resolution of screen hard copies and color printouts shall be at least 300 x 300 dpi.

H. Communication Server: Communication server shall allow for a remote access to the system. The server shall have at least four channels. The server shall be LanRover by Intel Network Systems (Shiva) or equal.

I. All SCS equipment shall be powered from the UPS.

2.02 SCS SOFTWARE

A. In addition to the SCADA system software described below, provide the following conventional software:

1. Microsoft Office, latest version
2. PCAnywhere, latest version
3. Wonderware - Intouch, latest version
4. Experttune with drivers for Modicon controllers, latest version
5. Specter - WIN911, for alarm paging, latest version

B. The Design Build Team shall provide all software which, when integrated into the installed hardware, shall form a complete system capable of performing all functional requirements as provided for in this specification. The software shall be modular in nature, consisting of previously proven operating system "tools" and application programs configured over the period of the contract.

In order to specify a particularly high level of technology and expertise in this field, certain items of the required software have been described generally below. It is realized that the supplier's software may differ in detail with that described herein. It is the functional aspects which are important. The supplier shall not be alleviated in any way of providing software not specifically delineated herein which is required to guarantee meeting all functional requirements of the control and monitoring operation.

The software shall be documented as provided for in this specification. IRWD realizes that certain portions of the supplier's software may be considered as proprietary, and he further realizes his position of confidence with regard to disposition of any technical information about such software. This situation shall in no way alleviate the supplier from providing a fully documented operable system, including all source code, computers, linkers, drivers and command files used to build the entire system from source.

C. Operating System: The operation of the computer system hardware and scheduling of application software shall be controlled by a real-time, multitasking operating system. The operating system shall be a complete package as offered by the computer manufacturer or shall have been field proven in other comparable process applications for a period of one year or more.

The SCS real time multitasking operating system shall allow concurrent execution of application programs in a time slice environment. The operating system and related software shall be fully field tested in other installed process applications. The operation system shall be Windows NT Advanced Server.

The executive shall control all peripheral devices and shall provide all timing, I/O, and inter-task communication services for the application software through resident device drivers and other executive services.

The executive shall provide access to the following general utilities for monitoring and controlling execution of the application software:

1. System Monitor: To monitor the entire system and indicate the priority, current state, and I/O activity of each task in the system.

2. Scheduler: To permit the scheduling of individual tasks on either a one-time or a repeated basis.

3. Batch File Processor: To provide execution of frequently used sequences of commands by a user or program. A batch file shall be provided to install and schedule all necessary application software each time the system is restarted.

4. Loader: To transfer executable code between on-line storage media and memory for scheduled activation by the real time executive.

5. I/O Drivers: To provide I/O from all peripherals in the system. Drivers shall interface with the executive via the interrupt system. Driver programs shall be included for all specified peripherals. Source code for all drivers not included with the standard operating system shall be included by the instrumentation system supplier.

D. System Utilities: In order to provide for efficient software development and system operation other than real time operation, the operating system shall provide a general operator's monitor. Through use of this, the operator shall be capable of running certain utilities on a batch mode basis, performing routine programming tasks. The following describes a number of these basic utility programs which shall be provided for in this software system:

1. Directory: The system shall maintain a directory of all programs, source files, and data files stored on disks. The directory program shall list all programs on a designated disk showing remaining free space left on that unit.

2. File Management: A file management routine shall be provided which shall allow for all basic file manipulations, such as create file, delete file, append file, change filename, etc. The file management routine shall also allow for file transfers, file copy, and file dump to/from selected I/O devices.

3. Text Editor: The text editor shall allow for keyboard entry/editing of data, such as source program code, for creation and/or modification of program files. Specifically, it shall be required that all supported language input files be created via the text editor. The editor shall be interactive in nature allowing a programmer to type commands, type in text data, and observe data displayed at the CRT, all done in conversational style. The text editor shall be a full-screen editor and shall be capable of being run on-line concurrent with the real time system.

4. Compilers: Compilers shall be provided to compile the programs and subroutines which are included as part of the application system. A set of batch files shall be provided for compiling all application software.

5. Linker: A utility shall be provided to link independently compiled software modules. Batch files shall be provided to link the entire application system.

6. Diagnostics: Provide a complete set of diagnostic programs to test, exercise, and report operation of the CPU memory and all peripheral devices. Included specifically with peripherals is the remote communication equipment.

E. Communication Software: Provide field-proven SCS software communication and programming packages for the PLC using a real-time environment that shall allow for multiple concurrent processes, providing error management and queuing functions.

The communication subroutine library shall provide the interface between the application program and the PLC. The communication subroutines shall be used for (1) Formatting commands for transmission and decoding PLC responses; (2) Error detection and logging.

Utility routines callable from the process control language shall interface with the communications software to:

1. Read/write PLC data bits or words.

2. Read/set status (start, run, and hold).

3. Read/clear error tables.

The SCS shall display and log an alarm condition whenever communication is lost with a PLC. When communication with the PLC is established again, a normal condition shall be displayed and logged.

The PLC communications alarm log shall include the time (days, hours, minutes) and PLC location.

F. SCS Application Software: The application software shall consist of individual programs designed to perform the various functions which make up a complete monitoring and control system. The functions shall be distributed between the individual programs and software modules in a logical manner such that related functions are performed within the same program or software module.

The distribution of functions between the different programs and software modules shall be clearly described in the system documentation. There shall be a complete description of all data structures used by the application software for data storage and message passing between program modules.

As a minimum, the following application software modules shall be included in separate programs all fully configured to perform the specified control and monitoring functions:

1. Database: A database shall be provided for the maintenance of data acquired from PLC. The system shall include up to 5,000 data points. Data points shall include current values, current status, set points, alarms, and calculated values from PLC. The database modification, deletion and append functions shall be provided in a full screen editor scrolling mode and a single point per page mode.

   A database editor shall enable the user to define or modify all the static and dynamic attributes of a process signal. The static attributes shall include the point description, range, units, its PLC address, alarm limits, alarm priority, blocked/unblocked status, etc. The dynamic attributes of a point shall include all attributes which are updated automatically by scheduled or event-driven software:

   a. Current value

   b. Filtered value

   c. Alarm status

   Data which is received from PLCs shall be tested for validity. The state of discrete points and the value of analog points shall be compared with the predefined normal state or limits associated with the point. Alarm and return-to-normal messages shall be logged when points transition between normal and alarm states; these messages shall include the date, time, point name, previous state/value, and current state/value of the point. All transitions from the normal condition to an alarm state shall set an indication for the point in question; this indication shall remain set until explicitly acknowledged (cleared) by the operator.

   A high level process control language shall be provided for manipulation of the database. Using this language, the operator shall be able to define complex logic and math functions to be performed using any of the point attributes including status points, current values, calculated values, alarm limits, totalizers and run-time accumulators. Functions shall be able to be performed according to a fixed schedule or conditionally based upon the current status of variables and discrete points in the database.

   Functions shall be used to derive indicators of overall system performance (such as net flow into a storage tank), to modify analog control loops by changing the value of constants, or to issue automatic commands to remote equipment. Functions shall be defined using a screen- oriented editor which checks the definition for errors before a permanent record of the executable instructions is saved on disk.

2. Historical Data Storage: The historical data storage module shall automatically record historical information on each of the data points being monitored. "By exception" data storage shall be used for discrete changes in state and analog deviations from previously stored values. Averages, maximum, minimum, flow totalization, and equipment run time values, calculated in the PLC/RTUs, shall be recorded on an operator-selectable periodic time basis (1 second to 30 minutes) for each individual point.

   The deviation (%) range for analog historical data shall be operator selectable (0.1% to 100%) for each point.

   Historical data shall be stored on a designated portion of the hard disk. The scheduler shall automatically backup data to the tape drive on an operator selectable frequency.

   System disk capacity shall be provided to retain historical data for a period of at least one year.

3. Scheduler: The scheduler shall automatically perform tasks that require execution periodically, on certain days or dates, or on certain process events or conditions. The scheduler shall have the capability of automatically scheduling:

   a. Printing of reports

   b. Data back-up to optical drive

   c. Other application software

   d. Other third party software

4. Security Entry: Provide a minimum three-level keyboard security entry using a minimum 6-digit alphanumerical code. The security levels shall be as follows:

   a. Level 1: Allows the operator to view all application software but does not permit the modification of set points or execution of commands.

   b. Level 2: Allows the operator to modify control set points and send commands to PLC but not to modify the system software or displays.

   c. Level 3: Allows the operator to modify and create all program software and displays.

5. SCS Menus: The purpose of the menu is to provide the operator with a summary in tabular format of all available displays in a two-step sequence. The first step shall allow the operator to select the type of menu from the following:

a. Graphic Displays.

b. Trend Selection.

c. Summary Reports.

d. Alarm Summary.

For each display, summary or report, the menu sublist shall include the description of each available display, summary or report and a mouse selectable link.

6. Graphics: The operator shall monitor and control the system using a number of preconfigured graphic displays which represent the particular equipment and processes being controlled.

A display editor shall be provided for the user to modify or configure additional custom graphic displays.

Set points for all controls, timers, counters, analog switches, and control algorithms shall be stored at the related PLC. The SCS shall have the task of transmitting set point information when updated by the operator.

The SCS operator shall have the capability of manually controlling all control loops and equipment from the operators CRT.

Each control display point shall include point number, description, and set point.

Multipage data selections (historical file and menu displays) shall be vertically scrolled.

Each analog or calculated value indicated on a graphic shall be linked to a live 8-hour trend. Live trends for process variables associated with a PID algorithm, ratio controller, or time proportional controller shall trend the process variable and setpoint along with indicating and allowing change of setpoints, PID constants, deadband settings, ratio constants, time, proportional settings, etc.

The operator shall be capable of printing graphic displays either by request or at a preselected time period on the color printer.

The system shall permit on-line modification of or addition of displays with relative ease using the operator's console without disturbing the normal system operation.

The display editor shall be capable of operating in interactive mode with the user and shall be capable of creating displays while the system is on-line and without disrupting the continuous monitoring, logging, and reporting functions.

7. Trend Displays: The SCS shall display data for live data and historical trends in groups of one to eight points.

   Live and historical trend recording shall simulate analog strip chart recording appearing as a continuous line. Trends shall be made up of points (not symbols) with a minimum signal resolution of one part in 200 (0.5%). Trend ranges shall be operator selectable with a range of two minutes to one month. Live trends shall be continuous, and as new entries appear, the oldest entries shall clear. The operator shall be capable of selecting any analog value for trending; historical trends which do not extend to the current time shall not be updated. The horizontal resolution of trend plots shall be one part in 480 (0.2%) of the trend period selected or the signal sample interval, whichever is the greater.

   The trend display shall include the following alphanumeric fixed and live data:

   a. Point number

   b. Signal name

   c. Current value or value at the time indicated by the cursor.

   The trend display shall include a moving cursor which enables the user to determine the exact value of analog signals at any time by moving the cursor to that position in the display.

   The operator shall be capable of printing trends either by request or at a pre-selected time period on the printer.

   An operator shall be capable of predefining trend groups and selecting predefined trend groups from graphic displays or a list of predefined trend groups.

8. Reports: The SCS shall automatically generate scheduled reports and operator-initiated reports. Reports shall be done in Microsoft Excel with an on-line Microsoft Windows DDE link to the distributed control software package.

   The format and content of reports to be printed by the SCS shall be defined at the SCS using an interactive full-screen editor. The user shall be able to enter descriptive text and designate the live/historical data to be included in the report. Designation of data to be included in a report shall include current values and the full range of historical data attributes recorded by the system. The system shall be capable of performing standard mathematical calculations on historical data for inclusion in the reports. The time from which individual data fields are to be included in a report shall be defined relative to a reference time; the reference time shall be the current time when the report is generated unless otherwise defined when the report is requested.

   Reports generated on demand or on a predetermined schedule shall be saved in ASCII files before they are printed.

Provide daily reports which list all hourly analog input values grouped by unit process or site for a 24-hour period. Minimum, maximum, average, and totals (where applicable) shall be displayed on the hour. At the bottom of the report, the minimum, maximum, average, and daily total (where applicable) shall be listed. An operator shall be able to request this report at any time during the day. The report shall display the value and exact summary for the day up through the last completed hour. At the end of each day, the SCS shall automatically print the report and store the report on hard disk.

The daily bottom line summary values shall roll over to the monthly report. The monthly report shall show a day by day summary of the values generated by the daily report. An operator, upon requesting the monthly report, shall receive a summary of the month up through the last whole day and at the bottom of the page the minimum, maximum, average and total values for the month. At the end of each month, the SCS shall automatically print the report and store the report on hard disk. This shall be a true monthly report reflecting the actual number of days in each month.

The monthly reports shall roll over to the yearly report. The same values shall be displayed upon operator request as described before except on a month to month basis.

Provide monthly summary reports which include hourly, daily, and monthly totals (ETMs, flow) and averages for all analog points. These reports shall be printed automatically at time intervals selected by the operator. The summary reports shall be separately grouped by type (i.e., flow totals, pump ETMs, turbidity, pH, etc.). Each summary report page shall include the description and date as a heading. Daily, monthly, and yearly reports shall be provided.

The SCS shall automatically print maintenance reports for each item of equipment for which maintenance is due. The user shall be able to define up to 1,000 items of equipment for maintenance scheduling and shall associate each item with a discrete input point to enable maintenance scheduling according to run time or number of starts. Once each 24 hours, the maintenance status of equipment shall be checked either by run time, number of starts, or by elapsed calendar time. The operator shall be able to acknowledge completion of the work, whereupon the timer/counter used to schedule maintenance for that particular piece of equipment shall be reset. At any time, the operator shall be able to display the maintenance status of individual pieces of equipment or request a report of all equipment for which maintenance is due; these reports shall include the date when maintenance was last completed (acknowledged) and the number of starts/run time which has elapsed since then.

The maintenance program may be a separate third-party package which works with SCS software.

9. Alarm Summary: The SCS shall be capable of logging and displaying status (event and alarm changes from the PLC) changes for all points in the system along with SCS initiated alarms.

A display shall be provided for presentation of all existing alarms in the system. Alarms shall be displayed in reverse chronological order with the most recent alarm shown first. Three levels of alarm status shall be provided in the alarm summary:

a. Alarm unacknowledged

b. Alarm acknowledged--not cleared

c. Alarm acknowledged—cleared

Alarms shall be acknowledged individually and the operator who acknowledged the alarm shall be indicated on the alarm summary printout. If a system-wide alarm acknowledgment is provided, it shall be available only to personnel with an appropriate security access category. Separate summaries shall be provided for analog alarms, discrete alarms, system alarms and points which are blocked or otherwise off-scan.

Alarm logs initiated from PLC set points, external discrete inputs or SCS setpoints shall be used to alert the operator to motor failures, severe analog limits, hazardous conditions, or PLC failures. Alarm points shall always be logged on the printer when they transition into an "alarm" condition, and when the alarm clears, they shall be logged on the printer when they transition back into the "normal" condition. Alarms which are enabled for reporting by the data-to-voice unit shall NOT be reported by data-to-voice unit when they transition into a normal condition. Provide a CRT summary display for all activated and deactivated alarm points. The alarm summary shall initiate and log every 1 to 24 hours on the printer at a time selected by the operator or upon demand.

The following information for each alarm point shall be required as a minimum:

a. Time (Day, Hour, Minutes).

b. Point Number.

c. Point Description.

d. Current Value (for Analogs).

e. Alarm Condition (Alarm/Normal).

G. SCADA application software shall be by Wonderware to match existing package. Provide a two-year Wonderware Comprehensive Support for each software license.

H. Auto Call Software: Software shall be provided for the SCS data-to-voice unit to perform the following functions:

1. Call operators and inform them of alarm conditions.

2. Accept incoming calls from operators with a valid access code.

3. Permit the operator to acknowledge alarms.

4. Permit an operator to access current analog values and discrete status.

5. Allow an operator to select which system alarms shall initiate a call out.

6. Announce alarms over intercom system.

The data-to-voice unit shall accept incoming calls at any time, and the caller shall be required to enter a valid code which identifies the caller. When it is enabled, the data-to-voice unit shall respond to system alarms by attempting to contact a system operator using procedures defined by the users.

The user shall be able to enter 10 telephone numbers and shall be able to define the order in which operators are to be called. When an alarm condition occurs during the period when the data-to-voice unit is enabled for call-out, the system shall dial the primary number of the operator who is first on call. If the on-call operator does not respond at the primary number, a secondary number assigned to the on-call operator shall be dialed. The dialing sequence shall continue until all 10 phone numbers have been tried. The dialing system shall include adjustments for the number of times each number is dialed before switching to the next number and for setting a time delay in between the system's outgoing calls.

When the telephone is answered (by the data-to-voice unit for incoming calls or by the operator for outgoing calls), the data-to-voice unit shall identify itself and prompt the operator to enter a pass code. If a valid pass code is entered, the identity of the operator and the time of the communication shall be logged and the system shall enter conversational mode.

In conversational mode, the system shall prompt the operator to request either all alarms, all unacknowledged alarms, or the current values of variables associated with each alarm condition. Outgoing messages shall be constructed from the data base fields used in presenting alarm messages on the event/alarm printer: signal description, current state/value, severity of alarm condition, etc. The database shall include a field for phonetically spelled descriptions for each point in the system.

Following each message in any of these lists, the operator shall be prompted to direct the system whether to repeat the message or to acknowledge the message and proceed to the next message. Acknowledgment of previously unacknowledged alarm messages shall be logged on the event/alarm printer. If, for any reason, conversational mode is terminated before all alarms have been acknowledged or the operator cannot provide a valid code, the data-to-voice unit shall attempt to call the next operator in line.

The data-to-voice unit shall be normally enabled to call out, and the operator shall be able to designate particular days of the week and particular periods within these days during which call-out would be disabled. The operator shall be able to designate particular dates (holidays) for which call-out would be enabled all day, without regard to the day of the week on which these holidays fall.

The SCS system shall include a graphics interface with the data-to-voice unit which allows the user to easily modify the auto-dial sequence, timing variables, and callout schedule parameters. In addition a database list shall be provided of all system alarms which will allow an operator to select which alarms shall prompt an auto-dialer call out.

The Auto Call Software shall be SCADAlarm by Wonderware, SCADAPhone by ScadaTEC, or equal.

2.03 SCADA IMPLEMENTATION GENERAL REQUIREMENTS

A. Graphic displays shall be provided illustrating a hydraulic flow diagram for the WTP using symbols to represent equipment with process flow direction lines connecting the symbols. Color active symbols shall be used for pumps, motors, valves, and primary elements. Each graphic page shall be capable of displaying a minimum of 128 analog and discrete points.

   Up to 150 configured graphic displays shall be provided by the system supplier.

B. All process lines, structures, and equipment shall be identified with the proper nomenclature. The process and instrumentation diagrams (P&IDs) provided under these specifications shall be used to help generate graphics displays.

C. Overview graphics shall be configured, illustrating the system overview, with pertinent system values and equipment status indicated. Graphics indicating unit processes and distribution sites shall be linked to the overview graphic.

D. A symbol library shall include symbols for equipment commonly found in water distribution and treatment applications. The user shall be able to add to this symbol library or modify existing symbols through simple interactive procedures.

E. Discrete graphic symbols for pumps, valves, and motors shall have the following color code information:

   1. Off/closed — Black

   2. Running/opened — Green

   3. Failed/alarm — Red

F. Adjacent to each discrete graphic symbol, the description shall be included. Adjacent to each analog graphic symbol, the point description, current value, and engineering units shall be displayed.

G. Reservoirs and storage structures shall have dynamic bar graphs illustrating analog levels.

H. The operator shall be capable of altering both discrete and analog set points and resetting and presetting totalizers and ETMs at the related CRT graphic display.

I. A minimum of 25 each additional daily, monthly, and yearly report formats shall be provided in accord with the requirements of IRWD. The report formats will be supplied to the system supplier during system configuration for integration into the system.

J. The top or bottom line shall be reserved for the time (day, hour, and minutes) and alarm messages. Alarm messages shall flash in red with a continuous audio alert and clear when acknowledged, allowing new entries to appear. An area on the screen shall be provided for operator-initiated messages, such as set points or control outputs.

2.04 SCADA PROGRAMMING WORKSHOP

A. When the equipment shop drawings have been approved and prior to submitting SCS screens, the Design Build Team shall hold a one-day programming workshop at IRWD's headquarters. IRWD personnel and IRWD will attend the workshop.

B. Notify IRWD in writing three weeks in advance of the scheduled workshop.

C. The workshop shall serve to clarify the intent of the drawings and specifications as they relate to control logic, SCS screens, report generation, etc. The Design Build Team shall provide SCS and from similar projects as an example of the quality and content of screens that will be submitted.

2.05 SPARE PARTS

A. The Design Build Team shall furnish to IRWD all necessary spare parts of components required to maintain the system. Prior to final acceptance of work, the Design Build Team shall provide a spare parts listing of all necessary spare parts and quantities for review by IRWD. The spare parts shall include the following minimum requirements:

Minimum Spare Parts Requirements		
No.	Part Description	Quantity
1	Fan-Fold Print Paper	20 boxes of 2,600 sheets
2	Printer Ribbons	10 each
3	Color Printer Paper	500 sheets
4	Color Printer Cartridge	3 each
5	B/W Printer Cartridge	5 each
6	Disk and Printer Cleaning Kit	1 of each type

B. The Design Build Team shall deliver to IRWD all the required spare parts upon final acceptance of the work. The spare parts shall not be used as replacement parts during the guarantee period.

PART 3 - EXECUTION

Refer to Section 17000.

END OF SECTION

SECTION 17350: TELEMETRY AND CONTROL SYSTEMS - COMMUNICATIONS EQUIPMENT

PART 1 – GENERAL

A. Description

1. This section includes materials and installation of telemetry system communications equipment and devices, such as radios, modems, and control system network equipment such as ethernet switches, routers and bridges.

B. Related work Specified Elsewhere

1. General Electrical Requirements: 16010
2. General Instrumentation Control Requirements: 17000
3. PLC's and Programmable Operator Interfaces: 17300

C. Submittals

1. Shop drawings shall be submitted in accordance with the General Provisions and as specified herein.
2. Submit material list for all devices, hardware, and related accessories.

PART 2 – MATERIALS

A. General

1. Provide all devices, hardware, and accessories required to make a fully functioning telemetry site.

B. Radio Equipment - Non-Licensed Spread Spectrum Radios, 900 MHz, Ethernet/-TCP/IP Data Communications

1. Provide Non-Licensed Spread Spectrum Radios, 900 MHz, Ethernet/TCP/IP Data Communications, as shown on the plans.
2. Ethernet TCP/IP Spread Spectrum radio transceiver shall be a 900 MHz, digital radio transceiver with remote loop back and internal diagnostics. 24 volt DC power.
3. Manufacturer shall be Microwave Data Systems, Model iNET-900, no equal.
4. ACCESS POINT radio transceiver shall be manufactured by Microwave Data Systems, model iNET-900 AP, and there is no equal.
5. REMOTE radio transceiver shall be manufactured by Microwave Data Systems, model iNET-900 IP, no equal.

C. Radio Equipment - Non-Licensed Spread Spectrum Radios, 5.8 GHz, Ethernet/-TCP/IP Data Communications

1. Provide Non-Licensed Radios, 5.8 GHz, Ethernet/TCP/IP Data Communications as shown on the plans.

2. Ethernet TCP/IP radio transceiver shall be 5.8 GHz, digital radio transceiver as manufactured by Redline, model 80i04-G-G-T58, RedCONNEX AN-80i-H, no equal.

3. Include Power over Ethernet Injector Module, as manufactured by Redline, model PSA-POE-1D, no equal.

4. Provide Radio Software. Software shall be as manufactured by Redline, model AN80i-H, software key for PTP 54Mb rate with a 10 & 20 MHz Channel.

5. Provide four year warranty.

D. Radio Equipment - Non-Licensed Spread Spectrum Radios, 5.4 GHz, Ethernet/-TCP/IP Data Communications

1. Provide Non-Licensed Radios, 5.4 GHz, Ethernet/TCP/IP Data Communications as shown on the plans.

2. Ethernet TCP/IP radio transceiver shall be 5.8 GHz, as manufactured by Redline, model 80i04-G-G-T54, RedCONNEX AN-80iMultiband-H, no equal.

3. Include Power over Ethernet Injector Module, as manufactured by Redline, model PSA-POE-1D, no equal.

4. Provide Radio Software. Software shall be as manufactured by Redline, model AN80i-H, software key for PTP 54Mb rate with a 10 & 20 MHz Channel.

5. Provide four year warranty.

E. Antenna Equipment 900 MHz

1. The antenna systems shall include, but not be limited to, antenna, antenna mounting mast, mounting hardware, and coaxial cables with connectors. The Contractor shall install antennas specified in the construction documents or required to complete the work. The approved antenna manufacturers and models include:

    a. Directional Antenna, Yagi type,– 10db Forward Gain – Manufactured by Scala, model TY-900, or as specified on the drawings.

    b. 3 dB Omni Directional Antenna for panel top mounting. Manufactured by Antennex, 3 dB Gain Antenna, part number TRA9023NP.

    c. 9 dB Omni Directional Antenna. Manufactured by Decibel, 9 dB Gain Antenna, part number DB589Y.

2. The approved Antenna Cables manufacturers and models include:

   a. 5/8-inch Cellflex foam cable Celwave type FLC 78-50J orders #81092-001, or 5/8-inch Heliax foam cable Andrew LDF4.5-50.

3. The approved Antenna Connectors manufacturers and models include:

   a. Cellflex or Heliax to type N female connector Celwave 738841 or Andrew 145N.

   b. Cellflex or Heliax to type N male connector Celwave 738842 or Andrew 145W.

4. The approved Antenna Cable Pigtails manufacturers and models include:

   a. Andrew cable type FSJ1-50 1/4-inch diameter Superflex Cable, 24-inch long, one end type N male, the other end type N female.

5. The approved Antenna Cable Pigtails (for MDS iNET 900 Radio) manufacturers and models include:

   a. Andrew cable type FSJ1, 3 FT Coax Cable, type N Male to type TNC Male.

6. Masts – 10 to 15 Feet High:

   a. Antenna mast shall 2-inch GRC conduit securely fastened to local control panel.

   b. All mounting hardware hardware including unistrut and fasteners shall be stainless steel.

7. Masts – 16 to 35 Feet High:

   a. Antenna mast shall be tapered tenon mount by U.S. Pole number 35-11 per IRWD Standard Drawing W-15 (E-10) or as otherwise specified in the contract documents.

   b. Antenna mast to be round, tapered and have an 18-inch long, 2-inch diameter tenon top for mounting the antenna.

   c. All antenna mounting components and hardware shall be galvanized or stainless steel. Aluminum antenna shall be anodized.

   d. Lightning suppressors shall be furnished on antenna coaxial feed lines.

   e. Antenna mast shall be the height as specified on the drawings, tapered tenon mount by U.S. Pole.

F. **<u>Ethernet to Serial Converter/Bridge</u>**

1. Manufacturer of the Ethernet to serial converter bridge, RS 232 or RS485/422 converter to Ethernet, with hardware handshaking shall be Lantronix, Model

XSDR22000-01, with industrial application protocols, with Modbus Protocol option, no equal.

G. **Ethernet Switch, Unmanaged, 8 Ports**

1. Manufacturer of the Ethernet 8 port switch shall be Phoenix Contact, FL Switch 8 TX, Model 2832218, no equal.

H. **Ethernet Switch, Managed, 4 Ports**

1. Manufacturer of the Ethernet 4 Port, 4 x 10/100Base-T(X) Copper RJ45 Ports, auto-crossing auto-negotiating, auto-polarity shall be Hirschmann, model number RS20-0400T1T1SDAE Managed Industrial Ethernet Switch, no equal.

I. **Ethernet Switch, Managed, 8 Ports**

1. Manufacturer of the Ethernet 8 Port, 8 x 10/100Base-T(X) Copper RJ45 Ports, auto-crossing, auto-negotiating, auto-polarity shall be Hirschmann, model number RS20-0800T1T1SDAE Managed Industrial Ethernet Switch, no equal.

J. **Ethernet Switch, Managed, 16 Ports**

1. Manufacturer of the Ethernet 16 Port, 10/100 Base TX, TP cable, RJ45 Socket, auto-crossing, auto-negotiating, auto-polarity shall be Hirschmann, Model RS20-1600T1T1SDAE, no equal.

K. **Ethernet Switch, Managed, 16 Ports, with Fiber Optic Cable Connections**

1. Manufacturer of the Ethernet 14 Port, 10/100 Base TX, TP cable, RJ45 Socket, auto-crossing, auto-negotiating, auto-polarity, with 2 x 100BASE-FX, Multimode Fiber Optic, SC sockets shall be Hirschmann, Model RS20-1600M2M2SDAE, no equal.

L. **Ethernet Router**

1. Ethernet router with four interfaces. Ports shall be 10/100 Ethernet copper.

2. Ethernet router shall be manufactured by RuggedCom, Model RX1000-F-DP-24-HI-XX-XXTX01-TX01-XXX-XXX, no equal.

M. **Ethernet Line Driver**

1. Ethernet line driver for Ethernet signal over private copper cable.

2. Ethernet line driver shall be provided in pairs. One device shall be located in the local panel. The other device shall be provided to the District for installation a remote location.

3. Ethernet extender shall be as manufactured by Patton Industries, model 2156, no equal.

N. **Ethernet Port for Control Panel Door**

1. An Ethernet port, with power receptacle, shall be door mounted for Ethernet connectivity at control panel.

2. Ethernet port, Cat 5E.

3. Power receptacle, 120 VAC, 15A.

4. Ethernet port and power receptacle shall be as manufactured by Grace Engineered Products, model P-R2-F2R3, or equal.

O. **Phone Company Analog Dial-up Modem**

1. Manufactured by MultiTech, model MT2834BL, no equal.

P. **Phone Company Digital Leased Line CSU/DSU (ADN Line)**

1. Digital leased line CSU/DSU shall be as manufactured by Adtran, Model shall be NetVanta 3200-56, with dialup option, and with RJ45 Interface, no equal.

2. Field station digital leased line CSU/DSU shall be as manufactured by Adtran, Model # DSU 5600 CSU/DSU, Adtran part no. 1200078L1, with RS-232 Interface option, and with RJ48S (RJ-45) Line Interface option, no equal.

Q. **PLC Communications Bridge Multiplexer**

1. Manufactured by Modicon, model NW-BM85C002 for 120 volt AC or 24 volt DC applications, no equal.

R. **PLC Communications Modbus Plus Cable**

1. Modbus Plus network cable shall be Belden, Model # 9841, no equal.

S. **Video Camera**

1. Ethernet based Video camera shall be outdoor pan and tilt IP based camera.

2. Camera shall have 18x motor driven optical zoom, and a 4x digital multiplier.

3. The camera shall be housed in a weather proof dome with an automatic heater and blower.

4. Camera shall include pan, tilt and zoom functions and shall be controlled automatically via a server.

5. The camera shall accept contact closures from auxiliary security or process monitoring devices to initiate automatic views and video recording.

6. The camera shall include on-board memory storage for up to 750 frames of video.

7. Video camera shall be manufactured by Industrial Video and Control, Model PTZ-3330-01, no equal.

PART 3 – EXECUTION

A. <u>900 MHz Non-licensed Ethernet Radios</u>

1. Install radio and antenna equipment according to manufacturer's instructions. Provide connectors and inter-connecting cables to provide a fully functioning system.

2. Provide to IRWD, for installation by IRWD, a matching set of equipment, radio and antenna, required at the receiving station location as shown on the drawings.

B. <u>Antenna</u>

1. Provide antenna type as shown on the drawings.

2. Provide antenna mast, style and height as shown on the drawings.

3. Antenna type, and mast style and height will be determined by IRWD based on radio system requirements and site aesthetic requirements.

4. Provide antenna cable with connectors installed on cable by manufacturer.

5. Contractor shall hire the following company to test the completed antenna installation:

   Total Telco Systems
   602 W. Southern Ave.
   Orange, CA 92685
   Contact: Eric Larsen

6. Antenna testing shall be as follows:
   a. Test antenna cable installation.
   b. Test antenna and cable installation.

C. <u>Buried Cable Line Driver</u>

1. Provide a line driver (modem) for a PLC to communicate over IRWD owned buried cable.

2. Install line driver equipment according to manufacturer's instructions. Provide connectors and inter-connecting cables to provide a fully functioning system.

3. The Line Driver (modem) shall provide an Ethernet interface.

4. Connect the line driver an Ethernet switch.

5. Provide to IRWD, for installation by IRWD, matching line driver components required at the receiving station location as shown on the drawings.

D. Phone Company Digital Leased Line CSU/DSU (ADN Line)

1. Provide a pair of CSU/DSU's for a PLC to communicate over telephone company digital leased line from the field location to the IRWD Operations Center SCADA Central Computers as shown on the drawings.

2. Provide a Field location CSU/DSU for the PLC at the local facility. Locate the CSU/DSU in the PLC control panel.

3. Install CSU/DSU equipment according to manufacturer's instructions. Provide connectors and inter-connecting cables to provide a fully functioning system.

4. The CSU/DSU output shall be ethernet protocol. Connection shall be RJ-45 interface.

5. Connect the CSU/DSU to the PLC communications equipment to provide a working system as shown on the drawings.

6. If conversion to serial protocol is required, provide an ethernet to serial converter per this specification.

7. Provide to IRWD, for installation by IRWD, the matching Master CSU/DSU components required at the IRWD Operations Center for the SCADA Central Computers, as shown on the drawings.

E. Dial-Up, Back-Up Communications Modem

1. Provide a dial-up phone line modem for back-up PLC communications as shown on the drawings.

2. Install dial-up communications modem equipment according to manufacturer's instructions. Provide connectors and inter-connecting cables to provide a fully functioning system.

3. The modem shall provide a RS-232 interface and will provide 4,800 baud communications.

4. Connect the back-up modem to a Modicon Bridge Mux which is connected to the PLC, or as shown on the drawings.

END OF SECTION

SECTION 17360: FIBER-OPTIC DATA TRANSMISSION SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

This section describes requirements for materials, testing, and installation of fiber-optic data transmission system.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. General Instrumentation Control Requirements: 17000.

B. PLC's & Programmable Operator Interfaces: 17300.

1.03 DESIGN BUILD TEAM SUBMITTALS

A. General: Shop drawings shall be submitted in conformance with the requirements of Sections 01300, 17000, and 17400.

B. System Drawings: The following information shall be submitted:

1. Communications system block diagram.

2. Details of connector installations.

3. Details of cable installation and cable entrance into and terminations inside enclosures.

PART 2 - MATERIALS

2.01 DESIGNATIONS OF COMPONENTS

In these specifications and on the plans, all systems and other elements designated by numbers, as derived from criteria in ISA standards. The nomenclature and numbers designated herein and on the plans shall be employed exclusively throughout shop drawings, data sheets, and the like. Any other symbols, designations, and nomenclature unique to a manufacturer's standard methods shall not replace those prescribed above, as used herein, and on the plans.

2.02 GENERAL

A. Current Technology: All data communication equipment and materials shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise required to match existing equipment.

B. Transmission Media: All transmission media, including connectors, patch panels, etc., shall be manufactured by a single manufacturer and shall include a manufacturer 15-year extended product warranty. Approved manufacturers include Lucent Technologies or equal.

C. Equipment to be utilized indoors shall be rated for continuous operation under ambient environmental conditions of 0°C to 50°C (32°F to 122°F) and 10% to 95% relative humidity, noncondensing. Fiber-optic cables to be utilized indoors shall be rated for continuous operation under ambient environmental conditions of -40°C to 70°C (-40°F to 158°F). Under this requirement fiber cables shall be rated higher than electronics and other equipment to ensure the use of quality performing fibers with minimal performance variation due to temperature fluctuation.

2.03 INDOOR FIBER-OPTIC CABLE

A. The indoor fiber-optic cable shall contain eight optical fibers. Cable fibers shall not be stranded but shall lay parallel to each other within the cable. The cable shall be jacketed with a PVC sheathing material. Aramid yarn strength members shall cover the fibers and fill the remaining cable space, without a central strength member and with no metallic elements, to preserve the intrinsic strength of the glass. Cables may not contain ripcords that may potentially damage fibers. All cables shall be from the same manufacturer, of the same cable type, and of the same size. Each fiber shall be continuous with no factory splices.

B. Optical conductors shall be multimode, graded index, solid glass waveguides with a fiber tensile rating of 100 kpsi and a numerical aperture of 0.275 ±0.015. Each fiber shall have a nominal core diameter of 62.5 μm ±3 μm. The outside diameter of the glass clad fiber shall be nominally 125 μm ± 1 μm and shall be concentric with the fiber core, with a core/cladding concentricity error ≤3.0 μm. Fibers shall have a protective 250 μm ±15 μm coating to ensure color retention, minimize microbending losses and improve handling. The coating shall be mechanically strippable. Each fiber shall be protected by a 900 μm (890 μm ±50 μm) color coated PVC buffer. Fibers shall have a minimum bending radius of 0.75 inch (1.9cm). Fibers shall have dual wavelength capability with transmission windows centered at 850 nm and 1300 nm wavelengths. The attenuation at 850 nm shall be 3.4 dB/km or less. The attenuation at 1300 nm shall be 1.0 dB/km or less. The minimum bandwidth shall be 200 MHz-km at 850nm and 500 MHz-km at 1300 nm. Fibers must comply with EIA/TIA specifications.

C. Cables shall be rated to withstand an installation tensile load of not less than 1110 N (250 pounds) as defined under EIA/TIA FOTP-33.

D. Crush resistance as defined under EIA/TIA FOTP-41 shall be ≤0.2 dB added. Cables shall be rated for a minimum bending radius of 20 times cable diameter during installation and 10 times cable diameter after installation.

E. The indoor fiber-optic cables shall be Lucent Technologies Series LGBC or equal.

2.04 OUTDOOR FIBER-OPTIC CABLE

A. The outdoor fiber-optic cable shall contain eight optical fibers. Cable fibers shall not be stranded but shall lay parallel to each other within the cable. The cable shall be jacketed with a PVC sheathing material. Aramid yarn strength members shall cover the fibers and fill the remaining cable space, without a central strength member and with no metallic elements, to preserve the intrinsic strength of the glass. Cables may not contain ripcords that may potentially damage fibers. All cables shall be from the same manufacturer, of the same cable type, and of the same size. Each fiber shall be continuous with no factory splices.

B. Optical conductors shall be multimode, graded index, solid glass waveguides with a fiber tensile rating of 100 kpsi and a numerical aperture of 0.275 ±0.015. Each fiber shall have a nominal core diameter of 62.5 μm ±3 μm. The outside diameter of the glass clad fiber shall be nominally 125 μm ±1 μm and shall be concentric with the fiber core, with a core/cladding concentricity error ≤3.0 μm. Fibers shall have a protective 250 μm ±15 μm coating to ensure color retention, minimize microbending losses and improve handling. The coating shall be mechanically strippable. Fibers shall have a minimum bending radius of 0.75 inch (1.9cm). Fibers shall have dual wavelength capability with transmission windows centered at 850 nm and 1300 nm wavelengths. The attenuation at 850 nm shall be 3.4 dB/km or less. The attenuation at 1300 nm shall be 1.0 dB/km or less. The minimum bandwidth shall be 200 MHz-km at 850nm and 500 MHz-km at 1300 nm. Fibers must comply with EIA/TIA specifications.

C. Cables shall be rated to withstand an installation tensile load of not less than 1110 N (250 lb) as defined under EIA/TIA FOTP-33.

D. Crush resistance as defined under EIA/TIA FOTP-41 shall be ≤0.2 dB added. Cables shall be rated for a minimum bending radius of 20 times cable diameter during installation and 10 times cable diameter after installation.

E. The outdoor fiber-optic cables shall be Lucent Technologies Series LXE-Metallic Sheath-3DSX or equal.

2.05 PATCH PANELS

Patch panels finish color shall be the manufacturer's standard, unless otherwise indicated. Patch panels may be rack or wall mounted. Provide a minimum of 24 fiber connection points. Each patch panel shall include an area for spare cable and splice trays. Provide a patch panel at each cabinet with fiber-optic cable. Mount patch panel on back or side subpanel.

2.06 FIBER-OPTIC CONNECTORS

Fiber-optic connectors shall be the straight tip (ST type), bayonet style, field installable, self-aligning and centering. Fiber-optic connectors shall match the fiber core and cladding diameters. The connector coupler shall be nickel plated, and the alignment ferrule shall be ceramic. The connector shall have a short boot for strain relief. Fiber-optic equipment and cable shall use the same type connectors for correct mating. Connector insertion loss shall not exceed 0.3 dB. Connectors must be capable of mounting on either 0.9 mm buffered fiber or 3.0 mm cordage. The connector shall be Lucent Technologies Series ST II or equal.

2.07 FIBER PATCH CORDS

Fiber patch cords shall consist of buffered, graded-index fiber with a 62.5 μm core and a 125 μm cladding consistent with all fiber properties noted under Part 2.C.2. The fiber cladding shall be covered by aramid yarn and a jacket of flame-retardant PVC. Duplex fiber jumpers/patch cords with a factory installed connectors and a tension rating of 888 N (200 pounds) on the cordage shall be provided. Cable retention shall be 220 N (50 pounds) minimum, and connection repeatability shall yield 0.20 dB maximum change per 100 reconnects with ST connectors attached. Factory produced patch cords shall be of cordage sized at 3.0 mm and utilize straight tip (ST) connectors that provide a pull-proof nonoptical disconnect feature. The patch cords shall be Lucent Technologies Series FL2EP-EP or equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Execution requirements of Section 17000 apply to the work of this section.

B. All system components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. Conduits shall be used for installation of fiber-optic cables. Each fiber-optic cable entering a PLC cabinet shall be terminated at a patch panel. Interfacing between a fiber-optic cable and a PLC fiber-optic communications module shall be through a patch panel.

C. A short cable slack of 10 feet minimum for repair shall be provided for all fiber-optic cable segments (FOCS) longer than 100 feet.

D. All necessary interconnections, services, and adjustments required for a complete and operable data transmission system shall be provided as shown on the drawings. The Design Build Team shall verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber-optic data transmission system. Prior to formal acceptance testing, field tests shall include a power attenuation test and a gain margin test. These tests shall be performed on each link and repeated from the opposite end of each link.

1. Power attenuation test shall be performed at the light wavelength of the transmitter to be used on the circuit being tested. The flux shall be measured at the receiver end and shall be compared to the flux injected at the transmitter end. There shall be a jumper added at each end of the circuit under test so that end connector loss shall be validated. Rotational optimization of the connectors will not be permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory and shall be examined to determine the problem. The IRWD shall be notified of the problem and what procedures the Design Build Team proposes to eliminate the problem. The Design Build Team shall prepare a report documenting the results of the test to be submitted to the Engineer.

2. The Design Build Team shall test and verify that each circuit has a gain margin which exceeds the circuit loss by at least 6 dB.

END OF SECTION

<u>SECTION 17500: UNINTERRUPTIBLE POWER SUPPLY</u>

PART 1 - GENERAL

A. <u>Description</u>

This section includes materials and installation of a complete uninterruptible power supply system for critical loads including but not limited to programmable logic controllers, instrumentation and telemetry systems.

B. <u>Related Work Specified Elsewhere</u>

1. General Electrical Requirements: 16010

2. Instrumentation and Control System: 17000

C. <u>Submittals</u>

1. Submit shop drawings in accord with the General Provisions and Section 16010.

2. Submit ratings and characteristics including voltage, connection, enclosure type and dimensions, and conduit entry restrictions.

PART 2 - MATERIALS

A. <u>General Requirements</u>

1. The UPS system shall be designed to protect the PLC, instruments, and telemetry system from line disturbance, subcycle power losses, and power outages. In normal operation the UPS shall supply filtered and regulated ac power to the load. Upon failure of the commercial ac power, the critical load shall continue to be supplied by the inverter, which shall obtain its power from the battery.

2. The interruption to the critical load upon failure or restoration of the commercial ac source shall not exceed 4 milliseconds. Upon restoration of the commercial source, the inverter/charger shall recharge the battery.

3. A manually operated switch shall be provided to transfer the load to the bypass line with a safety interlock to prevent the load from being transferred back during servicing.

B. <u>Uninterruptible Power Supply Unit</u>

1. The UPS shall be complete with power indication, common alarm dry contact, running status dry contact and inverter circuit breaker protection.

2. External batteries shall be sealed leak proof and maintenance free, and mounted adjacent to the UPS main unit.

3. The UPS unit shall be mounted in a freestanding cabinet provided by the manufacturer.

4. The UPS system shall meet the following requirements:

   a. Input/output voltage: 120 volts ac, single phase, 60 Hz.

   b. Minimum output rating:

      (1) Pressure Reducing Valve Telemetry Cabinets: 500 VA

      Other Facilities: 1.15 KVA.

      Provide higher rating as required based on specified equipment and minimum operating time requirement (see below for time requirement).

   c. Output Harmonic Distortion: 5 percent maximum at full load.

   d. Frequency stability: +/- 0.5 percent.

   e. Voltage regulation for line and load: +/-2 percent.

   f. Overload capacity: 125 percent for 3 seconds.

   g. Full recharge time: 48 hours.

   h. Battery lifetime: 3 years at ambient temperature 45º C.

   i. Isolation/maintenance bypass switch.

5. The UPS system shall be capable of delivering power to the connected load for the minimum time duration listed below:

   a. Reservoir Facilities: 8 hours

   b. Pump Stations with safety equipment (Chlorine leak monitoring, etc.), or with telemetry equipment that communicates status of a reservoir facility or safety equipment information to the SCADA system: 24 hours

   c. Pump stations with no safety equipment: 2 hours

   d. Other facilities not listed: 2 hours, or as specified on the drawings.

6. The UPS system shall be "FERRUPS" as manufactured by BEST Power Technology only, no equal.

PART 3 - EXECUTION

A. General

1. Install the UPS system in the designated location according to manufacturer's instructions.

B. UPS Status Monitoring

1. Install wiring from the UPS to the facility PLC. Status contacts internal to the UPS shall be connected to the PLC as follows:

   a. UPS Normal/UPS On Battery: This contact shall be closed when the UPS is running in Normal mode (line power), and open when the UPS is running in Battery mode (battery power).

   b. UPS Alarm: This contact shall be closed when the UPS is normal, and open when the UPS is in an alarm state.

B. Terminal Blocks

1. Wiring for external circuits, including the alarm contact, shall be brought to grouped terminal blocks located for convenient connection. Provisions shall include suitable marked terminal blocks for connection of 12 AWG copper wire. Terminal designations shall agree with the manufacturer's wiring diagram.

C. Functional Tests

1. Upon installation of the UPS system, the supplier shall conduct on-site functional testing which shall include a minimum of 10 transfer-retransfer cycles. The UPS supplier shall inform the Owner and Engineer of the onsite test schedule so that the test may be witnessed by the Owner and Engineer.

END OF SECTION