Wickenburg High School
Lift Station and Forcemain

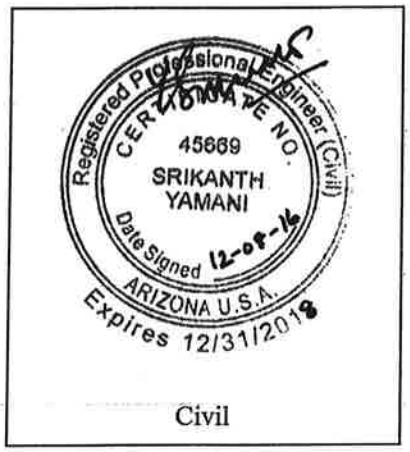
TECHNICAL SPECIFICATIONS

Wilson Project No. 16-008

December 2016

TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS
FOR
WICKENBURG HIGH SCHOOL
LIFT STATION AND FORCEMAIN



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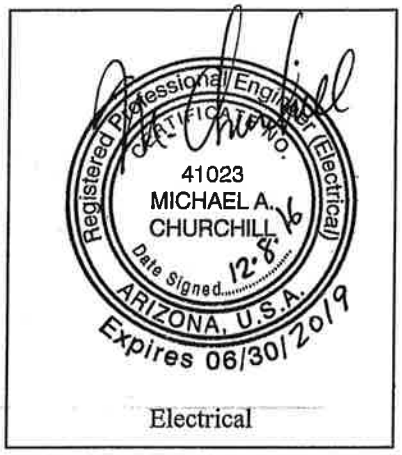

Electrical

DIVISION 1 GENERAL REQUIREMENTS

END OF TABLE OF CONTENTS

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

A. The Work to be accomplished under these Contract Documents consists of furnishing all labor, materials and equipment for the construction of the Wickenburg High School Lift Station and Forcemain to be complete and ready for use in accordance with the Contract Documents.

B. The CONTRACTOR shall be responsible for site and personnel safety during all phases and all aspects of construction.

C. The Work includes, but is not limited to, the following principal unit processes and structures as shown and specified in the Contract Documents:
   1. All yard piping as shown and specified in the Contract Documents.
   2. Sanitary sewer piping and manholes to connect wastewater flows to proposed wastewater lift station.
   3. Wastewater lift station with precast concrete wetwell lift station enclosure consisting of self priming pumps, motors, valves, control panel and appurtenances as specified in the Contract Documents.
   4. Discharge piping (forcemain) to connect/ the lift station to the Town of Wickenburg's municipal sewage collection systems.
   5. Perimeter chain link fence with access gate.
   6. Electric equipment, instrumentation, autodialer, conduit, wiring and appurtenances as shown and specified in the Contract Documents.
   7. Standby power to be provided by a portable generator supplied by the Town of Wickenburg. The lift station will include a cable connection from the generator and a manual transfer switch.
   8. Coordination and notification with all affected governmental, public agencies, and utility companies.
   9. Secure and close all applicable permits.
   10. All other miscellaneous items of Work specified in the Contract Documents.

1.2 ACCESS TO AND FROM THE SITE

A. Wickenburg High School is located at 1090 S Vulture Mine Rd, Wickenburg, AZ 85390.

1.3 COORDINATION WITH EXISTING UTILITIES

A. Various utilities, including, but not limited to, potable water pipes, sanitary sewer, electrical duct banks, communications cables, drainage channels, and associated structures are in existence on the construction site.

B. Where required by the Contract Documents the CONTRACTOR shall make connection to proposed or existing utilities.

C. The CONTRACTOR shall connect to existing utilities without disrupting or interrupting the operation of the services of the existing utilities.

D. The existing utilities shall be assumed to be in service at the time the CONTRACTOR makes connection.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01013

ENGINEERING SERVICES

PART 1 - GENERAL

1.1 SUMMARY

A. The Work to be accomplished under these Contract Documents has been designed for the OWNER by a registered Professional Engineer, retained by the OWNER for this purpose. It is understood that normal engineering for the purpose of interpretation of the Contract Documents is provided by the OWNER. Should any services of the ENGINEER be required to assist in the corrections of errors or omissions in construction by the CONTRACTOR, or services of the ENGINEER be required because of changes in structure or equipment where the CONTRACTOR has requested approval of substitute methods or materials, those services will be provided by the ENGINEER at the standard hourly rates previously negotiated with the OWNER and shall be paid for by the CONTRACTOR. Other services shall be described further in this Section.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 ENGINEERING SERVICES

A. The ENGINEER shall be reimbursed by the CONTRACTOR for the ENGINEER'S additional services to the Project through no fault of the OWNER or ENGINEER including, but not limited to, the following conditions:
   1. Additional Shop Drawing review(s) by the ENGINEER as described in Section 01300, Submittals.
   2. Additional site visits, investigations, inspections, design work and/or reports by the ENGINEER which are required due to damages to existing facilities or completed Work caused by the CONTRACTOR in his performance, the CONTRACTOR'S negligence, or the CONTRACTOR'S work which is rejected as defective or as failing to conform to the Contract Documents. An hourly rate of three times the direct labor cost, but not less than $125/hour, will be charged to the CONTRACTOR for every hour of additional engineering personnel time required.
   3. All retesting required due to the failure of the CONTRACTOR'S work to meet the requirements of the Contract Documents shall be at the CONTRACTOR'S expense.

4. The ENGINEER shall bill the OWNER for additional Engineering Services performed as described in these Documents. The OWNER shall withhold payment for this from the CONTRACTOR'S final payment. A Change Order shall be executed deleting the amount due from the Contract sum and final payment.

END OF SECTION

SECTION 01025

MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Payment for the completion of the Work performed by the CONTRACTOR under these Contract Documents shall be made at the approved Contract agreement lump sum price for each of the Bid Items listed in the Schedule of Values and further broken down as listed in the Schedule of Values. Such payment shall compensate the CONTRACTOR for all materials and labor incorporated into the Work in accordance with the Drawings and other Contract Documents.

B. The Bid Items listed under the Schedule of Values herein refer to and are the same pay items listed in the Bid Form. They constitute all of the pay items for the completion of the Work. No direct or separate payment shall be made for providing miscellaneous temporary or accessory works or all other requirements of the General Conditions, Supplementary Conditions, and the Contract Requirements. Compensation for all such services, items and materials shall be included in the prices stipulated for the lump sum and unit price pay items listed herein.

C. The lowest bidder will be determined based on the total bid amount for all Schedule of Values items (Bid Items 1 through 28 herein) regardless whether the OWNER deletes a bid item before or after award of the contract. The OWNER reserves the right to deduct or delete any of the bid items from the contract before or after award of the contract. The contact price deduction shall include costs for overhead and profit that would have been associated with the deleted item(s).

D. In the event the OWNER deducts and deletes an Item from the contract, the amount listed by the bidder as the Lump Sum unit price for such item shall be deducted from the contract and no other changes will be made to the Contract price on account of such deduct.

1.2 MEASUREMENT

A. Measurements of the completed Work will be made in place, with no allowance for waste.

B. Measurements of distances will be made in a horizontal plane, unless otherwise stated.

C. Measurements of areas will be made in a horizontal plane, unless otherwise stated. Widths of pavement removal areas and trenching will be measured based on Maricopa

County Association of Governments (MAG) limits, regardless of construction techniques used.

D. Each bid item shall include all Work including all labor, materials, equipment and appurtenances necessary to complete the construction in a satisfactory manner of said bid item for the satisfactory use and operation of said item as shown and specified in the in a satisfactory manner Contract Documents.

1.3 SCHEDULE OF VALUES

A. The following are descriptions of all the Bid Items which includes all of the Work for the Project.
   1. Bid Item No. 1 – "General Requirements" shall be paid for at the contract lump sum price and shall include compensation for the cost to complete all Work specified in Division 1 of the technical specifications. Items shall include mobilization and demobilization of CONTRACTOR'S construction equipment and personnel, temporary facilities required to complete the Project, including the CONTRACTOR'S storage yard, field office, construction photographs, permits, insurance, bonds, coordination, utility services, clean-up, record drawings, progress schedules, any design services specified or required to execute CONTRACTOR'S construction means and methods, and all other incidental and appurtenant work not specifically specified in other paragraphs of this Section.
   2. Bid Item No. 2 – "Site Work" shall be paid for at the contract lump sum price and shall include compensation for the cost to complete all work for chainlink fence, gate, and work specified in Division 2 of the technical specifications, and all other incidental and related appurtenances required to complete the site work.
   3. Bid Item No. 3 – "Sanitary Sewer" shall be paid for at the contract lump sum price and shall include compensation for the cost of the sewer piping, manholes, and all incidental and related work required to complete sanitary sewer work.
   4. Bid Item No. 4 – "Wastewater lift Station" shall be paid for at the contract lump sum price and shall include compensation for the cost of the precast concrete wetwell. enclosures, wetwell, self-priming pumps, valves, piping, control panel and appurtenances and all incidental work required to complete the forcemain work.
   5. Bid Item No. 5 – "Forcemain" shall be paid for at the contract lump sum price and shall include compensation for the cost of discharge piping, fittings, air release valves and other appurtenances required to complete the forcemain work.
   6. Bid Item No. 6 – "Electrical" shall be paid for at the contract lump sum price and shall include compensation for the cost in connection with installation of on-site power distribution, measurement and control systems, all electrical panels connections and wiring, switches, instrumentation, autodialer, manual transfer switch and all incidental and appurtenant work to complete the item and as specified in the Contract Documents.
   7. Bid Item No. 7 – "Miscellaneous work items" shall be paid for at the contract lump sum price and shall include compensation for all costs associated with installing all miscellaneous work items shown on the drawings and specified herein and not

included in the previous bid items but necessary to complete the work identified on the Drawings and specified herein.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01040

COORDINATION

PART 1 - GENERAL

1.1 SUMMARY

A. The CONTRACTOR will be required to coordinate his activities with the pertinent utilities, OWNER'S staff, subcontractors, and equipment suppliers in order not to delay the CONTRACTOR'S Project Schedule and to minimize the disruption to treatment operation throughout the construction period.

1.2 SEQUENCING AND SCHEDULING

A. CONTRACTOR shall submit to the ENGINEER and OWNER a construction schedule.

B. The CONTRACTOR shall be responsible for coordinating in a timely manner with pertinent utility companies to avoid conflicts with their facilities.

C. The CONTRACTOR shall receive approval of the construction schedule prior to commencement of Work.

D. The CONTRACTOR shall be responsible for coordinating Work among all subcontractors as necessary.

E. The CONTRACTOR shall be responsible for all construction coordination necessary so that the Project may remain on schedule.

F. The CONTRACTOR shall coordinate the following with the OWNER and ENGINEER:
   1. Testing.
   2. Inspections.
   3. Starting of Systems.
   4. Operations and Maintenance Training.
   5. Commissioning.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01050

FIELD ENGINEERING/SURVEYING

PART 1 - GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall hire a surveyor licensed in the State of Arizona to topographically survey the Project site to confirm the baseline conditions. It is also the CONTRACTOR'S responsibility to notify the ENGINEER of any discrepancy found between the topographic survey provided and the baseline conditions provided in the Contract Documents within 14 days of the Notice to Proceed in writing. The CONTRACTOR further takes the responsibility to correct any discrepancies not reported to the ENGINEER within the specified construction schedule as part of the finished grading required as part of this Project at no cost to the OWNER.

B. The licensed surveyor shall also fulfill construction staking requirements and responsibilities as specified in the General Conditions. A list of coordinates for structure and pipelines are included on civil sheets of the Drawings. Dimensions for site, grading, and piping layout are included on the Contract Drawings.

C. The CONTRACTOR shall provide competent, qualified personnel and materials required to perform all construction layout staking of the Work and will protect and preserve the established reference points and will make no change or relocations without the prior written approval of the OWNER.

D. The CONTRACTOR will report to the OWNER whenever any reference point is lost or destroyed or requires relocation because of necessary changes in grades or locations. The CONTRACTOR will replace and accurately relocate all reference points lost, destroyed, or moved.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01090

REFERENCE STANDARDS/ABBREVIATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section lists many of the construction industry organizations, professional and technical associations, societies and institutes, and government agencies issuing, promoting, or enforcing standards to which references may be made in the Contract Document along with the abbreviations commonly used for those references. Also included are certain general requirements for the use of industry standards specified and for application of the standards in quality control.

1.2 USE OF REFERENCE STANDARDS

A. Work specified by reference to the published standard or specification of a government agency, technical association, trade association, professional society or institute, testing agency, or other organization shall conform to or surpass the minimum standards of quality for materials and workmanship established by the designated standard or specification.

B. Where so specified, products or workmanship shall also conform to the additional prescriptive or performance requirements included within the Contract Documents to establish a higher or more stringent standard of quality than that required by the referenced standard.

C. Where the specific date or issue of the standard is not included with the reference to the standard, the edition, including all amendments published and available on the first published date of the Invitation to Bid, shall apply.

D. Where two or more standards are specified to establish quality, the product and workmanship shall conform to or surpass the requirements of both.

E. In case of conflict between referenced standards, the more stringent shall apply.

F. Where both a standard and a brand name are specified for a product in the Contract Document, the proprietary product named shall conform to or surpass the requirements of the specified reference standard. The listing of a trade name in a Contract Document shall not be construed as warranting that such product conforms to the respective reference standard.

G. Copies of Standards:

1. Copies of applicable referenced standards have not been bound in this Contract Document.
2. Where copies of standards are needed by the CONTRACTOR for superintendence and quality control of the Work, obtain a copy or copies directly from the publication source and maintain in an orderly manner at the job site, available to the CONTRACTOR'S personnel, subcontractors, OWNER, and ENGINEER.
3. Submittals: Submit for approval the requests to use products conforming to printed standards or publications with a different publication date from that effective under the Contract. Clearly indicate the changes in product or workmanship quality involved in the proposed change, if any, and reasons for the request.

1.3 ABBREVIATIONS

A. Abbreviations for trade organizations and government agencies. The following is a list of construction industry organizations and government agencies to which references may be made in the Contract Document, with abbreviations used.

AA	Aluminum Association
AAMA	American Architectural Manufacturers Association
AAMA	Architectural Aluminum Manufacturers' Association
AASHTO	American Association of State Highway and Transportation Officials
ABPA	Acoustical and Board Products Association
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
AFBMA	Anti-Friction Bearing Manufacturers' Association
AGA	American Gas Association
AGC	Associated General Contractors
AGMA	American Gear Manufacturers' Association
AHC	Architectural Hardware Consultant
AI	Asphalt Institute
AIA	American Institute of Architects
AIA	American Insurance Association
AIEE	American Institute of Electrical Engineers
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ALS	American Lumber Standards
AMCA	Air Moving and Conditioning Association
AMG	Arizona Masonry Guild
ANSI	American National Standards Institute
APA	American Plywood Association

API	American Petroleum Institute
AREA	American Railway Engineering Association
ARI	Air Conditioning and Refrigeration Institute
ARMA	Asphalt Roofing Manufacturers Association
ASAE	American Society of Agricultural Engineers
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers' Association
AWPB	American Wood Preservers Bureau
AWPI	American Wood Preservers' Institute
AWS	American Welding Society
AWSC	American Welding Society Code
AWI	Architectural Woodwork Institute
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers' Association
BIA	Brick Institute of America
CBMA	Certified Ballast Manufacturers' Association
CDA	Copper Development Association
CGA	Compressed Gas Association
CISPI	Cast Iron Soil Pipe Institute
CLFMI	Chain Link Fence Manufacturer's Institute
CMAA	Crane Manufacturers' Association of America
CRA	California Redwood Association
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standards
CSI	Construction Specifications Institute
CTI	Cooling Tower Institute
FGMA	Flat Glass Manufacturer's Association
FIA	Factory Insurance Association
FM	Factory Mutual
FS	Federal Specification
FTI	Facing Tile Institute
GA	Gypsum Association
HI	Hydraulic Institute
HMI	Hoist Manufacturers' Institute

IBC	International Building Code
ICBO	International Conference of Building Officials
ICEA	Insulated Cable Engineers' Association
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IES	Illuminating Engineering Society
IFC	International Fire Code
IFGC	International Fuel Gas Code
IMC	International Mechanical Code
IPC	International Plumbing Code
ISA	Instrument Society of America
JIC	Joint Industry Conferences of Hydraulic Manufacturers
LIA	Lead Industries Association
MAG	Maricopa Association of Governments
MIA	Marble Institute of America
MIA	Masonry Institute of America
MLMA	Metal Lath Manufacturers Association
MS	Military Specifications
MMA	Monorail Manufacturers' Association
NAAMM	National Association of Architectural Metal Manufacturers
NBFU	National Board of Fire Underwriters
NBHA	National Builders' Hardware Association
NBS	National Bureau of Standards
NCMA	National Concrete Masonry Association
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NESC	National Electric Safety Code
NFPA	National Fire Protection Association
NFPA	National Forest Products Association
NGA	National Glass Association
NHLA	National Hardwood Lumber Association
NKCA	National Kitchen Cabinet Association
NLMA	National Lumber Manufacturers' Association
NMWIA	National Mineral Wool Insulation Association
NTMA	National Terrazzo and Mosaic Association
NWMA	National Woodwork Manufacturers' Association
OECI	Overhead Electrical Crane Institute
OSHA	Occupational Safety and Health Administration (both Federal and State)
PCA	Portland Cement Association
PCI	Precast/Prestressed Concrete Institute

PDI	Plumbing Drainage Institute
PEI	Porcelain Enamel Institute
PS	Product Standards Section - U.S. Department of Commerce
RLM	RLM Standards Institute, Inc.
RMA	Rubber Manufacturers' Association
SAE	Society of Automotive Engineers
SDI	Steel Deck Institute
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturing Association
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SSPC	Steel Structures Painting Council
SWI	Steel Window Institute
TEMA	Tubular Exchanger Manufacturers' Association
TCA	Tile Council of America
TIMA	Thermal Insulation Manufacturers Association
TPI	Truss Plate Institute
UBC	Uniform Building Code
UFC	Uniform Fire Code
UL	Underwriters' Laboratories, Inc.
UPC	Uniform Plumbing Code
USDA	United States Department of Agriculture
USPS	United States Postal Service
VI	Vermiculite Institute
WCLA	West Coast Lumberman's Association
WCLB	West Coast Lumber Bureau
WCLIB	West Coast Lumber Inspection Bureau
WIA	Woodwork Institute of Arizona
WPOA	Western Plumbing Officials Association
WWPA	Western Wood Products Association

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01201

PRE-CONSTRUCTION CONFERENCE

PART 1 - GENERAL

1.1 SUMMARY

A. Date, Time, and Location: Conference will be held after execution of the Contract and before construction is started at the site. The ENGINEER will fix the date, time, and location of the meeting.

B. The CONTRACTOR shall provide data required, contribute appropriate items for discussion, and be prepared to discuss all items on agenda.

1.2 REQUIRED ATTENDANCE

A. The CONTRACTOR and major subcontractors.

B. The OWNER'S representative.

C. The ENGINEER.

D. Representatives of government agencies having any degree of control or responsibility, if available.

E. Representatives of utility companies having any degree of control or responsibility, if available.

1.3 AGENDA

A. Agenda will include, but will not necessarily be limited to, the following:
   1. Designation of responsible personnel.
   2. Subcontractors.
   3. Contract Time.
   4. Coordination and cooperation with other contractors and projects.
   5. Progress Schedule.
   6. Processing of Shop Drawings and distribution of Submittals.
   7. Processing of field decisions and Change Orders.
   8. Requirements for copies of Contract Documents.
   9. Insurance in force.
   10. Schedule of Values.
   11. Processing and Schedule of Payments.
   12. Use of premises.
   13. The CONTRACTOR'S responsibility for safety and first aid procedures.

14. Security.
15. Housekeeping.
16. Field Offices.
17. Record Drawings.
18. Letter of Notice to Proceed.
19. Operation and Maintenance Manuals.
20. Meetings.
21. Temporary Utilities.
22. Permits.
23. Emergency telephone numbers.
24. Any other Project related items.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01202

PROGRESS MEETINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Date and Time:
   1. Regular weekly meetings for the duration of construction or as designated by ENGINEER.
   2. Other Meetings: On call.

B. Place: CONTRACTOR'S field office or mutually agreed upon location.

C. ENGINEER shall prepare agenda, preside at meetings, and prepare and distribute a transcript of proceedings to all parties.

D. CONTRACTOR shall provide data required and be prepared to discuss all items on agenda.

1.2 MINIMUM ATTENDANCE

A. CONTRACTOR, subcontractors and suppliers as required, representatives present for each party shall be authorized to act on their behalf.

B. ENGINEER.

C. Others as appropriate.

1.3 AGENDA

A. Agenda will include, but will not necessarily be limited to, the following:
   1. Summary of previous meeting.
   2. Progress since last meeting.
      a. CONTRACTOR.
      b. Subcontractors.
   3. Planned progress for next period.
   4. Shop Drawings.
   5. Problems, conflicts, and observations.
   6. Change Orders.
   7. Applications for Payment.
   8. Quality standards and control.
   9. Schedules, including status of off-site fabrication and delivery schedules. Corrective measures required.

10. Coordination between parties.
11. Safety concerns.
12. Other business.
13. Next meeting date.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall include a completed transmittal form for all submittals. Submittals shall be sent to the ENGINEER.

1.2 SECTION INCLUDES

A. Shop Drawings.

B. Material and Equipment Record.

C. Samples.

D. Operation and Maintenance Manuals.

E. Equipment Inventory Sheets

F. Progress Schedule.

G. Progress Reports.

H. Daily Reports.

I. Testing Results.

J. Construction Photographs.

K. Record Drawings.

1.3 SHOP DRAWINGS

A. A minimum of eight copies of Shop Drawings are required for submittal. Disposition of the Shop Drawings will be in accordance with the following schedule:

Action by ENGINEER	**Retained by ENGINEER**	**Returned to CONTRACTOR**	**No. Required for Resubmittal**
No Exceptions Noted	5	3	0

Action by ENGINEER	Retained by ENGINEER	Returned to CONTRACTOR	No. Required for Resubmittal
Exceptions Noted	5	3	0
Revise and Resubmit	1	7	8
Rejected	1	7	8
No Action Taken	1	7	0

ENGINEER shall return Shop Drawings to CONTRACTOR within 35 days of receipt by ENGINEER.

B. Only one copy of "Revise and Resubmit" and "Rejected" Shop Drawings will be stamped.

C. If the CONTRACTOR requires more than three copies of "No Exceptions Noted" or "Exceptions Noted" Shop Drawings, additional copies shall be included in original submittal.

D. The CONTRACTOR may request submittals be reviewed up to two times for each equipment or construction material item, regardless of manufacturer or supplier, by the ENGINEER. For additional reviews, CONTRACTOR will reimburse ENGINEER for additional labor as specified in Section 01013, Engineering Services.

E. The CONTRACTOR will be held responsible for any delay in progress of the Work due to resubmittal of Shop Drawings. Time for completion of the Contract will not be extended due to his failure to promptly submit complete and acceptable Shop Drawings, product data and samples.

F. Do not execute Work required by Shop Drawings until accepted Shop Drawings are received from ENGINEER.

G. Before submitting Shop Drawings for review, CONTRACTOR shall check Shop Drawings for accuracy, ascertain that all Work contiguous with and having bearing on other Work shown on Shop Drawings is accurately drawn, and that Work shown is in conformity with Contract requirements. The CONTRACTOR is responsible for all submittals from subcontractors and suppliers.

H. All such Drawings and details, when submitted, must bear the stamp of approval of CONTRACTOR, bearing checked data, as evidence that such Drawings and details have been checked by him. Said "stamp" shall clearly state that the CONTRACTOR has checked the Drawings and, by his signature, he so certifies. Any Drawings submitted without such executed stamp of approval, or whenever it is evident (despite the stamp) that the Drawings have not been checked, they will be returned to the CONTRACTOR for re-submission and will not be considered.

In such event, it will be deemed that CONTRACTOR has not complied with this provision and the CONTRACTOR shall bear risk of all delays to the same extent as if no Drawings or details had been submitted.

I. The CONTRACTOR shall prepare composite drawings and installation layouts, when required to solve tight field conditions. Such Drawings shall consist of dimensioned plans and elevations, and must give complete information particularly as to size and location of sleeves, inserts, attachments, openings, conduits, ducts, boxes, structural interferences, etc. These composite drawings and installation layouts shall be coordinated in the field by the CONTRACTOR and his subcontractors for proper relationship to the work of other trades, based on field conditions, and shall be checked and approved by them before submission to the ENGINEER for his final review. The CONTRACTOR shall have competent technical personnel readily available for such coordinating and checking, as well as for supervision of field installation of Work as per the Drawings and installation layouts, which have been previously determined by him to be correct and carry the ENGINEER'S review stamp.

J. Submission of Shop Drawings (in either original submission or when resubmitted with corrections) constitute evidence that the CONTRACTOR has checked all information thereon, and that he accepts and is willing to perform the Work as shown in a workmanlike manner and in accordance with best standard practice.

K. Cost of any changes in construction due to improper checking and coordination by the CONTRACTOR shall be paid for by the CONTRACTOR, and the CONTRACTOR shall be responsible for all additional costs, including coordination.

L. Shop Drawings shall clearly delineate the following information:
   1. ENGINEER'S name and Project number, Project name and address.
   2. Drawing title, number, date, and scale.
   3. Names of CONTRACTOR, subcontractor, and fabricator.
   4. Working and erection dimensions.
   5. Arrangements and sectional views.
   6. Necessary details, including complete information for making connections with other work.
   7. Kinds of materials and finishes.
   8. Show descriptive names of materials and equipment, classified item numbers, and locations at which materials or equipment are to be installed in the Work. Use same reference identification as shown on Contract Drawings.
   9. The ENGINEER shall provide the CONTRACTOR with a form to accompany the Shop Drawings.

M. If Shop Drawings show variations from Contract Documents because of standard shop practice or other reasons, make specific mention of such variations in Transmittal Form.

N. Shop Drawing review will be general. It shall not relieve the CONTRACTOR of responsibility for accuracy of such Shop Drawings, nor proper fitting, construction of Work, furnishing of materials, or Work required by Contract Documents and not indicated on Shop Drawings. Shop Drawing review shall not be construed as approving departures from Contract Documents.

O. Review of Shop Drawings and schedules shall not relieve the CONTRACTOR from responsibility for any violation indicated on such Drawings or schedules of local, County, State or Federal laws, rules, ordinances, or rules and regulations of commissions, boards or other authorities or utilities having jurisdiction.

P. When product data, consisting of manufacturer's printed literature, is required to be submitted to ENGINEER, it shall be submitted in original form. Any fading type of reproduction will not be accepted.

Q. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

R. CONTRACTOR shall submit soft copies and hard copies per Specification 01300, Submittals. Soft copies shall be in DVD format and shall include all information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

1.4 MATERIAL AND EQUIPMENT RECORD

A. The CONTRACTOR shall maintain an up-to-date record of all materials and equipment furnished by him and any subcontractors to be incorporated in the Work.
   1. The ENGINEER will furnish the CONTRACTOR a master of the materials and equipment form. The CONTRACTOR shall maintain the records on reproductions of this form in the field office.

B. The CONTRACTOR shall provide the following information on these forms:

1. The Specification paragraph and Section number where material or equipment are called for.
2. Date ordered.
3. Date required.
4. CONTRACTOR'S purchase order number.
5. Supplier's purchase order number.
6. Date promised.
7. Date received.
8. Supplier's name and address.
9. Remarks.
10. Shop Drawings and samples with approval date.
11. Physical dimensions and ratings.
12. Other items that shall be submitted with the material and equipment record include performance curves for all pumps and fans. Where submittal sheet describes items in addition to that item being submitted, the submitted item shall be clearly marked on the sheet and superfluous information shall be crossed out.

C. Three copies of the materials and equipment record shall be submitted to the ENGINEER with each application for payment. If the current record has not been submitted, the application shall not be reviewed and shall be returned to the CONTRACTOR as incomplete.

D. The CONTRACTOR shall permit free access to these records, including information on items recently received and not yet posted to the record, by the ENGINEER or authorized representative of the OWNER at any time.

1.5 SAMPLES

A. Deliver no material to the building site prior to receipt of ENGINEER'S written approval. Furnish materials equal in every respect to approved samples and execute Work in conformity therewith. Samples shall be provided with respective Shop Drawings.

B. The approval or acceptance of samples will not preclude the rejection of any material upon the discovery of defects in same prior to the final acceptance of the completed Work.

C. After a material has been approved, no change in brand or make will be permitted unless satisfactory written evidence is presented to, and approved by the ENGINEER that the manufacturer cannot make scheduled delivery of approved material, or that material delivered has been rejected and substitution of suitable material is an urgent necessity, or that other conditions are apparent which indicate approval of such substitute materials to be in best interest of OWNER.

D. All samples of materials requiring laboratory tests shall be submitted to laboratory for testing not less than 90 days before such materials are required to be used in the Work. Submit all other samples for approval within 30 days after signing of the Contract.

E. Submit samples in duplicate, except where greater or lesser number is specifically required by these Specifications. Submittal shall be made only by the CONTRACTOR, unless he has authorized his subcontractor to submit them and has notified the ENGINEER to this effect. Ship all samples prepaid.

F. Samples shall be submitted along with Shop Drawings. Each sample shall be accompanied by a Shop Drawing form and an itemized transmittal form. The transmittal shall contain list of samples, Project, CONTRACTOR, manufacturer, brand, quarry, quality, etc.; also Project number, Specifications reference, ASTM number (if any) and material being furnished. Enclose copies of transmittal with samples. Any deviation from Contract requirements shall be so stated in the transmittal.

G. Label each sample by a securely attached label giving the Project, CONTRACTOR, subcontractor or supplier, manufacturer's name, product trade name and number, material type, Specification Section and Paragraph reference etc.; also Project name and number, and ASTM number (if any).

H. Samples shall be of adequate size to permit proper evaluation. The samples submitted shall show the full range of colors, textures and dimensions, and other variable characteristics expected. Samples of different items that must match or whose finish relates shall be delivered at the same time to facilitate coordination.

I. Samples which are rejected by the ENGINEER must be resubmitted as soon as possible after notification of rejection, and shall be marked "Resubmitted Sample", in addition to other information required.

J. The right is reserved to require submission of samples of any material or any material lists whether or not specifically specified in the Specifications.

1.6 OPERATION AND MAINTENANCE MANUALS

A. Six copies of an Operations and Maintenance (O&M) Manual (including two electronic copies in pdf format) containing the following items, in addition to any instructions packed with the equipment, are required for each individual item of equipment:
   1. Specifications.
   2. Drawings.
   3. Description of each individual item of equipment.
   4. Manufacturer name, model number, and serial numbers.

5. Name address and phone number of both the manufacturer's customer service department and the local manufacturer's representative.
6. Installation instructions.
7. Operation and maintenance instructions, including lubrication schedule and lubricant specification.
8. Parts list.
9. Additional data to be included in the manual shall be as required in these Specifications.
10. Temporary storage recommendations.

B. These manuals are to be submitted to the ENGINEER upon delivery of the equipment to the site. Overall Project substantial completion will not be scheduled until all manuals are approved.

C. The respective manuals for the individual items of equipment shall be combined into bound volumes covering the complete operating installation with individual equipment items tabled separately. Information for equipment subassemblies not manufactured by the major supplier shall also be included with the respective equipment item.

D. The volumes of manuals shall be bound in substantial three-ring binder hardback covers. Labels on the cover and spine of the binders shall indicate the equipment items addressed, each manufacturer's name, Project name, and the year of purchase. Manuals for particular items of equipment, which are in the same area (i.e., mechanical barscreens and screenings conveyor), should be bound in the same volume where practicable.

E. Upon completion of the installation of each item of equipment, the CONTRACTOR shall provide Drawings of the local control panel to be added to the O&M Manual. Manuals for particular items of equipment, which are in the same area (i.e., Belt Press, Belt Press Feed Pumps, and Conveyors), should be bound in the same volume where practicable.

F. All final O&M Manuals shall be scanned and placed into a .pdf document. All .pdf documents shall be placed onto compact discs and inserted into the O&M Manual.

1.7 TESTING RESULTS

A. CONTRACTOR shall furnish to ENGINEER copies of all testing results for all tests required in the Specifications.

1.8 RECORD DRAWINGS

A. CONTRACTOR shall update Record Drawings monthly and submit updated Record Drawings to ENGINEER monthly for review with the pay application.

Failure of CONTRACTOR to maintain updated Record Drawings shall be justification for refusal of pay application.

1.9 SUBMITTALS

A. All additional submittals as required by the Contract Documents.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01310

PROGRESS SCHEDULE

PART 1 - GENERAL

1.1 SUMMARY

A. To assure completion of the Work within the Contract Times established, all activities of the CONTRACTOR shall be scheduled and monitored by use of a CPM (Critical Path Method) Schedule. The CONTRACTOR shall provide a CPM Schedule for Work done under this Contract in accordance with the requirements of this Section and the General Conditions.

B. The CONTRACTOR shall employ or retain services of at least one person experienced in CPM Scheduling for the duration of the Contract. This person shall cooperate with the ENGINEER and shall update the CONTRACTOR'S schedule as required by these Specifications.

C. A preliminary CPM Schedule for the entire Project shall be submitted to the ENGINEER at the Pre-Construction Conference in bar chart forms. The bar chart shall be referenced to time.

D. At the Pre-construction Conference, the CONTRACTOR shall furnish to the ENGINEER a detailed preliminary CPM Schedule in bar chart form showing the CONTRACTOR'S proposed operations for the first four months of the Contract period.

E. The CONTRACTOR shall submit, at the Pre-Construction Conference, a projection of estimated monthly payments through the life of the Contract. Initial projections shall be correlated with and provided at the same time as the Schedule of Values. Projections shall be updated when requested by the ENGINEER.

1.2 DEFINITIONS

A. Unless otherwise noted, terms shall be defined for this Project as follows:
   1. Activity - a component step or operation in the construction of Work.
   2. Event - a point in time during construction of the Work.
   3. Network or Network Diagram - a flow diagram which is a symbolic representation of activities and events that must be performed in accordance with the Contract and which shows the order and interdependence of activities and the sequence in which Work is to be accomplished as planned by the CONTRACTOR.
   4. Earliest Start Date - the earliest date on which an activity can start.
   5. Earliest Finish Date - the earliest date on which an activity can finish without changing the Contract duration.

6. Latest Start Date - the latest date on which an activity can start without changing the Contract duration.
7. Latest Finish Date - the latest date on which an activity can finish without changing the Contract duration.
8. Latest Free Start Date - the latest date on which an activity can start without affecting the scheduling of any other activities.
9. Latest Free Finish Date - the latest date on which an activity can finish without affecting the scheduling of any other activities.
10. Total Float - the number of calendar days by which an activity can be delayed without necessarily extended a pertinent Contract Time. Total Float is by definition at least equal to Contract Float.
11. Contract Float - If the schedule anticipates early completion of all or any part of the Work, Contract Float is the number of calendar days between CONTRACTOR'S anticipated date for early completion of all or any such part of the Work and the corresponding specified Contract Time.
12. Free Float - the amount of time in calendar days by which an activity can be delayed without affecting the scheduling of any other activity.
13. Duration - the amount of time in consecutive calendar days required to perform an activity from the date on which Work commences on the activity to the date on which the activity is complete.
14. Milestone - a significant event such as date of Notice to Proceed, Substantial Completion, Final Completion and specified mandatory completion dates when portions of the Work or site are to be turned over to the OWNER or other contractors.
15. Critical Path - the continuous sequence of activities and events throughout the network that comprises the longest time path through the network from start to finish.
16. Critical Activity - an activity which cannot be delayed without altering the Contract Times.
17. Mandatory Date - the date specified for completion of a Work activity or when other contractors must be permitted to start Work.
18. Sub-network - a network relating to a particular phase, portion, or subdivision of the Work.
19. Arrow Method - that method of network diagram construction in which activities are represented by arrows.
20. Lag - the amount of time between the commencement of an activity and the commencement of an activity which immediately follows it, expressed in the number of calendar days.
21. Lag Factor - the amount of time between the commencement of an activity and the commencement of an activity which immediately follows it, expressed as a percentage of the duration of the first activity.

1.3 SUBMITTALS

A. All CPM Schedules (both original and revisions) submitted shall include four hard copies. Each CPM Schedule submittal shall bear CONTRACTOR'S stamp

or written indication of approval as representative to OWNER that CONTRACTOR has determined or verified all data on that CPM Schedule, and that CONTRACTOR and the subcontractors and suppliers have reviewed and coordinated the sequences in that CPM Schedule with the requirements of the Work.

B. At the Pre-Construction Conference, the CONTRACTOR shall submit to the OWNER and ENGINEER sufficient descriptive information about the CPM software that the CONTRACTOR has chosen to employ in order to comply with the requirements of this Section.

C. Neither the OWNER'S or ENGINEER'S review of a CPM Schedule, nor a statement of "Resubmittal Not Required", will relieve the CONTRACTOR from responsibility for complying with the Contract Times and those sequences of Work indicated in or required by the Contract Documents, or completing any Work omitted from that Progress Schedule within the Contract Times. The CONTRACTOR shall make appropriate adjustments or corrections in a CPM Schedule returned as "Revise and Resubmit" and shall submit to the ENGINEER the corresponding CPM Schedule resubmittal as required herein. CPM Schedule resubmittals shall use the same revision number followed by the letters "A", "B", etc., as applicable.
   1. CONTRACTOR shall submit to ENGINEER with the first Application for Payment, the initial Progress Schedule, and the schedule of Shop Drawing and sample submittals. CONTRACTOR shall correct all schedules returned for revision and resubmission, taking into account comments made by OWNER and ENGINEER and shall resubmit any schedule if directed by ENGINEER. The final revision of the schedule shall be the As Planned Schedule from which subsequent schedules revisions shall be developed and used by CONTRACTOR when making proposals or claims for adjustments in Contract Time or Contract Price.
   2. Early dates in the Progress Schedule shall be based on proceeding with all or part of the Work exactly on the date when the corresponding Contract Time commences to run. Late dates shall be based on completing all or part of the Work exactly on the corresponding Contract Time, regardless of whether CONTRACTOR anticipates early completion. If sequences of Work are imposed by the Contract Documents, the Progress Schedule shall show in detail CONTRACTOR'S approach to conforming with those sequences.
   3. Progress Schedule revisions submitted shall: (a) adequately depict CONTRACTOR'S current approach to remaining Work, (b) report on progress or schedule recovery actions, and (c) facilitate evaluation of progress
   4. payments, and (d) accurately depict the progress and sequence of the Work to date.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 MONTHLY PROGRESS REPORTS

A. On the first working day (or as otherwise scheduled) of each month, the CONTRACTOR shall meet with the ENGINEER and present, in duplicate, a report of his operations during the preceding month, including actual starting and ending dates on activities shown on the network diagram. Where such starting or ending dates were delayed beyond those required by the CPM Schedule, the CONTRACTOR shall describe the action he is taking to regain lost time, and state the anticipated completion dates of subsequent activities affected by the delayed items. He shall also point out known or anticipated delays on continuing activities and outline the action he is taking to regain lost time, or avoid future delays, and state the anticipated completion dates of subsequent activities affected by the delayed items. On the basis of the reports presented at the meeting, the CONTRACTOR will develop a revised mathematical analysis, bar chart and narrative report, and will furnish eight copies thereof to the ENGINEER not later than the fifth working day of the month. The updated bar chart shall detail one-month window in the CPM Schedule. Each activity covering Work at the site shall reflect the Work of a specific crew, span 15 business days or less, and indicate which CPM Schedule Activity includes the same Work. Activities covering submittals and the procurement of items of materials or equipment shall segregate the time required for preparation of submittals, review and return of submittals, and fabrication and delivery, as applicable, and shall not combine items furnished by separate suppliers (first and second tiers).

B. Updated mathematical analyses shall include the information included in the initial submittal and the following additional information:
   1. Actual start date of activities which have been started by calendar date.
   2. Actual finish date of activities which have been completed by calendar date.
   3. Actual number of days worked on activities which have been completed.
   4. Percentage completion of activities which have been started.
   5. Actual dates on which attained milestones were achieved.
   6. Additions or deletions of activities or events since the previous report.
   7. Changes in sequence or estimated duration of activities.
   8. Where progress along any path is behind schedule such that activities lying on the path are delayed by an amount greater than their initial Total Float, the Total Float shall show as a negative value.

C. The updated bar chart shall be a revision of the initial accepted bar chart based upon the updated mathematical analysis and shall show changes from the initial bar chart.

D. The updated narrative report shall be based upon the initial narrative report and shall describe in detail any revisions, either current or forecast, to information submitted with the initial narrative reports, together with a description of current and anticipated problems and delaying factors affecting progress of the Work, their impact on progress of the Work, and an explanation of corrective actions taken or proposed. The narrative shall, at a minimum, compare current Late Dates vs. Contract Times and Milestone Times; provide sufficient detail to allow objective verification of the progress of the Work; identify the assumptions made and Activities affected in incorporating Work involved in Change Orders; describe actual or potential delays and their extent, related causes and the steps taken or anticipated to mitigate their impact; and itemize any revisions, and their bases, made in CPM Schedule Activities and sequences.

3.2 REVISION OF NETWORK DIAGRAM

A. Unless the ENGINEER directs otherwise, the network diagram shall be revised every three months during the duration of the Project to reflect departures and changes from the previous network diagram. The revised network diagram shall be furnished to the ENGINEER with the corresponding Application for Payment. Each submittal shall consist of the required copies of the updated CPM Schedule narrative, and an electronic format.
   1. Schedule Revisions shall be solely for the purpose of showing how the CONTRACTOR'S planning, scheduling, and execution of Work remaining demonstrates continued compliance with the Contract Times and those sequences of Work indicated in or required by the Contract Documents, and preparing schedule recovery plans. CPM Schedule Revisions shall accurately represent all changes, adjustments or updates in the sequencing and timing of Work remaining made or required to be made by the CONTRACTOR.
   2. Schedule Revisions shall accurately portray how completed Work was performed and any delays and any other significant events experienced since the previous CPM Schedule Revision.
   3. Schedule Revisions shall incorporate changes in Activities and sequence agreed upon in previously authorized Change Orders.
   4. The CONTRACTOR shall ensure that the CPM Schedule diagram accurately reflects for each Activity the "as-built" information shown on the pertinent documents, such as daily reports and submittal logs (and in the later case, reflect dates for resubmissions and re-reviews). As a minimum, schedule as-built data shall include actual start dates (discounting early starts not representing true as-built conditions), remaining days of Work, percent complete, and actual finish dates (when the Activities were completed so that dependent Work could proceed).
   5. The ENGINEER will return a CPM Schedule Revision Submittal with comments limited to the unprogressed portion within 20 days. If a resubmittal of a CPM Schedule Revision is required, the CONTRACTOR shall, within 10 days, submit the required copies of a corrected and adjusted

6. CPM Schedule Revision. Once an issue of a CPM Schedule Revision is returned to the CONTRACTOR as "Resubmittal Not Required", with or without comments, it shall represent the most current CPM Schedule as of the date of the revision, and it shall be the basis for monitoring of the CONTRACTOR'S performance and progress against Late Dates.
7. 6. Each CPM Schedule Revisions Submittal shall include a statement signed by the CONTRACTOR certifying that the CONTRACTOR has not, as of the cut-off date of that CPM Schedule Revision, been delayed by any actions, of or failure to act by the OWNER or ENGINEER, except as otherwise specifically stated.

3.3 REPORTS

A. CPM Schedule reports shall include cost updates, written narratives, network logic diagrams, graphic bar tabular printouts, and graphic bar charts, in both detailed and summary format.

B. Network Diagrams shall legibly show the order and interdependence of activities, and the sequence in which the Work is to be accomplished as planned by the CONTRACTOR.

C. Tabular printouts shall show one activity per line along with appropriate data for the purpose intended including various combinations of the following:
   1. Activity number or label.
   2. Activity description.
   3. Preceding and succeeding activity numbers or labels and descriptions.
   4. Original duration (in calendar days).
   5. Revised duration (in calendar days).
   6. Days remaining (in calendar days).
   7. Percent complete.
   8. Earliest start date (by calendar date).
   9. Earliest finish date (by calendar date).
   10. Latest start date (by calendar date).
   11. Latest finish date (by calendar date).
   12. Actual start date (by calendar date).
   13. Actual finish date (by calendar date).
   14. Total Float.
   15. Free Float.

D. Activities shall include in addition to the construction activities; the status of interrelated submittals, samples, manufacturers' data, and Shop Drawings, the procurement of materials and equipment, installation and testing.

E. Bar charts will be required for summary purposes to compare actual progress with baseline As-Planned Schedule.

F. The network diagram shall be made to a time schedule and shall show the order and interdependence of activities and sequence in which the Work is to be accomplished as planned by the CONTRACTOR. The diagram shall show how the start of a given activity is dependent upon completion of preceding activities and how its completion restricts the start of following activities. Float need not be shown on the network diagram.
   1. The diagram shall be constructed in such a manner that sub-networks relating to particular phases or portions of the Work can be readily extracted or revised as required. Each sub-network shall show time allocations for Shop Drawing review and fabrication time in addition to Work time. The network diagram shall show the following information related to the activities.
   2. Activity number or label if the precedence method of diagramming is being used or the preceding and following event numbers if the arrow method of diagramming is used.
   3. A brief description of the activity.
   4. Estimated duration, in consecutive calendar days, of each activity.
   5. If the precedence method of diagramming is being used, lags or lag factors may be used at the CONTRACTOR'S option.
   6. All activities relating to the furnishing and performance of the Work shall be shown. Activities which are interdependent because of restrictions of available manpower or construction equipment shall be shown.
   7. In addition to construction activities, the diagram shall show the date of the Work authorization and mandatory completion dates.
   8. Detail of information shall be such that duration times of activities shall span 40 calendar days or less with not over 2% of the activities exceeding these limits. The activities which comprise separate portions of the Work shall be separately identifiable by coding.
   9. The network diagram shall be drawn on 24-inch by 36-inch size sheets with flow of activities generally from left to right. Printing shall be suitable for half size and microfilm reproduction. No lettering or numbering shall be less than 1/8-inch in height (for capitals and numbers). The critical path shall be clearly marked. Wherever possible, activities relating to a particular sub-network shall be grouped together on a single sheet.

G. Mathematical analysis of the network diagram shall be based on the network diagram and shall be a computer printout tabulating each activity and showing the following information for each activity:
   1. Activity number or label if the precedence method of diagramming is being used or the preceding and following event numbers if the arrow method is being used.
   2. Activity description.
   3. Estimated duration, in consecutive calendar days, or each activity.
   4. Earliest start date by calendar date.
   5. Earliest finish date by calendar date.
   6. Latest start date by calendar date.
   7. Latest finish date by calendar date.

8. Latest free start date by calendar date.
9. Latest free finish date by calendar date.
10. Total Float.
11. Free Float.
12. Critical activities and activities on critical path shall be marked.

H. Earliest start and finish dates shall be regarded as the CONTRACTOR'S scheduled start and finish dates.

I. The bar chart shall be based on the network diagram and mathematical analysis. Related activities may be grouped together into a single item. However, the completed bar chart shall consist of not less than 50 items. The length of each bar shall correspond to the net aggregate durations of activities represented by the bar. Portions of bars which represent critical activities shall be marked. Bars shall be broken during extended periods of no Work such as shutdowns for inclement weather.
   1. The bar chart shall be drawn on 24-inch by 36-inch size sheets showing the total Contract duration in months. Printing shall be suitable for half size and microfilm reproduction. No lettering or numbering shall be less than 1/8-inch in height (for capitals and numbers). Bars representing related activities for any given portion of the Work shall be grouped together and a descriptive title shall be shown for each bar. A list of all activities represented by each bar shall be included with the bar charts.

J. The narrative report shall describe in detail, but not be limited to, the CONTRACTOR'S proposed methods of carrying out each phase or portion of the Work together with the number of personnel, number of shifts, hours per shift, work week, and the number, size and type of major pieces of construction equipment required for the Work. The report shall include a charge showing the CONTRACTOR'S estimated monthly earnings and accumulated earnings.

K. Except where directed in writing by the OWNER, the CONTRACTOR shall promptly take appropriate action to recover schedule whenever the CONTRACTOR fails to achieve a Contract Time or Milestone Time or perform Activities within the Late Dates in the most current revision of the CPM Schedule, or the CONTRACTOR'S progress falls behind that required to comply with that Contract Time, Milestone Time, or Late Dates. The CONTRACTOR shall submit with the Application for Payment following recognition of the problem a schedule recovery plan describing the cause of schedule slippage or delayed progress and the actions taken to correct them within the shortest reasonable time.
   1. Appropriate schedule recovery actions may include, but not be limited to, assignment of additional labor, subcontractors, or construction equipment, Work during other than normal working hours (subject to the requirements of the General Conditions), expediting of Submittals or deliveries, or any combination of any of them. Overlapping or resequencing of activities to

increase activity concurrence shall be appropriate only if properly substantiated in the schedule recovery plan.

2. The CONTRACTOR'S failure, refusal or neglect to (a) submit a schedule recovery plan furnishing sufficient and convincing evidence that the CONTRACTOR can recover schedule within the shortest reasonable time acceptable to the OWNER, or (b) take appropriate schedule recover action, shall be reasonable evidence that the CONTRACTOR is not prosecuting the Work with all due diligence and shall give sufficient basis to the OWNER to demand adequate, written assurance of performance under the General Conditions, withhold from any payment an amount based on the OWNER'S estimate of the liquidated damages that would become due because of the actual or anticipated late completion, and in the OWNER'S sole discretion, order alternate schedule recovery actions.
3. An extension in Contract Time or an increase in Contract Price arising from delays which postpone, extend or in any other manner alter the schedule or completion of all or part of the Work will not be granted unless the CONTRACTOR, through an analysis of a schedule reflecting data as of the date prior to the origination of the delay, as designated in Paragraph 3.2 A.1., demonstrates that conditions justifying extensions in Contract Time or increases in Contract Price as provided in Articles 8 and 11 of the General Conditions, have been met, and that analysis by the CONTRACTOR is verifiable by objective evaluation.
4. A version of the As-Planned Schedule shall accurately show (a) all Work progress (by the cut-off date) and any delays and any other significant events experienced before the cut-off date, and (b) any changed in Activities and sequences agreed upon in previously authorized Change Orders considering the proper records and all valid data provided under the requirements of Paragraphs 3.2 A.2. and 3.2 A.3., respectively. Any such As-Planned Schedule shall purposely exclude all Activity and sequencing changes initiated by the CONTRACTOR that affect Work after the cut-off date (whenever incorporated into any contemporaneous CPM Schedule Revisions under the requirements of Paragraph 3.2 A.1. or otherwise), until the timing and sequences suggested by those changes actually take place.

L. The ENGINEER may refuse to recommend any part of the payment if, in the ENGINEER'S judgment, the CONTRACTOR'S failure, refusal or neglect to provide the required CPM Schedule information precludes a proper evaluation of the CONTRACTOR'S progress. The OWNER may withhold a set-off from any payment recommended by the ENGINEER, if in the OWNER'S judgment, the CONTRACTOR'S failure, refusal or neglect to provide the required CPM Schedule information precludes a proper evaluation of whether the CONTRACTOR is prosecuting the Work, or any separable part of the Work, with all due diligence or not.

END OF SECTION

SECTION 01380

CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.1 SUMMARY

A. Pre-Construction Video:
   1. The CONTRACTOR shall furnish a Pre-Construction Video recording of the entire Project site showing the existing condition of all pavement, concrete, piping, equipment, structures, landscaping, building, and other site features. The pre-construction video shall be in color DVD format. Two copies of the DVD(s) shall be submitted to the ENGINEER and approved prior to mobilization or initiating any construction activities. The CONTRACTOR shall notify the ENGINEER at least 48 hours prior to making the recording so that the ENGINEER may accompany the recorder.

B. Ground Level Construction Photographs:
   1. The CONTRACTOR shall furnish progress photographs of the Project. The photographer selected by the CONTRACTOR shall be approved by the ENGINEER and shall be either a commercial photographer or an individual experienced and equipped for such photography. The CONTRACTOR shall submit to the ENGINEER three representative prints of photos taken by the selected photographer for approval of the photographer's qualifications prior to taking the first photographs.
   2. The CONTRACTOR shall deliver to the ENGINEER color digital photographs taken during that period with each application for payment. If the current photographs do not accompany the application, the application shall not be reviewed and shall be returned to the CONTRACTOR as incomplete. At least 50 photographs shall be taken per each application of payment. Color digital photographs shall be submitted on CD/DVD.
      a. Each digital file shall be in *.jpg extension. Each photograph shall be named according to the areas listed in this Section and the date the photograph was taken and a unique identifier.
      b. File naming shall consist of the two digit area designation, followed by the four digit year, followed by the 2 digit month the photo was taken, followed by the two digit day the photo was taken. A digit unique identifier shall be included within the filename following the date.
         1) Example file naming for the photo was taken of the headworks screen on December 2, 2014 would be: HW 20141202 00121.jpg

HW	2014	12	02	00121	.jpg
Area	Year	Month	Day	Unique Identifier	

2) Spaces shall be included in file name between the area designation number and the year, and between the day and the unique identifier number. Minimum digital file size shall be 5 mega pixels.

3. Area designation shall follow the area designation on Drawings as presented in the following table.

DESCRIPTION	AREA DESIGNATION
Aerial Photo	AP
Sanitary Sewer	SS
Forcemain	FM
Lift Station	LS
Electrical	ELEC
Site Work	SW

4. Processing and reproduction work shall be accomplished in accordance with standard practice to ensure that the color digital photographs and any subsequent prints are clear and sharp in detail, of good tonal quality, and uniform in range of density. The photographs shall be taken at regular intervals, which provide a step by step progress of each process area.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PROCEDURES

A. Requirements: Photographic exposures shall be taken during the construction period. The ENGINEER may vary the specified frequency so that significant progress or changes can be recorded on the photographs. Approximately 50 ground level construction photographs will be required every two weeks through the construction period.

B. The construction photographs shall be of aesthetic composition and shall depict the progress of the Work from the beginning of construction, through and including the finished product and shall include, but not be limited to, the items listed in Section 01010, Summary of Work.

C. Construction photographs shall be submitted monthly with the application for payment. The Application for Payment shall not be reviewed and shall be returned to the CONTRACTOR as incomplete if the currently due photographs have not been submitted.

D. All buried piping larger than 4-inches in diameter shall be photographed prior to backfill. One photograph shall be taken at every 20 feet of length. These shall be in addition to the 50 photographs per two week period.

END OF SECTION

SECTION 01400

QUALITY CONTROL

PART 1 - GENERAL

1.1 QUALIFICATIONS

A. Installation of materials and equipment shall be performed in a workmanlike manner by mechanics skilled in their particular trade.

B. The determination for the performance qualification is the responsibility of CONTRACTOR and each welder or welding operator shall be qualified by tests using equipment, procedures and a base metal and electrode or filler wire from the same compatible group number that will be encountered in the applicable procedure. Welders or welding operators who make acceptable procedure qualification test welds will be considered performance qualified for the welding procedures used. Performance qualification shall be determined in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. Welders and welding operators qualified by another employer may be accepted as permitted by ANSI B31.1. ENGINEER shall be notified 24 hours in advance as to the time and place of tests and wherever practical, the tests shall be performed at the Work site. The CONTRACTOR shall furnish a list of the welder names and identification symbols as noted on the performance qualification test records to be used to identify the Work performed by the welder or welding operator who after completing a welded joint shall identify it as his Work by applying his assigned symbol for permanent record.

1.2 REGULATORY REQUIREMENTS

A. Unless indicated or specified otherwise, all materials and workmanship for the mechanical trades shall conform to the editions of the various standards, codes, manuals, and Specifications in effect on the date of advertisement for bids.

1.3 CERTIFICATIONS

A. Submittals of certifications of compliance from the CONTRACTOR or manufacturer required as specified for equipment in these documents shall be submitted to the ENGINEER as specified in Section 01300, Submittals.

1.4 FIELD TESTING

A. All testing called for in the Specifications shall be the responsibility of the CONTRACTOR, including soils and concrete tests per Specification Section 02200, Earthwork, and Specification Section 03300, Cast-In-Place Concrete. All

retesting required due to the failure of the CONTRACTOR'S Work to meet the requirements of the Contract Documents shall be at the CONTRACTOR'S expense.

1.5 SUPERVISION OF INSTALLATION BY MANUFACTURER

A. As required in the individual equipment Specifications, an experienced, competent, and authorized factory representative of the equipment manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation, and shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the job site as often as necessary until any trouble is corrected and the equipment installation and operation is satisfactory to ENGINEER. The equipment supplier's representative shall furnish to ENGINEER, through CONTRACTOR a written report certifying that the equipment: (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from any undue stress imposed by connecting piping or anchor bolts; and (4) has been operated under full load conditions and that it operated satisfactorily.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 DEMONSTRATION

A. The CONTRACTOR shall demonstrate, as Specified in Section 01650, Starting of Systems, to the satisfaction of the ENGINEER, OWNER and manufacturer's representative that all newly installed equipment operates in a satisfactory manner.

END OF SECTION

SECTION 01412

STORMWATER POLLUTION PREVENTION PLAN AND PERMIT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Comply with the terms and conditions of Arizona Pollutant Discharge Elimination System (AZPDES) administered by the Arizona Department of Environmental Quality (ADEQ). Under provisions of that permit, CONTRACTOR is designated as permittee and responsible for providing necessary material and for taking appropriate measures to minimize pollutants in stormwater runoff from the Project. Obtain a DeMinimus Discharge Permit from ADEQ for any discharge that is to Waters of the U.S., and comply with the requirements of the permit.

B. The Contract Price shall include all material, labor, and other permits and incidental costs related to:
   1. Preparing, updating, and revising the Stormwater Construction Pollution Prevention Plan (SWPPP).
   2. Installing and maintaining all structural and nonstructural items chosen by CONTRACTOR to comply with the construction SWPPP.
   3. Cleanup and disposal costs associated with cleanup and repair following storm events or CONTRACTOR-caused spills on the Project.
   4. Implementing and maintaining Best Management Practices to comply with the OWNER'S stormwater code.
   5. Preparing the Notice of Intent and Notice of Termination shall be covered by the AZPDES General Permit for Arizona.
   6. Obtain and comply with DeMinimus Permit, if such permit is required.

C. Coordinate the requirements under this Section with Section 02200, Earthwork, requirements. All necessary SWPPP controls and practices must be implemented prior to commencement of any construction activity.

1.2 SUBMITTALS

A. Submit, at least two days prior to the initial start of construction on the Project, completed and signed Notice of Intent form to the State of Arizona online or by mail to:

Arizona Department of Environmental Quality
Surface Water Section - Stormwater and General Permits Unit
1110 West Washington Street, 5415A-1
Phoenix, Arizona 85007

B. Submit to the OWNER, at least 30 days prior to submitting to the State agency the following:
   1. Notice of Intent (NOI) to be covered by the AZPDES General Permit for Arizona, including certifications of signature.
   2. SWPPP for the Project, including certification of signature. Stormwater Plan shall include CONTRACTOR'S proposed temporary means for stormwater control during all phases of construction and include stormwater pumping/retention plans. This submittal shall be coordinated with CONTRACTOR'S Excavation Plan Submittal, specified in Section 02200, Earthwork.

C. Submit to the OWNER, as part of the Construction SWPPP, a construction site inspection report that includes the following:
   1. Inspection scope.
   2. Inspector qualifications.
   3. Observations of SWPPP non-compliance and corrective steps taken.
   4. Certificate of Compliance with SWPPP and the AZPDES General Permit for Stormwater Discharge in the event of no incidents. Reports shall be submitted each quarter, at a minimum, throughout the Contract duration.

D. Submit to the OWNER, upon Project completion, the Notice of Termination (NOT) of coverage under AZPDES General Permit.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01414

EARTHMOVING AND DUST CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION

A. CONTRACTOR shall obtain all permits required for earthmoving and dust generating operations related to the Work, as required by Arizona Department of Environmental Quality (DEQ) Air Quality Division.

B. CONTRACTOR shall not cause or allow any dust generating operation, earthmoving operation, use of property, or any other operation which causes fugitive dust emissions that exceed 20% visible emission opacity limit.

C. If requested by the OWNER, ENGINEER, or State representative, CONTRACTOR shall conduct opacity observations for visible emissions of fugitive dust in accordance with techniques specified in USEPA Reference Method 9.

D. In addition to Earthmoving Permits, CONTRACTOR shall develop a Dust Control Plan. At a minimum, the Dust Control Plan shall include the following information:
   1. Name(s), address(es), and phone number(s) of the person(s) responsible for the preparation, submittal, and implementation of the Dust Control Plan and responsible for the dust generating operations.
   2. A site plan that describes the total area of land surface to be disturbed (in acres); the operations and activities to be performed on the site; actual and potential sources of fugitive dust emissions; and the delivery, transportation, and storage areas for the site (including types of materials stored and appropriate size of material stock piles).
   3. Description of the Reasonably Available Control Measures (RACM) to be applied during all periods of dust generating operations at all actual and potential sources of fugitive dust.
   4. Description of dust suppressants to be applied, including product specifications; method, frequency, and intensity of application; type, number, and capacity of application equipment; and certifications related to the suppressant's appropriate and safe use.
   5. Description of specific surface treatment(s) or RACM used to control material track-out where unpaved or access points join paved surfaces.
   6. Description of at least one alternative RACM for each actual and potential fugitive dust source shall be designated as a contingency measure.

E. CONTRACTOR shall post a copy of all Earthmoving Permits as well as the approved Dust Control Plan, in a conspicuous location at the Work site and provide a copy of each to the ENGINEER.

F. CONTRACTOR shall maintain a daily written log that records the actual application or implementation of the RACMS described in the approved Dust Control Plan. CONTRACTOR shall maintain this written log and supporting documentation on-site and shall make available for review on request by ENGINEER, OWNER, or State representative. CONTRACTOR shall retain copies of the Dust Control Plan, RACM implementation records, and all supporting documentations for a minimum of three years.

G. CONTRACTOR, at a minimum, shall provide all necessary equipment and materials to apply sufficient dust suppressants (e.g., water, etc.), properly clean (sweep, etc.) all track-out areas, and provide adequate physical stabilizations (e.g., gravel, recycled asphalt, etc.) to meet all requirements of the Earthmoving Permit and approved Dust Control Plan. CONTRACTOR shall use these methods to control fugitive dust generation from all CONTRACTOR operations on all CONTRACTOR areas including, but not limited to:
   1. Construction areas.
   2. Vehicle and equipment parking areas.
   3. Material storage areas.
   4. Office and trailer areas.
   5. Haul and access roadways.
   6. Track-out areas.
   7. All other areas where CONTRACTOR shall be working, storing, or parking vehicles, equipment, and materials.

H. CONTRACTOR shall pay all fines issued to the OWNER by the USEPA, ADEQ, or County due to violation as a result of earthmoving and dust generating operations by the CONTRACTOR related to the Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01451

TESTING LABORATORY SERVICES FURNISHED BY THE CONTRACTOR

PART 1 - GENERAL

1.1 DESCRIPTION

A. The CONTRACTOR will employ and pay for an independent testing laboratory to perform the specified services.

B. Inspection, sampling, and testing shall be as specified in the individual Sections. These include, but are not limited to:
   1. Section 02200, Earthwork.
   2. Section 03300, Cast-In-Place Concrete.
   3. Section 03600, Grout.

C. The CONTRACTOR will pay for the testing listed above, including repeat testing which results from CONTRACTOR'S negligence or his repeated failure to meet Contract Document requirements.

D. CONTRACTOR shall also pay for:
   1. Tests not specifically listed above.
   2. Tests made for CONTRACTOR'S convenience.

E. The testing laboratory is not authorized to approve or accept any portion of the Work; rescind, alter, or augment the requirements of the Contract Documents; or perform any duties of CONTRACTOR.

1.2 QUALIFICATIONS OF LABORATORY

A. Where applicable, the testing laboratory will meet "Recommended Requirements for Independent Laboratory Qualification", latest edition published by American Council of Independent Laboratories, and the basic requirements of ASTM E329 "Standard Specifications for Agencies Engaged in Construction Inspection, Testing, or Special Inspection".

B. Testing equipment used by the laboratory will be calibrated at maximum twelve month intervals by devices of accuracy traceable to either National Institute of Standards and Technology or accepted values of natural physical constants.

C. CONTRACTOR shall submit a written description of the proposed soils testing agency giving qualification of personnel, equipment, and other information which may be required by ENGINEER.

1.3 LABORATORY DUTIES

A. The Testing Laboratory shall:
   1. Cooperate with CONTRACTOR and provide qualified personnel promptly on notice.
   2. Perform specified inspections, sampling, and testing of materials and methods of construction; comply with applicable standards; and ascertain compliance with requirements of Contract Documents.
   3. Promptly notify ENGINEER and CONTRACTOR of irregularities or deficiencies of Work that are observed during performance of services.
   4. Promptly submit five copies of reports of inspections and tests to ENGINEER, including:
      a. Date issued.
      b. Project title and number.
      c. Testing laboratory name and address.
      d. Date of inspection or sampling.
      e. Record of temperature and weather.
      f. Date of test.
      g. Identification of product and Specification Section.
      h. Location in Project.
      i. Type of inspection or test.
      j. Results of tests and observations regarding compliance with Contract Documents.
   5. Perform additional tests and services as required by OWNER.

1.4 CONTRACTOR'S RESPONSIBILITIES

A. CONTRACTOR shall:
   1. Cooperate with laboratory personnel and provide access to Work and to manufacturer's operations.
   2. Provide to laboratory preliminary representative samples of materials to be tested, in required quantities.
   3. Furnish copies of product test reports.
   4. Provide to the laboratory the preliminary design mix proposed for concrete and other material mixes that require testing by the testing laboratory.
   5. Furnish labor and facilities:
      a. To provide access to Work to be tested.
      b. To obtain and handle samples at the site.
      c. To facilitate inspections and tests.
      d. For laboratory's exclusive use for storage and curing of test samples.
      e. Forms for preparing concrete test beams and cylinders.
   6. Notify laboratory and ENGINEER sufficiently in advance of operations to allow for assignment of personnel and scheduling of tests.
   7. Arrange with laboratory and pay for additional samples and tests required for CONTRACTOR'S convenience.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01500

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Temporary utilities required during construction.

B. Temporary construction facilities including field offices.

C. Requirements for security and protection of facilities and property.

D. Requirements for access to the Work.

E. Temporary controls for protection of environment.

F. Project sign.

1.2 SUBMITTALS

A. Temporary Utility Submittals:
   1. Electric power supply and distribution plans.
   2. Temporary water supply and distribution plans.
   3. Copies of approvals of local utility companies for CONTRACTOR'S intended temporary utility plans.

B. Temporary Construction Submittals:
   1. Access roads and parking area plans.
   2. Storage yards and building plans, including gravel surfaced area.
   3. Fencing, protective barrier, and gate locations and details.
   4. Staging area plan and notification of any obstructions encountered during mobilization.

1.3 STAGING AREA

A. Use an area designated for CONTRACTOR'S temporary facilities as approved by OWNER. CONTRACTOR shall use a separate entrance, to enter the staging area and the trailer area as approved by OWNER.

B. Notify ENGINEER of obstructions not shown or not readily apparent by visual inspection of the staging area. Do not remove obstructions without OWNER'S prior consent.

1.4 TEMPORARY UTILITIES

A. Costs after Substantial Completion:
   1. Upon acceptance of the Work or a portion of the Work defined and certified as substantially complete by ENGINEER, and OWNER commences full-time successful operation of the facility or portion thereof, the OWNER will bear the cost for utilities used for OWNER'S operation. CONTRACTOR shall continue to pay for temporary utilities used until Final Acceptance of the Work, except as provided herein.

B. Electric Power:
   1. The CONTRACTOR shall make arrangements with local electric power company for obtaining temporary electric power service, metering equipment, and pay all costs for the electric power used during the Contract period, except as specifically provided for utilities used by the OWNER on portions of the Work designated in writing by the ENGINEER as substantially complete.
   2. Temporary electric power installations shall meet construction safety requirements of OSHA, State, and other governing agencies.
   3. Maintain installation throughout construction period to provide continuous service and to provide safe working conditions.
   4. Cost of electric power used in performance and acceptance testing will be borne by CONTRACTOR.
   5. Completely remove temporary materials and equipment after permanent installation is in use.

C. Water:
   1. CONTRACTOR shall pay costs to establish temporary water service, including costs of installation, metering, maintenance, and removal of pipe and equipment. CONTRACTOR shall pay costs for water used by all trades.
   2. CONTRACTOR shall provide water source by connecting to existing utility mains at locations designated by OWNER. CONTRACTOR shall provide all facilities necessary to convey the water from the OWNER designated source to the points of use in accordance with the requirements of the Contract Documents. CONTRACTOR shall provide backflow prevention devices, where required. Hydrants cannot be taken out of service.
   3. The CONTRACTOR shall not make connection to or draw water from any other water system without first obtaining permission from the OWNER. For each water system connection, the CONTRACTOR shall first attach to the water system a valve and a meter. The size and type of valve and meter shall be acceptable to OWNER.
   4. Before Final Acceptance of the Work, all temporary connections to the said water system shall be entirely removed. All affected improvements shall be restored to their original condition or better, to the satisfaction of the ENGINEER and to the OWNER.

5. All potable water used by CONTRACTOR'S employees, subcontractor's employees and the temporary construction facilities during construction shall be furnished by the CONTRACTOR and shall be bottled water or water furnished in approved metal dispensers. Notices shall be posted conspicuously throughout the site warning temporary piped water may be contaminated.

D. Temporary Fire Protection:
   1. The CONTRACTOR shall provide all facilities and equipment necessary to provide temporary fire protection for the construction site in accordance with the requirements of the 2003 International Fire Code.

E. Sanitation:
   1. Provide and maintain sanitary facilities for CONTRACTOR'S employees and subcontractors' employees that comply with regulations of local and State health departments.
   2. Provide chemical toilets of suitable types and maintain them in a sanitary condition at all times conforming to code requirements and acceptable to health authorities. They shall be of watertight construction so that no contamination of the area can result from their use. The CONTRACTOR shall make arrangements for frequent emptying of toilets. Upon completion of Work, CONTRACTOR shall remove toilets and restore area to original condition.
   3. Use of OWNER'S existing sanitary facilities by construction personnel will not be allowed.

F. Communications:
   1. The CONTRACTOR shall provide and maintain, at all times during the progress of the Work, not less than one cellular phone in good working order.

1.5 PROJECT SIGN

A. The CONTRACTOR shall furnish and erect one Project sign in a location selected by the OWNER. The Project sign shall conform to the description below. The cost for the sign shall be considered incidental to the Project. No separate payment will be made for the sign.

B. The CONTRACTOR shall provide two 4 foot by 8 foot by 0.75 inch multicolored signboards. Signboards shall be provided with 1-1/4-inch by 4-inch edging, shall be constructed of exterior grade high density overlaid plywood, and shall be mounted and located in an acceptable manner which will permit public viewing. Sign shall list the following information:
   1. Names of OWNER, ENGINEER, and CONTRACTOR.
   2. Project Signs, “Wickenburg High School Lift Station and Forcemain.
   3. CITY, ENGINEER, and CONTRACTOR Logos (CONTRACTOR Logo at CONTRACTOR'S option).

C. Submit a layout drawing for approval showing the location, size, and color of logos and lettering.

D. The sign shall be maintained in good condition until completion of the Contract, at which time the sign shall become the property of the OWNER. The OWNER may elect to have the CONTRACTOR remove the signs at the CONTRACTOR'S cost.

E. Sign supports shall be 4-inches by 6-inches posts painted black, set a minimum 3 feet 6-inches in the ground. Paint shall be exterior type. The lettering shall be by professional sign painter or commercial sign company, using no more than five colors.

F. The CONTRACTOR and his subcontractors may erect signs for information and direction. No commercial or advertising signs will be allowed on the site of the Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SECURITY

A. The CONTRACTOR shall provide security to prevent unauthorized persons from entering the construction site and a secured storage area for materials and equipment.

B. The CONTRACTOR shall safely guard all work, materials, equipment, and property from loss, theft, damage, and vandalism. The CONTRACTOR'S duty to safely guard property shall include the OWNER'S property and other private property from injury or loss in connection with the performance of the Contract.

C. The CONTRACTOR shall make no claim against the OWNER for damage resulting from trespass.

D. Party responsible for security shall make good all damage to property of the OWNER and others arising from failure to provide adequate security.

E. Maintain security program throughout construction until Final Acceptance and occupancy precludes need for the CONTRACTOR'S security program.

F. All costs for security as specified in this Section shall be borne by the CONTRACTOR.

3.2 TEMPORARY CONSTRUCTION FACILITIES

A. Access Roads and Parking:
   1. Construct temporary construction access roads and detours as necessary to execute the Work and as approved by the ENGINEER. Maintain in good condition until no longer needed, then remove the temporary roads and leave the area in a condition satisfactory to the ENGINEER. Construction traffic shall use the construction access road to enter and exit the staging and trailer areas.

B. Storage Yards and Buildings:
   1. Construct temporary storage yards for the storage of products that are not subject to damage by weather conditions. Materials such as pipe, reinforcing, and structural steel shall be stored on pallets or racks, off the ground, and in a manner to allow ready access for inspection and inventory. Temporary gravel surfacing of storage yards must be approved by the ENGINEER.
   2. Erect or provide temporary storage buildings of various sizes needed to protect mechanical and electrical equipment and other materials, as recommended by manufacturers of such equipment and materials.
      a. Provide environmental control systems that meet recommendations of manufacturers of equipment and materials stored in the buildings.
      b. Buildings shall be of sufficient size.
      c. Arrange or partition buildings to provide security for their contents and ready access for inspection and inventory.
      d. At or near completion of the Work, temporary storage buildings shall be dismantled, removed from the site, and remain the property of the CONTRACTOR.
   3. Store combustible materials (paints, solvents, fuels, etc.) in a well ventilated building remote from other buildings.

C. Fencing and Barricades:
   1. Barricades: Provide barricades as necessary to prevent unauthorized entry to construction areas, both inside and outside of fenced area. Also provide barricades to protect existing facilities and adjacent properties from potential damage. Locate barriers to enable access by facility operators and property owners.

D. Office:
   1. CONTRACTOR shall provide, maintain, and subsequently remove as its property, one field office as specified below for the use of CONTRACTOR, OWNER, and its representatives. Field office shall be new or like new in appearance and function.
   2. The field office, featured as specified below, shall be available within two weeks after commencement of Contract Time and shall remain on the site for 30 days after Final Acceptance of all Work.

a. All metal frame and roof.
b. Aluminum exterior siding.
c. Panel walls.
d. Security guard screens on all windows.
e. Toilet and wash basin with hot and cold water and drains.
f. Insulated double walls, floor, and ceiling.
g. Self-contained, built-in electric heater capable of maintaining 70º F in winter and self-contained air conditioning unit capable of maintaining 75º F in summer.
h. Fluorescent ceiling lights in all rooms.
i. 110 volt electric wall plugs in all rooms, with maximum spacing between receptacles not to exceed 8 feet.
j. Minimum Interior Height: 8 feet.
k. Minimum Exterior Width: 12 feet.
l. Minimum Exterior Length: 36 feet.
m. Railed stairway to entrances.
n. Sign on entrance door.
o. Trailer shall contain a minimum of two offices, meeting room, lavatories, and work areas.
p. Doors with cylinder locks: Entrance door, exit door. In addition, one office shall have interior door with cylinder lock keyed differently than exit and entrance door locks.
q. Sliding windows with blinds: 1 per office.

3. The field office shall be equipped as specified below.
a. Bottled Water Service: 1 with cooler.
b. Waste Refuse Disposal Service.
c. Refrigerator with freezer compartment: 16.5 cubic foot.
d. Microwave Oven: 1000 watt minimum.
e. Paper Towel Dispenser with Towels: 2 each.
f. Paper Cup Dispenser with Cups: 1 each.
g. Desks: 2, 30-inches by 60-inches.
h. Swivel Chairs: 3 each.
i. Folding Tables: 4, 3-feet by 6-feet long.
j. Folding Chairs: 12 each.
k. Four-Drawer Steel File with Lock: 2 each, legal width.
l. Drawing Rack with Drawing Hangers: 1 each.
m. Bookcase: 3 each.
n. Wastepaper Basket: 5 each.
o. First-Aid Kit: 1 each.
p. Carbon Dioxide (10-Pound) Fire Extinguisher: 2 each.
q. Printer/Copy Machine: One, dry-type, multiple sheets self-feeding, capable of providing 8-1/2-inch by 11-inch, 8-1/2-inch by 14-inch (legal), and 11-inch by 17-inch copies, enlargement and reduction capabilities, collating and double-sided copy capabilities; with wireless print server. Provide Kyocera Copystar CS-8030, or equal. Provide maintenance service contract throughout term of Contract.

r. Internet broadband connection with modem and service with no less than 10 Mbps download and 5 Mbps upload speeds.
s. Dual Band WiFi Gigabit Router.
t. CONTRACTOR shall include an allowance of $3,000 in the cost for personal computer systems, software's and printers.

4. All items shall be furnished and maintained by the CONTRACTOR from the notice to proceed to the date of final acceptance. The cost of these items shall be considered incidental to the cost of the Project. No separate measurement of payment shall be made for these items.
5. The field office shall be leveled, blocked, tied down, and skirted as directed; and relocated when necessary and approved.
6. The CONTRACTOR shall provide and maintain connections to the City's potable water including backflow prevention as required, connections to the City's sanitary sewer, and electrical service to the field offices, including an adequate disconnect switch and an automatic circuit breaker panel located on the inside of the office.
7. Potable water hose bibb with 20 feet of hose connected to potable water supply, near main entrance to ENGINEER'S trailer. Hose bibb shall be freeze protected.
8. CONTRACTOR shall maintain field offices in good repair and acceptable appearance. Provide weekly cleaning service and maintenance and replenishment, as applicable, of paper towels, paper cups, soap, toilet paper, bottled water service, printer paper, and toner.
9. Provide gravel or crushed rock under and around the field offices to a minimum distance of 40 feet. Provide sanitary facilities in compliance with State and local health authorities.

3.3 EXAMINATION OF EXISTING FACILITIES

A. General:
1. After the Contract is awarded and before the commencement of Work, CONTRACTOR and ENGINEER shall make a thorough examination of all existing buildings, structures, and other improvements in the vicinity of the Work, as applicable, which might be damaged by construction operations.
2. Periodic examinations of existing buildings, structures, and other improvements in the vicinity of the Work shall be made jointly by authorized representatives of the CONTRACTOR, ENGINEER, and the OWNER. The scope of the examination shall include cracks in structures, settlement, leakage, and similar conditions.
3. Records in triplicate of all observations shall be prepared by the CONTRACTOR and each copy of every document shall be signed by the authorized representative of the OWNER and of the CONTRACTOR. Photographs, as requested by the OWNER, shall be made by the CONTRACTOR and signed in the manner specified above. One signed copy of every document and photograph will be kept on file in the office of the ENGINEER.

4. These records and photographs are intended for use as indisputable evidence in ascertaining whether and to what extent damage occurred as a result of the CONTRACTOR'S operations and are for the protection of the adjacent property owners, the CONTRACTOR, and the OWNER.

3.4 SAFETY REQUIREMENTS

A. General:
   1. CONTRACTOR shall do whatever Work is necessary for safety and be solely and completely responsible for conditions of the job site, including safety of all persons (including employees) and property during the Contract period. This requirement shall apply continuously and not be limited to normal working hours.
   2. Safety provisions shall conform to Federal and State Departments of Labor Occupational Safety and Health Act (OSHA), and other applicable Federal, State, County, and local laws, ordinances, codes, requirements set forth herein, and regulations that may be specified in other parts of these Contract Documents. Where these are in conflict, the more stringent requirement shall be followed. CONTRACTOR shall become thoroughly familiar with governing safety provisions and shall comply with the obligations set forth therein.
   3. CONTRACTOR shall develop and maintain for the duration of the Contract, a safety program that will effectively incorporate and implement required safety provisions. CONTRACTOR shall appoint a qualified employee who is authorized to supervise and enforce compliance with the safety program.
   4. ENGINEER'S duty to conduct construction review of the CONTRACTOR'S performance is not intended to include a review or approval of the adequacy of CONTRACTOR'S safety supervisor, safety program, or safety measures taken in, on, or near the construction site.
   5. As part of safety program, CONTRACTOR shall maintain at its office or other well known place at the job site, safety equipment applicable to the Work as prescribed by the governing safety authorities, and articles necessary for giving first-aid to the injured. Establish procedures for the immediate removal to a hospital or a doctor's care of persons who may be injured on the job site.
   6. CONTRACTOR shall do all Work necessary to protect the general public from hazards, including, but not limited to, surface irregularities or unramped grade changes in pedestrian sidewalk or walkway, and trenches or excavations in roadway. Barricades, lanterns, and proper signs shall be furnished in sufficient amount to safeguard the public and the Work.
   7. Construct and maintain satisfactory and substantial temporary chain-link fencing, solid fencing, railing, barricades, steel plates, as applicable, at all openings, obstructions, or other hazards in streets, sidewalks, floors, roofs, and walkways. Such barriers shall have adequate warning lights as necessary or required for safety.
   8. Comply with OWNER'S safety rules while on OWNER'S property.

9. If death or serious injuries or damages are caused, the accident shall be reported immediately by telephone or messenger to the ENGINEER and OWNER. In addition, CONTRACTOR shall promptly report in writing all accidents whatsoever arising out of, or in connection with, the performance of the Work whether on or adjacent to the site, giving full details and statements of witnesses.
10. If claim is made by anyone against CONTRACTOR or any subcontractor on account of accident, CONTRACTOR shall promptly report the facts in writing, giving full details of the claim.

B. Traffic Safety and Access:
   1. Comply with rules and regulations of the City, State, and County authorities regarding closing or restricting the use of public streets or highways. No public or private road shall be closed except by written permission of the proper authority. Assure the least possible obstruction to traffic and normal commercial pursuits.
   2. Where traffic will pass over backfilled trenches before they are paved, maintain top of trench to allow normal vehicular traffic to pass over. Provide temporary access driveways where required. Cleanup operations shall follow immediately behind backfilling.
   3. When flagmen and guards are required by regulation or when deemed necessary for safety, furnish them with approved orange-wearing apparel and other regulation traffic control devices. Traffic control procedures and devices used on all local rights-of-way shall meet the requirements of the applicable current laws and regulations for traffic control.
   4. Notify the fire department, police department and obtain required permits before closing any street or portion thereof. Notify said departments when the streets are again passable for emergency vehicles. Do not block off emergency vehicle access to consecutive arterial crossings or dead-end streets in excess of 300 linear feet without written permission from the fire department. Conduct operations with the least interference to fire equipment access, and at no time prevent such access.
   5. CONTRACTOR shall leave its night emergency telephone number(s) with the police department, so that contact may be made easily at all times in case of barricade and flare trouble or other emergencies.
   6. Maintain postal service facilities in accordance with the requirements of the U.S. Postal Service. Move mailboxes to temporary locations designated by the Service, and on completion of Work in each area replace them in their original location and in a condition satisfactory to the service.

C. Fire Prevention:
   1. Perform all Work in a fire safe manner. Furnish and maintain on the site adequate firefighting equipment capable of extinguishing incipient fires. Comply with applicable Federal, State, and local fire prevention regulations. Where these regulations do not apply, follow applicable parts of the current

edition of NFPA 241: Standard for Safeguarding Building Construction, Alteration, and Demolition Operations.

D. Protection of Work and Property:
   1. General:
      a. CONTRACTOR shall employ such means and methods necessary to adequately protect public property and property of the OWNER against damage. In the event of damage to such property, immediately restore the property to a condition equal to its original condition and to the satisfaction of the ENGINEER and the OWNER of said property, and bear all costs therefore.
      b. Protect stored materials and other items located adjacent to the proposed Work.
   2. Finished Construction:
      a. General construction CONTRACTOR shall assume the responsibility for protection of finished construction and shall repair and restore any and all damage to finished work to its original or better condition.
      b. Prevent wheeling of loads over finished floors, either with or without plank protection, except in rubber-tired wheelbarrows, buggies, or dollies. Protect finished floors and concrete floors exposed as well as those covered with composition tile or other applied surfacing. All finished floors shall be protected from stains due to spillage of oil, paint, or any other construction-related materials. Any such stains that are allowed to occur shall be removed, if necessary by removing and replacing the floor, at the CONTRACTOR'S expense.
      c. At such time temporary facilities and utilities are no longer required for the Work, notify ENGINEER of intent and schedule for their removal. Remove temporary facilities and utilities from the site as CONTRACTOR'S property and leave the site in such condition as specified, as shown on the Drawings, or as directed by the ENGINEER.
      d. In unfinished areas, leave the site evenly graded, seeded, or planted as necessary, in a condition that will restore original drainage and with an appearance equal to or better than original.

3.5 ENVIRONMENTAL CONTROLS

A. General:
   1. The CONTRACTOR, in executing the Work, shall maintain affected areas within and outside Project boundaries free from environmental pollution that would be in violation of Federal, State, or local regulations.
   2. Do not impair operation of existing sewer systems. Prevent construction material, pavement, concrete, earth, volatile and corrosive wastes, and other debris from entering sewers, pump stations, or other sewer structures. Maintain original site drainage wherever possible.

B. Waste Material Disposal:

1. Excess excavated material not required or suitable for backfill, and other waste material, must be disposed of in licensed landfills. However, a site is exempt from licensing where only earth containing less than 25% by volume of concrete and building stone is disposed. The CONTRACTOR shall submit the proposed haul route(s) for each site intended to be used.
2. Unacceptable disposal sites include, but are not limited to, sites within a wetland or critical habitat and sites where disposal will have a detrimental effect on surface water or groundwater quality.
3. In lieu of the foregoing, CONTRACTOR may make his own arrangements for disposal subject to submission of proof that the OWNER(s) of the proposed site(s) has a valid fill permit issued by the appropriate governmental agency. Submit intended haul route plan, including a map of the proposed route(s). Provide watertight conveyance for liquids, semi-liquids, or saturated solids that tend to bleed during transport.
4. Maintain areas covered by the Contract and affected public properties free from accumulations of waste, debris, and rubbish caused by construction operations. Remove excavated materials from the site.
5. Cleaning and disposal shall comply with local ordinances and pollution control laws. Do not burn or bury rubbish or waste materials on the Project site. Do not dispose of volatile wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains. Disposal of wastes into streams or waterways is prohibited. Provide acceptable containers for collection and disposal of waste materials, debris, and rubbish.

C. Air Pollution Control:
1. CONTRACTOR shall comply with City, County, and State requirements regarding dust control.
2. Minimize air pollution likely to occur from construction operations by wetting down bare soils during windy periods, requiring proper combustion emission control devices on construction vehicles and equipment, and by shutdown of motorized equipment not in use. Trash burning will not be permitted on the construction site.
3. Operations of dumping rock and of carrying rock away in trucks shall be conducted to cause a minimum of dust. Give unpaved streets, roads, detours, or haul roads used in the construction area a dust-preventive treatment, or periodically water to prevent dust. Strictly adhere to applicable environmental regulations for dust prevention.

D. Noise Control:
1. Minimize noise by executing Work using appropriate construction methods and equipment. Provide acoustical barriers so noise emanating from tools or equipment will not exceed legal noise levels.
2. Submit plans to mitigate construction noise impacts and to comply with noise control ordinances including method of construction, equipment to be used, and acoustical treatments.

3. If piles are required, use spudding or drilling techniques to penetrate through fill and overburden. Penetrate intermediate hard layers to minimize noise impact by minimizing the number of piledriver hammer blows. Use only piledriver hammers with mufflers capable of reducing noise, and use barriers or shielding techniques to comply with applicable noise criteria.

E. Pest and Rodent Control:
   1. Comply with local health requirements for pest and rodent control. Cooperate with agencies and companies authorized to spray or provide other treatments to prevent insect outbreaks.
   2. Maintain closures of means of entry into finished buildings by rodents. Inspect for rodents during cleaning, remove debris, and treat infested areas to OWNER'S satisfaction.

END OF SECTION

SECTION 01640

MATERIALS AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall furnish all materials and equipment and perform all operations required to completely install and place in operation the various mechanical apparatus and systems indicated on the Drawings and as specified herein. It is not the intent to mention herein each and every item required. However, all installations shall be complete and operable in the methods intended. These general equipment requirements apply, in general, to all equipment. They shall supplement the detailed equipment specifications, but in case of conflict, the equipment specifications shall govern.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials and equipment shall be of new, of first quality and best grade, essentially the standard catalog products of reputable manufacturers, and shall be of the type, size and capacity, and for the type of service specified. It is the intent of these Specifications that the highest quality equipment shall be provided for the intended service. Units proposed shall be carefully matched to the particular hydraulic and mechanical requirements for each installation, and the CONTRACTOR shall submit complete hydraulic and mechanical data for approval by the ENGINEER. Where two or more units of the same class of equipment are required, these units shall be the products of a single manufacturer; however, the component parts of the system need not be the products of the same manufacturer unless otherwise specified.

1. Materials and Workmanship: Materials used in the manufacture of the equipment shall be of the best quality used for the purpose in commercial practice. Materials shall be suitable for service conditions. Iron castings shall be tough, close-grained gray iron free from blowholes, flaws, or excessive shrinkage, and shall conform to ASTM A48. Except where otherwise specified, structural and miscellaneous fabricated steel used in items of equipment shall conform to the Standards of the American Institute of Steel Construction. All structural members shall be considered as subject to shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, all or in part, during normal operation of the equipment shall have a minimum nominal thickness of 1/4-inch. Equipment shall be installed

in accordance with the recommendations of the manufacturer and the best standard practice for each type of equipment.

2. Approval of Materials, Equipment, and Shop Drawings: Detailed Shop Drawings shall be prepared for the equipment to be furnished under this Project. General Drawings for equipment will not be acceptable. Approval of equipment under this provision shall not be construed as authorizing any deviations from the Specification unless the attention of the ENGINEER has been directed to the specific deviation.
    a. The decision of the ENGINEER on any questions concerning the acceptability of materials, equipment, or installation shall be final and binding. The Shop Drawing material required for the various submittals shall be in accordance with Section 01300, Submittals, and as indicated and specified under various headings of these Specifications.
3. Nameplates: Equipment shall be furnished with nameplates of bronze, monel, or stainless steel. Aluminum will not be acceptable. Each nameplate shall include pertinent hydraulic and mechanical data. Information shown shall be permanently stamped or cast into each nameplate and shall include the manufacturer's name and model number.
4. ASME Stamp: Where materials and equipment are specified to be constructed in accordance with the standard of the American Society of Mechanical Engineers Code for Unfired Pressure Vessels, the CONTRACTOR shall submit proof that the items furnished under this Section of the Specifications conform to such requirements. The ASME stamp, label, or listing will be acceptable as sufficient evidence that the items conform to these requirements and shall be provided on all pressure vessels falling within the ASME Code jurisdiction.

B. Electric Motors:
1. General: Unless otherwise required by the detailed equipment specifications, motors furnished with equipment shall be rated for continuous duty at 50° C ambient temperature with a 1.15 service factor. Motors designated for use with variable speed drives and where indicated shall be derated to accommodate the application. Where frequent starting occurs, motors shall be designed for frequent starting duty equivalent to the duty service required by the driven equipment. The horsepower rating of each motor shall be as required to drive the equipment under full load, including all losses in speed reducers and power transmission, and to be non-overloading over the entire range of equipment head capacity curves without the use of motor service factors. It is the intent of this general Specification to allow the manufacturer's standard motor on integrally constructed motor driven equipment such as appliances, hand tools, etc., that is specified by model number in which a redesign of the complete unit would be required for a motor with other features as may be specified herein. All motors furnished under these Specifications shall be of recognized manufacture, of adequate capacity for the loads involved, and wound to the current characteristics noted. All motors shall conform to the standards of manufacture and

performance of the National Electrical Manufacturers Association as shown in their latest publications.

2. Enclosures: Unless otherwise required by the detailed equipment specifications, the enclosures for motors shall be as indicated below:
   a. Motors installed outdoors shall be totally enclosed or totally-enclosed fan-cooled (TEFC), except that vertically mounted motors may be weather protected Type I.
   b. Motors installed indoors may be open drip-proof, unless otherwise indicated.
3. Motor horsepower requirements in the equipment specifications are estimated. If the horsepower requirements for the equipment furnished vary from the estimated horsepower, the CONTRACTOR shall be responsible for making all necessary revisions to wiring, conduit, motor starters, circuit breaker, and other electrical equipment at no additional cost to OWNER.
4. Anchor Bolts: Equipment suppliers shall furnish suitable anchor bolts of specified metallurgy for each item of equipment. Anchor bolts, together with templates or setting drawings, shall be delivered sufficiently early to permit setting the anchor bolts when the structural concrete is placed. Two nuts shall be furnished for each bolt. Unless otherwise shown or specified, anchor bolts for items of equipment mounted on baseplates shall be long enough to permit 1-1/2-inches of grout beneath the baseplate and to provide adequate anchorage into structural concrete.
5. Equipment Bases: A cast iron or welded steel baseplate shall be provided for each pump and other item of equipment that is to be installed on a concrete base. Each baseplate shall support the unit and its drive assembly, and shall be of a neat design with pads for anchoring the units. Baseplates shall be anchored to the concrete base with suitable anchor bolts and grouted in place.

C. Equipment Guards: All belts or chain drives, fan blades, couplings, and other moving or rotating parts shall be covered on all sides by a safety guard. All safety guards in outdoor locations shall be designed to prevent the entrance of rain and dripping water.

D. Special Tools and Accessories: Equipment requiring periodic repair and adjustment shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.

E. Standard Specifications prepared by recognized organizations mentioned elsewhere shall govern except as provided otherwise by these Specifications and/or its accompanying drawings. Special care shall be exercised in requests for quotations and in orders, to refer to the Standard Specifications and to all modifications thereof.

F. Standard Codes, Regulations, and Specifications: Unless indicated or specified otherwise, all materials and workmanship for the mechanical trades shall conform

to the editions of the various standards, codes, manuals, and Specifications in effect on the date of advertisement for bids, which are referred to in the various Sections herein.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT

A. General: All equipment shall be boxed, crated, or otherwise completely enclosed and protected during shipment, handling, and storage. All equipment shall be protected from exposure to the elements and shall be kept thoroughly dry at all times.

B. Painted surfaces shall be protected against impact, abrasion, discoloration, and other damage. All painted surfaces which are damaged prior to acceptance of equipment shall be repainted to the satisfaction of the ENGINEER.

C. Electrical equipment, controls, and insulation shall be protected against dust, moisture, or water damage.

3.2 INSTALLATION

A. Installation of materials and equipment specified herein shall be performed in a workmanlike manner by mechanics skilled in their particular trade. Piping and equipment shall be installed square and plumb and accessible for proper operation and service. Installations shall be consistent in completeness and appearance whether enclosed or exposed. Any item which does not present a neat and workmanlike appearance shall be replaced without additional cost to OWNER.

3.3 ELECTRIC WIRING

A. The CONTRACTOR shall do all electric wiring of every type for both power supply and for instrumentation and control in accordance with the provisions specified herein, except for such items as are normally wired at their point of manufacture and so delivered, and unless specifically noted to the contrary herein. The CONTRACTOR shall erect all motors and shall mount all starters and controls, furnishing the supporting structures.

3.4 GUARANTEE

A. The CONTRACTOR shall guarantee all equipment against:
   1. Faulty or inadequate design.
   2. Improper assembly or erection.
   3. Defective workmanship or materials.
   4. Leakage, breakage, or other failure.

B. The guarantee period shall be as defined in the General Conditions.

END OF SECTION

SECTION 01650

STARTING OF SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Description
   1. This Section contains requirements for CONTRACTOR'S performance in documenting testing Work required under this Contract. In addition, this Section contains requirements for CONTRACTOR'S starting of systems, performance testing during start-up, performance testing of all process, mechanical, electrical, instrumentation, and training. This Section supplements, but does not supersede specific testing requirements, found elsewhere in the Contract Documents.

1.2 SUBMITTALS

A. Descriptive submittals shall be made in accordance with Section 01300, Submittals. Submit for approval the following:
   1. A complete description of CONTRACTOR'S plan for documenting the results from the test program in conformance with the requirements of Paragraph 2.1.A., below, including:
      a. Proposed plan for documenting the calibration of all test instruments.
      b. Proposed plan for calibration of all instrument systems, including flow level meters and all temperature, pressure, weight, and analysis systems.
      c. Sample forms for documenting the results of field pressure and performance tests.
   2. The credentials and certification of the testing laboratory proposed by CONTRACTOR for calibration of all test equipment.
   3. Pre-start-up check out procedures reviewed and approved by the respective equipment manufacturers.
   4. Detailed testing plans, setting forth step-by-step descriptions of the procedures proposed by CONTRACTOR for the systematic start-up and performance testing of all equipment and systems installed under this Contract.
   5. A schedule and subsequent updates, presenting CONTRACTOR'S plan for start-up and performance testing the equipment and systems installed under this Contract.
   6. A schedule establishing the expected time period (calendar dates) when CONTRACTOR plans to commence performance testing of the completed systems, along with a description of the temporary systems and installations planned to allow operational testing to take place.
   7. All records produced during the start-up and testing program.

8. Systems or unit process or any piece of equipment shall not be started up without the approved Operation and Maintenance Manuals being turned over to the OWNER.
9. Written notice to ENGINEER a minimum of 72 hours prior to beginning of any test.

B. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. CONTRACTOR shall submit soft copies and hard copies per Specification 01300, Submittals. Soft copies shall be in DVD format and shall include all information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

PART 2 - PRODUCTS

2.1 DOCUMENTATION

A. Documentation Plans:
1. CONTRACTOR shall develop a records keeping system to document compliance with the requirements of this Section. Calibration documentation shall include identification (by make, manufacturer, model, and serial number) of all test equipment, date of original calibration, subsequent calibrations, calibration method, and test laboratory.
2. Equipment and system documentation shall include date of test, equipment number or system name, nature of test, test objectives, test results, test instruments employed for the test and signature spaces for the OWNER'S and ENGINEER'S witnesses. A separate file shall be established for each system and item of equipment. These files shall include the following information as a minimum:
   a. Metallurgical tests.
   b. Factory performance tests.

c. Accelerometer recordings made during shipment.
d. Field calibration tests[1].
e. Field pressure tests[1].
f. Field performance tests[1].
g. Field operational tests[1].

([1] Each of these tests are required even though not specifically noted in detailed Specification Section.)

3. Upon completion of testing described in this Section, the CONTRACTOR shall provide the results to the OWNER on complete set of the final as-built P&ID drawings to be kept at the project site for reference. The drawings shall be on 11-inch by 17-inch bond and shall be laminated.

B. Test Plans:
1. CONTRACTOR shall develop test plans detailing the coordinated, sequential testing of each item of equipment and system installed under this Contract. Each test plan shall be specific to the item of equipment or system to be tested. Test plans shall identify by specific equipment or tag number each device or control station to be manipulated or observed during the test procedure and the specific results to be observed or obtained. Test plans shall also be specific as to support systems required to complete the test work, temporary systems required during the test work, subcontractors, and manufacturers' representatives to be present and expected test duration. As a minimum, the test plans shall include the following features:
   a. Step-by-step proving procedure for all control and electrical circuits by imposing low voltage currents and using appropriate indicators to affirm that the circuit is properly identified and connected to the proper device.
   b. Calibration of all analysis instruments and control sensors.
   c. Performance testing of each individual item of mechanical, electrical, and instrumentation equipment. Performance tests shall be selected to duplicate the operating conditions described in the Contract Documents.
   d. System performance tests designed to duplicate, as closely as possible, operating conditions described in the Contract Documents.
2. Test plans shall contain a complete description of the procedures to be employed to achieve the desired test environment.
3. As a condition precedent to receiving progress payments in excess of 75% of the Contract amount, or in any event, progress payments due to CONTRACTOR eight weeks in advance of the proposed date the CONTRACTOR intends to begin any testing work (whichever occurs earliest in the Project Schedule), CONTRACTOR shall have submitted all test plans required for the systematic field performance and operational tests for all equipment and systems installed under this Contract. Once the ENGINEER has reviewed and approved CONTRACTOR'S test plans, CONTRACTOR shall reproduce the plans in sufficient number for CONTRACTOR'S purposes and an additional 10 copies for delivery to the ENGINEER. No test

work shall begin until the CONTRACTOR has delivered the specified number of final test plans to the ENGINEER.

C. Testing Schedule: CONTRACTOR shall provide a start-up and testing schedule setting forth the sequence contemplated for performing the test work. The schedule shall be a CPM format, plotted against calendar time, shall detail the equipment and systems to be tested. The schedule shall show the contemplated start date, duration of the test, and completion of each test. The test schedule shall be submitted no later than four weeks in advance of the date testing is to begin. The ENGINEER will not witness any testing work for the purpose of acceptance until CONTRACTOR has submitted a test schedule and the ENGINEER approves. The test schedule shall be updated weekly, showing actual dates of test work, indicating systems and equipment testing completed satisfactorily, and meeting the requirements of the Contract Documents.

2.2 SYSTEM AND EQUIPMENT PERFORMANCE TESTS

A. Each item of mechanical, electrical, and instrumentation installed under this Contract shall be tested to demonstrate compliance with the performance requirements of the Contract Documents. Each process, electrical instrumentation, mechanical, and piping installed or modified under this Contract shall be tested in accordance with the requirements of the Contract Documents.

B. Once all equipment and systems have been tested individually, CONTRACTOR shall proceed with performance testing in accordance with the requirements of Part 3, below, simulating actual operating conditions to the greatest extent possible. CONTRACTOR shall install temporary connections, bulkheads and make other provisions to recirculate process fluids or otherwise simulate anticipated operating conditions. During the operational testing period, CONTRACTOR'S quality assurance manager and testing team shall monitor the characteristics of each machine and system and report any unusual conditions to the ENGINEER.

PART 3 - EXECUTION

3.1 GENERAL

A. CONTRACTOR shall organize teams made up of qualified representatives of equipment suppliers, subcontractors, CONTRACTOR'S independent testing laboratory, and others, as appropriate to efficiently and expeditiously calibrate and test the equipment and systems installed and constructed under this Contract. The objective of the testing program shall be to demonstrate, to the OWNER'S and ENGINEER'S complete satisfaction, that the structures, systems, and equipment constructed and installed under this Contract meets all performance requirements and the facility is substantially complete and ready for the commissioning process

to commence. In addition, the testing program shall produce baseline-operating conditions for the OWNER to use in a Preventive Maintenance Program.

3.2 CALIBRATION OF FIXED INSTRUMENTS

A. Calibration of analysis instruments, sensors, gages, and meters installed under this Contract shall proceed on a system-by-system basis. No equipment or system performance test shall be performed until all instruments, gages, and meters to be installed in that particular system have been calibrated and the calibration work has been witnessed by the OWNER and ENGINEER.

3.3 PERFORMANCE TESTS

A. General: Performance tests shall consist of the following:
   1. Pressure or leakage tests.
   2. Electrical testing as specified in Division 16, Electrical.
   3. Wiring and piping, individual component, loop, loop commissioning, and tuning testing as specified in Division 17, Instrumentation.
   4. Pre-start-up check out for all mechanical equipment specified in Division 15, Mechanical. Pre-start-up check out procedures shall be reviewed and accepted by the respective equipment manufacturer.
   5. Individual and system tests of all process, mechanical, electrical, and instrumentation equipment and systems shall demonstrate compliance with the performance requirements of the Contract Documents.

B. Performance tests for any individual system shall be performed in the order listed above. The order may be altered only on the specific written authorization of the ENGINEER after receipt of a written request, complete with justification for the change in sequence.

C. Pressure and Leakage Tests: Pressure and leakage tests shall be conducted in accordance with applicable Sections. All acceptance tests shall be witnessed by the ENGINEER. Evidence of successful completion of the pressure and leakage tests shall be the ENGINEER'S signature on the test forms prepared by CONTRACTOR.

D. Equipment Checkout: Prior to energization (in the case of electrical systems and equipment), all circuits shall be rung out and tested for continuity and shielding in accordance with the requirements of Division 16, Electrical.

E. Component Calibration and Loop Testing: Prior to energization (in the case of instrumentation system and equipment), all loops and associated instruments shall be calibrated and tested, as specified in Division 17, Instrumentation.

F. Electrical Resistance: Electrical resistance testing shall be in accordance with the requirements of Division 16, Electrical.

G. Pre-Start-up Tests: Pre-start-up tests shall include the following:
   1. Alignment of equipment using reverse dial indicator method.
   2. Pre-operation lubrication.
   3. Tests in accordance with the manufacturers' recommendations for pre-start preparation and pre-operational check out procedures.

3.4 EQUIPMENT START-UP

A. The CONTRACTOR, in the presence of OWNER and ENGINEER, shall place the newly installed equipment and facilities into operation and test, observe, and adjust all items until the units are properly adjusted and operating in accordance with the requirements of the manufacturer's data and the Contract Documents. After the new equipment has been put into operation, CONTRACTOR, ENGINEER, and plant operator shall go over in detail the standard operating procedures of the equipment. The Work performed by CONTRACTOR shall include, but not be limited to, the following items:
   1. Marking and numbering all valves, gates, and equipment which have been numbered in the Contract Documents. All valves and gates shall be labeled with the appropriate equipment identification tag as shown on the Drawings.
   2. Labeling switches.
   3. Testing of pumps and equipment for proper operation and verifying alignment and capacity.
   4. Checking all electrical, electronic, and remotely controlled equipment for proper operation as specified under Section 01400, Quality Control.
   5. Marking all new exposed pipelines for identification as specified in Section 09900, Painting, and as labeled on the Drawings for pipe material, size, service, and direction of flow.
   6. Testing of unit processes for proper operations.
   7. Making all equipment adjustments required.

3.5 SUPERVISION OF INSTALLATION AND START-UP BY MANUFACTURER

A. An experienced, competent, and factory employed representative of the equipment manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation and shall be present when the equipment is placed in operation. The equipment manufacturer's representative shall revisit the job site as often as necessary until any trouble is corrected and the equipment installation and operation is satisfactory to the OWNER. The equipment manufacturer's representative shall furnish to OWNER a written report certifying that the equipment:
   1. Has been properly installed and lubricated.
   2. Is in accurate alignment.
   3. Is free from any undue stress imposed by connecting piping or anchor bolts.
   4. Has been operated under full load conditions and that it operated satisfactorily.

B. A resume of each factory personnel assigned to supervise installation and train OWNER'S personnel shall be submitted to the ENGINEER for approval prior to scheduling training and installing the equipment.

3.6 SYSTEM PERFORMANCE TESTS

A. General: Once all affected equipment has been subjected to the required pre-operational check out procedures and the ENGINEER has witnessed and has not found deficiencies in that portion of the Work, individual items of equipment and systems may be started and operated under simulated operating conditions to determine, as nearly as possible, whether the equipment and systems meet the requirements of these Specifications.

B. For each system performance test phase, the equipment shall be operated a sufficient period of time to determine machine operating characteristics, including noise, temperatures and vibration; to observe performance characteristics; and to permit initial adjustment of operating controls and shall last no less than seven continuous days. When testing requires the availability of auxiliary systems such as looped piping, electrical power, compressed air, control air, or instrumentation which have not yet been placed in service, CONTRACTOR shall provide acceptable substitute sources, capable of meeting the requirements of the machine, device, or system, at no additional cost to the OWNER. Disposal methods for test media shall be subject to review and approval by the OWNER and ENGINEER. During the performance test period, CONTRACTOR shall obtain baseline-operating data on all equipment with motors greater than 1 horsepower to include amperage, bearing temperatures, and vibration. The baseline data shall be collected for the OWNER to enter in a Preventive Maintenance Program.

C. Test results shall be within the tolerances set forth in the detailed Specification Sections of the Contract Documents. If no tolerances have been specified, test results shall conform to tolerances established by recognized industry practice. Where, in the case of an otherwise satisfactory performance test, any doubt, dispute, or difference should arise between the ENGINEER and CONTRACTOR regarding the test results or the methods or equipment used in the performance of such test, then the ENGINEER may order the test to be repeated. If the repeat test, using such modified methods or equipment as the ENGINEER may require, confirms the previous test, then all costs in connection with the repeat test will be paid by the OWNER. Otherwise, the costs shall be borne by CONTRACTOR. Where the results of any performance test fail to comply with the Contract requirements for such test, then such repeat tests as may be necessary to achieve the Contract requirements shall be made by CONTRACTOR at his expense.

D. CONTRACTOR shall provide, at no expense to the OWNER, all power, fuel, compressed air supplies, water, and chemicals, all labor, temporary piping, heating, ventilating, and air conditioning for any areas where permanent facilities

are not complete and operable at the time of functional tests, and all other items and Work required to complete the functional tests. Temporary facilities shall be maintained until permanent systems are in service.

E. Should the testing period be halted for any reason, the operational testing program shall be repeated, until the specified continuous period has been accomplished without interruption. All process units shall be brought to full operating conditions, including temperature, pressure, flow and level.

F. Record Documents shall conform to the requirements of Section 01300, Submittals, of facilities involved shall be accepted and ready for turnover to the OWNER 72 hours prior to operational testing.

G. Phase Retesting: If under test, any portion of the Work should fail to fulfill the Contract requirements and is adjusted, altered, renewed, or replaced, tests on that portion when so adjusted, altered, removed, or replaced, together with all other portions of the Work as are affected thereby, shall, unless otherwise directed by the ENGINEER, be repeated within reasonable time and in accordance with the specified conditions. CONTRACTOR shall pay to the OWNER all reasonable expenses incurred by the OWNER, including the costs of the ENGINEER, as a result of repeating such tests.

H. Post-Test Inspection: Once testing has been completed, all machines shall be rechecked for proper alignment and realigned, as required. All equipment shall be checked for loose connections, unusual movement, or other indications of improper operating characteristics. Any deficiencies shall be corrected to the satisfaction of the ENGINEER. All machines or devices which exhibit unusual or unacceptable operating characteristics shall be disassembled and inspected. Any defects found during the course of the inspection shall be repaired or the specific part or entire equipment item shall be replaced to the complete satisfaction of the ENGINEER, at no additional cost to the OWNER.

3.7 TRAINING

A. The CONTRACTOR shall provide experienced, competent manufacturers' representatives to train OWNER'S personnel in operation and maintenance procedures for equipment items specified below during the start-up period at no additional cost to OWNER. The lesson plans for these sessions shall be reviewed with the OWNER and the ENGINEER in one meeting prior to initiating training. Lesson plans shall be submitted to the ENGINEER not less than one week prior to this meeting. CONTRACTOR will video tape the manufacturers' training sessions and provide OWNER with DVD format professional quality discs of the training sessions. The representatives shall present training programs and on-site demonstrations designed to fully acquaint plant personnel with all equipment features, routine scheduled maintenance procedures, alternative operational modes, emergency procedures, spare parts inventories, and demonstrate

performance requirements of the Specifications. Representatives shall remain on-site to observe operation of the equipment and further advise plant personnel for a minimum number of days as specified below, unless specified otherwise in equipment specifications. The following table is not a complete list of equipment training. See individual Specifications for additional training.

Equipment	Additional Training Days (Day = 8 hrs min.)
11200, Above Ground Pump Station with Duplex Self-Priming Pumps	1
11400, Pre-cast Lift Station	1/2
16001, Pump Systems and Control Panels	1/2
16161, Control Panels	1/2
Division 17, Instrumentation	1

B. A complete schedule of representatives and dates for operator training shall be submitted to OWNER prior to commencement of the start-up period. This schedule shall be prepared to accommodate the plant staff's work schedules, including training on all shifts and staff's flex time.

END OF SECTION

SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.1 SUMMARY

A. Tasks listed under this Section shall be completed prior to Contract closeout and approval of the CONTRACTOR'S final pay request.

1.2 RELATED SECTIONS

A. Section 01300, Submittals.

B. Section 01650, Starting of Systems.

1.3 CONTRACT CLOSEOUT SUBMITTALS

A. The following documents are to be submitted as specified to the ENGINEER prior to approval of the CONTRACTOR'S final pay request:
   1. Record Drawings shall be furnished by the CONTRACTOR. One set of bluelines annotated to show all changes shall be delivered by the CONTRACTOR to the ENGINEER. The Record Drawings shall reflect all changes made by Change Order, addenda, field order, work directive, and any other changes made and approved during the course of the Work.
   2. Certification of Final Completion.
   3. Evidence of Payment and Release of Labor and Material Liens as outlined in the Conditions of the Contract. These documents shall be furnished by the CONTRACTOR and all subcontractors.
   4. Release of claims as outlined in the Conditions of the Contract.
   5. Copies of written warranties shall be furnished for each individual item of equipment. The names, addresses, and phone numbers of the manufacturer's representatives shall be included.
   6. Operation and Maintenance Manuals shall be furnished for each individual item of equipment as specified in Section 01300, Submittals.
   7. Evidence of compliance with requirements of governing authorities, including Certificate of Occupancy and Certificates of Inspection.
   8. Equipment manufacturer's start-up reports shall be furnished as specified in Section 01400, Quality Control.
   9. The CONTRACTOR shall submit all maintenance stock items, spare parts, and special tools.
   10. Two copies of all training video tapes made in accordance with Section 01650, Starting of Systems.

1.4 SITE CONDITIONS

A. Prior to approval of the CONTRACTOR'S final pay request and after Work has been completed, the CONTRACTOR shall dispose of all waste material.

B. All areas shall be restored to a condition equal to or better than the original.

C. Site grading shall be performed to the lines and grades as shown or conforming to adjacent contours.

1.5 MAINTENANCE AND GUARANTEE

A. The CONTRACTOR shall comply with the maintenance and guarantee requirements contained in the General Conditions.

B. Replacement of earth fill or backfill, where it has settled below the required finish elevations, shall be considered as a part of such required repair work, and any repair or resurfacing constructed by the CONTRACTOR which becomes necessary by reason of such settlement shall likewise be considered as a part of such required repair work, unless the CONTRACTOR shall have obtained a statement in writing from the affected private owner or public agency releasing the OWNER from further responsibility in connection with such repair or resurfacing.

C. The CONTRACTOR shall make all repairs and replacements promptly upon receipt of written order from the OWNER. If the CONTRACTOR fails to make such repairs or replacements promptly, the OWNER reserves the right to do the Work and the CONTRACTOR and his surety shall be liable to the OWNER for the cost thereof.

1.6 BOND

A. The CONTRACTOR shall provide a bond to guarantee performance of the provisions contained in Paragraph 1.5, above, and the General Conditions.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01710

CLEANING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section outlines requirements for cleaning of the Project Work. This Section is complementary to the General Conditions and nothing herein shall be considered to waive any requirements of the General Conditions.

1.2 REQUIREMENTS OF REGULATORY AGENCIES

A. Safety and Insurance Standards: Maintain Project in accordance with the following safety and insurance standards:
   1. Occupational Safety and Health Administration (OSHA).

B. Fire Protection: Store volatile waste in covered metal containers and remove from premises daily.

C. Pollution Control: Conduct cleanup and disposal operations to comply with local ordinances and anti-pollution laws. Burning or burying of rubbish and waste material on the Project site is not permitted. Disposal of volatile fluid waste (such as mineral spirits, oil, or paint thinner) in storm or sanitary sewer systems or into streams or waterways is not permitted.

PART 2 - PRODUCTS

2.1 CLEANING MATERIAL

A. Use only cleaning materials recommended by manufacturer of surface to be cleaned. Use cleaning materials only on surfaces recommended by cleaning material manufacturer.

PART 3 - EXECUTION

3.1 DURING CONSTRUCTION

A. During the construction period, the material to be used in the Work shall be kept in an orderly manner, neatly stacked, or piled.

B. Clean up frequently (at least weekly) all refuse, rubbish, scrap materials, and debris caused by operations, to the end that at all times the site of the Work shall present a neat, orderly, and workmanlike appearance. Sprinkle dusty debris with water.

C. Provide for the disposal of all waste products, trash, debris, etc., and make necessary arrangement for legal disposal of same off the site. Never throw rubbish from windows or other parts of building. Lower waste materials in a controlled manner with as few handling as possible.

D. Remove all surplus material, false-work, temporary structures, including foundations thereof, plant of any description and debris of every nature resulting from operations and put the site in a neat, orderly condition.

E. Vacuum clean interior building areas when ready to receive finish painting and continue vacuum cleaning on an as-needed basis until building is ready for acceptance.

F. Schedule cleaning operation so that dust and other contaminants resulting from cleaning process will not fall on wet, newly painted surfaces.

G. General Contractor shall provide trash gondolas or containers for use by all trades.

3.2 FINAL CLEANING

A. Use experienced workmen or professional cleaners for final cleaning. Provide adequate ventilation during use of volatile or noxious substances.

B. Besides general broom cleaning, do the following special cleaning for all trades at completion of Work:
   1. Remove putty stains from glass; wash, polish same inside and outside. Exercise care not to scratch glass.
   2. Remove marks, stains, fingerprints, other soil, dirt from painted, decorated, or stained work.
   3. Clean, polish, and wax woodwork.
   4. Clean and polish hardware for removal of stains, dust, dirt, paint, and the like.
   5. Remove spots, soil, paint from tile and similar work; wash same.
   6. Clean fixtures and equipment; remove stains, paint, dirt, and dust.
   7. Remove temporary floor protections.
   8. Clean and polish all floors.
   9. Remove all temporary protections at the site.
   10. Clean exterior and interior metal surfaces including doors and windows of oil, stains, dust, dirt, paint and the like.
   11. Clean and vacuum all carpeted areas.

C. Make buildings ready for occupancy in all respects. Lay heavy building paper in main circulation areas to protect the floors until final inspection and acceptance.

D. All existing improvements inside or outside the property which are disturbed, damaged, or destroyed by the Work under the Contract shall be restored to the condition in which they originally were, or to the satisfaction of the ENGINEER.

END OF SECTION

SECTION 01715

TESTING OF HYDRAULIC STRUCTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, appurtenances, and services required to clean, flush, and test following structure:
      a. Lift Station Wet Well.

B. The structure shall be cleaned in accordance with Paragraph 3.1 of this Section.

C. Water for initial testing shall be furnished by the CONTRACTOR. CONTRACTOR shall provide all temporary piping, hose, valves, appurtenances, and services required. Cost of water for retesting will be paid by CONTRACTOR.

1.2 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Letters of Certification of Compliance on materials, equipment, etc.
   2. Testing procedures, methods, coordination, and schedules.
   3. General bullet and product literature describing concrete void filter.

B. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. CONTRACTOR shall submit soft copies and hard copies per Specification 01300, Submittals. Soft copies shall be in DVD format and shall include all

information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CLEANING

A. All scaffolding, planks, tools, rags, dirt, debris, and any other material not part of the structural or operating facilities shall be removed prior to hydraulic testing. The surfaces of the walls, floors, and operating facilities shall then be thoroughly cleaned by sweeping, a high pressure water hose, scrubbing, or another equally effective method. All water, dirt, or foreign material accumulated in this operation shall be removed from the storage facility.

3.2 HYDRAULIC TESTING

A. Testing shall be performed prior to backfilling, except where otherwise permitted by the ENGINEER. Testing shall not be performed sooner than 14 days after all portions of structure walls have been completed. The test shall consist of filling the structure with water to the maximum operating water surface. After testing has been completed, water shall be disposed of as directed by the ENGINEER.

B. The structure shall remain filled for an initial 48 hour period to allow for absorption. Following this initial period, add make up water to fill the tank to the maximum level specified above. Measure the drop in liquid level following the next 24 hour period to determine the volume of liquid loss. An allowance for loss due to evaporation over the 24 hour test period, calculated by an approved method, shall be subtracted from the measured liquid loss. The net amount shall not exceed 0.1% of the tank capacity or the volume to which the tank was filled. No visible running leaks, water puddles, or damp spots which show on the exterior surface of the tank will be permitted.

C. The structure shall not be backfilled until the ENGINEER has accepted the results of the leakage tests.

D. After all testing is complete and accepted, the structure shall be emptied.

END OF SECTION

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Preparing and grading subgrades for the lift station site.
   2. Excavating and backfilling for underground piping and electrical utilities and appurtenances.

B. Related Section: The following Section contains requirements that relate to this Section.
   1. Section 03300, Cast-In-Place Concrete, for concrete encasings, cradles, mechanical equipment pads, and appurtenances for utility systems.

1.2 DEFINITIONS

A. Excavation consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.

B. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

C. Borrow: Soil material obtained off-site when sufficient approved soil material is not available from excavations.

D. Subbase Course: The layer placed between the subgrade and base course in a paving system or the layer placed between the subgrade and surface of a pavement or walk.

E. Base Course: The layer placed between the subbase and surface pavement in a paving system.

F. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the ENGINEER. Unauthorized excavation, as well as remedial work directed by the ENGINEER, shall be at the CONTRACTOR'S expense.

G. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.

H. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within building lines.

1.3 SUBMITTALS

A. General: Submit the following according to Specification Section 01300, Submittals.

B. Product Data for the following:
   1. Each type of plastic warning tape.

C. Samples of the following:
   1. 60 lb representative samples of each proposed fill and backfill soil material from on-site or borrow sources.

D. Test Reports: In addition to test reports required under field quality control, submit the following:
   1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources.
   2. One optimum moisture-maximum density curve for each soil material.

E. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

F. CONTRACTOR shall submit soft copies and hard copies. Soft copies shall be in DVD format and shall include all information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Perform earthwork complying with requirements of authorities having jurisdiction.

B. Pre-installation Conference: Before commencing earthwork, meet with representatives of the governing authorities, OWNER, ENGINEER, consultants, independent testing agency, and other concerned entities. Review earthwork procedures and responsibilities, including testing and inspection procedures and requirements. Notify participants at least three working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.

C. Soils Testing Service: CONTRACTOR shall employ, at his own expense, an independent testing agency, certified in the State of Arizona, to perform all testing services specified herein. Selection of the testing agency is subject to ENGINEER'S approval. Submit a written description of the proposed soils testing agency giving qualifications of personnel, equipment, and other information which may be requested by ENGINEER.

1.5 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the OWNER or others, except when permitted in writing by the ENGINEER and then only after acceptable temporary utility services have been provided.
   1. Provide a minimum 48 hours' notice to the ENGINEER and receive written notice to proceed before interrupting any utility.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide approved borrow soil materials from off-site when sufficient approved soil materials are not available from excavations.

B. Site Soils: Granular site soils may be used as fill in all areas of the site. Any clayey site soils shall not be used as subsurface wall or retaining wall backfill. Clayey sand site soils may be used in all other areas, provided these soils are placed and compacted at moisture contents at or above optimum in exterior slab and facility areas. All materials shall be free of organics, debris, and rubble.

C. Imported Soils: Additional fill required at the site shall be imported soils meeting the following requirements:
   1. Maximum Particle Size: 6-inches.
   2. Maximum Swell Potential: 1.5% based on a sample which is remolded to 95% of the ASTM D698 maximum dry density at a moisture content of 2% below optimum placed under a surcharge of 100 psf and wetted.
   3. Maximum Percent Passing No. 200 Sieve: 50.

D. Backfill and Fill Materials: Site soils as described above.

E. Subbase and Base Material: Maricopa Association of Governments (MAG) Specification Section 702 for Select (Subbase) Type A or B and aggregate base (base).

F. Engineered Fill: Site soils as described above, subbase or base materials, or aggregate base course (ABC) according to MAG Standard Specification Section 702.

G. Bedding Material: Subbase or base materials with 100% passing a 1-inch sieve and not more than 8% passing a No. 200 sieve.
   1. If on-site material can be used as bedding material, the CONTRACTOR shall take necessary steps to separate the suitable bedding material from the sandy clay and sandy silt found on-site. The bedding material must meet all requirements of this Specifications Document and MAG Standard Specification Section 601.
   2. If on-site material does not meet the bedding material requirements, the CONTRACTOR shall supply the specified bedding material at no additional cost to the OWNER.

H. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6-inches wide and 4 mils thick, continuously inscribed with a description of the utility.
   1. Tape Colors: Provide tape colors to utilities as follows:
      a. Red: Electric.
      b. Yellow: Gas, oil, steam, and dangerous materials.
      c. Orange: Telephone and other communications.
      d. Blue: Water systems.
      e. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

B. Provide erosion control measures following the most current Town of Wickenburg Best Management Practices (BMP) to prevent erosion or displacement of soils and discharge of soil-bearing water runoff per the National Discharge Elimination System (NPDES) or airborne dust to adjacent properties.

3.2 DEWATERING

A. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

3.3 EXCAVATION

A. Explosives: Do not use explosives.

B. Unclassified Excavation: Excavation is unclassified and includes excavation to required subgrade elevations regardless of the character of materials and obstructions encountered.

C. Classified Excavation: Excavation is classified and includes excavation to required subgrade elevations. Excavation will be classified as earth excavation or rock excavation as follows:
   1. Earth excavation includes excavation of obstructions visible on surface; underground structures, utilities, and other items not indicated that are required to be demolished and removed; together with soil and other materials encountered that are not classified as rock or unauthorized excavation.
      a. Intermittent drilling, blasting, or ripping to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation.

3.4 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of ±0.10 feet. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspections. Structure excavation, backfilling, and compaction shall be as specified in MAG Section 206.
   1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other Work.
   2. Excavation for Storage Tanks, Basins, and Mechanical or Electrical Appurtenances: Excavate to elevations and dimensions indicated within a tolerance of ±0.10 feet. Do not disturb bottom of excavations intended for bearing surface.

3.5 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated slopes, lines, depths, and invert elevations.

B. Trench excavation, backfilling, and compaction shall be as specified in MAG Section 601.

3.6 APPROVAL OF SUBGRADE

A. Notify the ENGINEER when excavations have reached required subgrade.

B. When the ENGINEER determines that unforeseen unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
   1. Unforeseen additional excavation and replacement material will be paid according to the Contract provisions for changes in Work.

C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities as directed by the ENGINEER.

3.7 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending indicated bottom elevation of concrete foundation or footing to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position when acceptable to the ENGINEER.
   1. Fill unauthorized excavations under other construction as directed by the ENGINEER.

B. All backfill shall be in accordance with the geotechnical report unless otherwise stated in the Specifications and Drawings.

3.8 STORAGE OF SOIL MATERIALS

A. Stockpile excavated materials acceptable for backfill and fill soil materials, including acceptable borrow materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.
   1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 BACKFILL

A. Backfill excavations promptly, but not before completing the following:
   1. Acceptance of construction below finish grade including, where applicable, damp proofing, waterproofing, and perimeter insulation.

2. Surveying locations of underground utilities for record documents.
3. Testing, inspecting, and approval of underground utilities.
4. Concrete formwork removal.
5. Removal of trash and debris from excavation.
6. Removal of temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. All fill soils to be used beneath foundations, slabs, and pavements must be approved by the Engineer.

3.10 UTILITY TRENCH BACKFILL

A. Place and compact bedding course on rock and other unyielding bearing surfaces and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

B. Concrete backfill trenches that carry below or pass under footings and that are excavated within 18-inches of footings. Place concrete to level of bottom of footings.

C. Provide 4-inch thick concrete base slab support for piping or conduit less than 2 feet 6-inches below surface of roadways. After installation and testing, completely encase piping or conduit in a minimum of 4-inches of concrete before backfilling or placing roadway subbase.

D. Place and compact initial backfill of satisfactory soil material or subbase material, free of particles larger than 1-inch, to a height of 12-inches over the utility pipe or conduit.
   1. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.

E. Coordinate backfilling with utilities testing.

F. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.

G. Place and compact final backfill of satisfactory soil material to final subgrade.

H. Install warning tape directly above utilities, 12-inches below finished grade, except 6-inches below subgrade under pavements and slabs.

3.11 FILL

A. The following apply to the areas within and extending 5 feet beyond the footprint of the facilities and exterior slabs.
   1. Clear and grub the site by removing and disposing of all vegetation, debris, rubble, and remnants of former developments.
   2. Strip the area of all stockpiled fill zones, loose backfill zones, and unstable soils. During stripping observe the surface for evidence of buried debris, vegetation or disturbed materials that shall require additional removal. If encountered, these materials should be removed. Areas steeper than 5H to 1V shall be benched and any depressions widened to accommodate compaction equipment.
   3. Prepare the ground surface in fill areas and in areas cut to grade by scarifying, moisture conditioning, and compacting the exposed surface soils to a depth of 8-inches.
   4. Moisture condition and place all fill and backfill materials to achieve specified grades. Fill materials shall be moisture conditioned, placed, and compacted in horizontal lifts.

B. Place fill material in layers to required elevations for each location listed below.
   1. Under grass, use satisfactory excavated or borrowed soil material.
   2. Under walks and pavements, use subbase or base material, or satisfactory excavated or borrow soil material.
   3. Under steps and ramps, use subbase material.
   4. Under building slabs, use drainage fill material.
   5. Under footings and foundations, use engineered fill.

3.12 MOISTURE CONTROL

A. The moisture content of soil and base materials at the time of compaction shall be:

Type	Area of Use	Moisture Content
On-site Granular	Structure, Exterior Slab	Optimum ±3%
On-site Clayey Soils	Structure, Exterior Slab	Optimum to Optimum +3%
On-site Soils	Pavement	2% Below Optimum or Lower
Imported Soils	Structure, Exterior Slab, Pavement	Optimum ±3%
Base Material	Structure, Pavement	Optimum ±3%

3.13 COMPACTION

A. Place backfill and fill materials 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.

B. Place backfill and fill materials evenly on all sides of structures to required elevations. Place backfill and fill uniformly along the full length of each structure.

C. Compact subgrade, fill, backfill, subbase fill or base material to the following minimum percent compaction of the ASTM D698 maximum dry density in each lift:

Material	Minimum Percent Compaction
Soil	
Below foundations and pavement sections (fill thickness less than 5 feet):	95
Below foundations (fill thickness greater than 5 feet):	100
Below concrete floor slabs (above footings):	90
Subsurface wall backfill:	95
Base Material (Subbase and Base Courses)	
Below concrete floor slabs:	95
Below pavement surfacing:	100
Backfill (Not adjacent to structures and beyond exterior slab areas.):	90
Lift Station Site (Not adjacent to structures.):	90

3.14 GRADING

A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross-sections, lines, and elevations indicated.
   1. Provide a smooth transition between existing adjacent grades and new grades.
   2. Cut out soft spots, fill low spots, and trim high spots to conform to required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
   1. Lawn or Unpaved Areas: ±0.10 feet.
   2. Walks: ±0.10 feet.
   3. Pavements: ±1/2-inch.

C. Grading Inside Building Lines: Finish subgrade to a tolerance of 1/2-inch when tested with a 10 foot straightedge.

3.15 FIELD QUALITY CONTROL

A. Testing Agency Services: Allow testing agency to inspect and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements.
   1. Perform field in-place density tests according to ASTM D 1556 (sand cone method), ASTM D 2167 (rubber balloon method), or ASTM D 2937 (drive cylinder method), as applicable.
      a. Field in-place density tests may also be performed by the nuclear method according to ASTM D 2922, provided that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D 1556. With each density calibration check, check the calibration curves furnished with the moisture gages according to ASTM D 3017.
      b. When field in-place density tests are performed using nuclear methods, make calibration checks of both density and moisture gages at beginning of Work, on each different type of material encountered, and at intervals as directed by the ENGINEER.
   2. Footing Subgrade: Footing subgrades to be reviewed and approved by a representative of the Engineer prior to placement of reinforcing steel.
   3. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, perform at least one field in-place density test for every 2,000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
   4. Foundation Wall Backfill: In each compacted backfill layer, perform at least one field in-place density test for each 100 feet or less of wall length, but no fewer than two tests along a wall face.
   5. Trench Backfill: In each compacted initial and final backfill layer, perform at least one field in-place density test for each 150 feet or less of trench, but no fewer than two tests.
   6. Lift Station Site: At subgrade and at each compacted fill and backfill layer, perform at least one field in-place density test for every 2,000 sq. ft. or less, but in no case fewer than three tests.

B. When testing agency reports that subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, recompact and retest until required density is obtained.

3.16 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace material to depth directed by the ENGINEER; reshape and recompact at optimum moisture content to the required density.

C. Settling: Where settling occurs during the Project correction period, remove finished surfacing, backfill with additional approved material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.17 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Surplus satisfactory soil needs to be hauled to the landfill. Store this soil on the properties until the landfill is ready to accept this soil.

B. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the OWNER'S property.

END OF SECTION

SECTION 02531

MANHOLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, to furnish and install all precast and cast-in-place manholes.

B. General:
   1. Manholes shall conform in shape, size, dimensions, material, and other respects to the details shown on the Drawings or as directed by ENGINEER.
   2. Cast iron frames, grates and covers shall be the standard frame and grate or cover, unless otherwise shown on the Drawings, and shall be as specified in the Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments (MAG).
   3. All manholes shall be precast construction, unless otherwise shown on the Drawings.
   4. All proposed manholes shall not have access steps of any kind.
   5. All proposed manhole lids shall be non-locking.
   6. All proposed manholes that receive raw sewage shall be lined with a corrosion resistant lining system, Saureisen 210 or approved equal.

1.2 QUALITY ASSURANCE

A. Standard Specifications and Details:
   1. Conform to all applicable requirements of Section 625 and all applicable requirements of Part No. 600 and 700 of the Uniform Standard Specifications for Public Works Construction by MAG. If there is a conflict between MAG Standard Specifications and these Specifications, the provision of these Specifications shall govern.
   2. All precast concrete sewer manholes shall conform to MAG Standard detail 420.

B. Reference Standards: Comply with the applicable provisions and recommendations of the following, unless otherwise shown or specified.
   1. ASTM C 139, Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.
   2. ASTM C 140, Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   3. ASTM C 207, Specification for Hydrated Lime for Masonry Purposes.

4. AWWA C 302, Reinforced Concrete Pressure Pipe, Noncylinder Type, for Water and Other Liquids.
5. MAG Section 625.
6. ASTM A48, Specification for Gray Iron Castings.
7. American Concrete Institute (ACI):
    a. 318; Building Code Requirements for Structural Concrete.
    b. 350; Code Requirements for Environmental Engineering Concrete Structures
8. International Counsel Code:
    a. IBC, International Building Code, 2003.
9. Precast/Prestressed Concrete Institute (PCI):
    a. Manuals.
    b. ASTM C478-06a, Standard Specification for Precast Reinforced Concrete Manhole Sections
    c. ASTM C857-95 (2001), Standard Practice for minimum Structural Design Loading for Underground Precast Concrete Utility Structures.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
    1. Drawings showing design and construction details of all precast concrete and cast-in-place manholes, including details of joints between the manhole bases and riser sections and stubs or openings for connections.

PART 2 - PRODUCTS

2.1 PRECAST CONCRETE MANHOLES

A. Precast manholes shall conform to the details shown on the Drawings. Provide cast-in-place concrete bases.

B. Except where otherwise specified, precast manhole components shall consist of reinforced concrete pipe sections especially designed for manhole construction and manufactured in accordance with ASTM C 478, except as modified herein.

C. Precast, reinforced concrete manhole bases, riser sections, flat slabs and other components shall be manufactured by wet cast methods only, using forms which will provide smooth surfaces free from irregularities, honeycombing or other imperfections.

D. Joints between manhole components shall be the tongue and groove type employing a single, gasket per MAG 420-1 and shall conform to AWWA C478. The circumferential and longitudinal steel reinforcement shall extend into the bell and spigot ends of the joint without breaking the continuity of the steel. Joints

between the base sections, riser sections and top slabs of manholes shall be gasket per MAG 420-1.

E. All precast manhole components shall be of approved design and of sufficient strength to withstand the loads imposed upon them. They shall be designed for a minimum earth cover loading of 130 pounds per cubic foot, an H-20 wheel loading, and an allowance of 30 percent in roadways and 15 percent in rights-of-way for impact. Manhole bases shall have two cages of reinforcing steel in their walls, each of the area equal to that required in the riser sections. Wall thickness shall not be less than 5-inches. Concrete adjusting rings shall not be less than 6-inches thick.

F. Lifting holes, if used in manhole components, shall be tapered, and no more than two shall be cast in each section. Tapered, solid rubber plugs shall be furnished to seal the lifting holes. The lifting holes shall be made to be sealed by plugs driven from the outside face of the section only.

G. The point of intersection (P.I.) of the sewer pipe centerlines shall be marked with 1/4-inch diameter steel pin firmly enclosed in the floor of each manhole base and protruding approximately 1-inch above the finished floor of the base.

H. Mark date of manufacture and name or trademark of manufacturer on inside of barrel.

I. The barrel of the manhole shall be constructed of various lengths of riser pipe manufactured in increments of one foot to provide the correct height with the fewest joints. Openings in the barrel of the manholes for sewers or drop connections will not be permitted closer than one foot from the nearest joint. Special manhole base or riser sections shall be furnished as necessary to meet this requirement.

J. A precast or cast-in-place slab or precast eccentric cone, as shown on the Drawings or approved by the ENGINEER, shall be provided at the top of the manhole barrel to receive the cast iron frame and cover.

2.2 MISCELLANEOUS METALS

A. Metal frames, covers, and similar required items shall be provided.

B. Castings:
   1. Gray Iron Castings: ASTM A48, Class 30A.
   2. Materials:
      a. Manhole Frames with Covers:
         1) Roadway standard with 30-inch opening and cast covers conforming to the MAG Standard Detail No. 424, except where otherwise shown on the Drawings.

2) Lettering:
a) Agency name shall be “Town of Wickenburg”
b) Utility name shall be “Sanitary Sewer.”

b. Product and Manufacturer:
1) Neenah Foundry Company R-1743.
2) Or approved equal.

3. Design and Fabrication:
a. Design round frames and covers to prevent rocking and rattling under traffic.
b. Fabricate castings true to pattern so that component parts fit together.

2.3 DROP CONNECTIONS

A. Drop connections for manholes shall be constructed where required by MAG detail 426 or directed by the ENGINEER and shall conform to MAG detail 426. Pipe and fittings shall be reinforced concrete, as shown on the Drawings or otherwise approved by the ENGINEER. Concrete for pipe encasement shall be Class "C" as specified under MAG specification section 725. Concrete shall be bonded to manhole in the manner shown on the Drawings or otherwise approved by ENGINEER.

PART 3 - EXECUTION

3.1 PLASTERING

A. The outside of grading rings shall be neatly plastered with 1/2-inch of cement mortar as the Work progresses.

3.2 MANHOLE BASES

A. Cast-in-place bases shall be placed on suitable foundations after the pipes are laid. They shall be cast monolithically to an elevation at least 3-inches above the top of the highest pipe entering the manhole, except where a drop connection is to be installed. Base, walls and bottom shall be at least of the thickness shown on the Drawings and reinforced to withstand the loads to be expected. Connections for sewer pipes shall conform to the details shown on the Drawings.

B. Precast bases shall be set on a concrete or crushed stone foundation, as shown on the Drawings. Precast bases shall be set at the proper grade and carefully leveled and aligned.

3.3 PRECAST MANHOLE SECTIONS

A. Set sections vertical and in true alignment. The base of the bell or groove end at joints between components shall be buttered with 1:2 cement-sand mortar to provide a uniform bearing between components. All joints shall be sealed with cement mortar inside and out and troweled smooth to the contour of the wall surface. Raised or rough joint finishes will not be accepted.

B. Install sections, joints and gaskets in accordance with manufacturer's recommendations.

C. Lifting holes shall be sealed tight with a solid rubber plug driven into the hole from the outside of the barrel and the remaining void filled with 1 to 2 cement-sand mortar.

3.4 MANHOLE CHANNELS

A. All invert channels through manholes shall be constructed of Class "AA" concrete as specified under MAG Specification section 725. Channels shall be properly formed to the sizes, cross sections, grades and shapes shown on the Drawings or as directed by the ENGINEER. Benches shall be built up to the heights shown on the Drawings or as directed by the ENGINEER and given a uniform wood float finish. Care shall be taken to slope all benches for proper drainage to the invert channel.

3.5 GRADING RINGS

A. Grading rings shall be used for all precast manholes, where required. Grade rings shall be a maximum of 12-inches in height, constructed on the roof slab or cone section on which the manhole frame and cover shall be placed. The height of the grade rings shall be such as is necessary to bring the manhole frame to the proper grade.

B. Each grading ring shall be laid in a full bed of mortar and shall be thoroughly bonded.

3.6 STUBS FOR FUTURE CONNECTIONS

A. As shown on the Drawings or required for connections, vitrified-clay pipe stubs with approved watertight plugs shall be installed in manholes. Where pipe stubs, sleeves or couplings for future connections are shown on the Drawings or directed by the ENGINEER, provide all materials and labor in order to complete the Work.

3.7 GRADING AT MANHOLES

A. All manholes in unpaved areas shall be built, as shown on the Drawings or directed by the ENGINEER, to an elevation higher than the original ground. The

ground surface shall be graded to drain away from the manhole. Fill shall be placed around manholes to the level of the upper rim of the manhole frame, and the surface evenly graded on a 1 to 5 slope to the existing surrounding ground, unless otherwise shown on the Drawings or directed by the ENGINEER. The slope shall be covered with 4-inches of top soil, seeded and maintained until a satisfactory growth of grass is obtained.

B. Manholes in paved areas and areas receiving gravel shall be constructed to meet the final surface grade as shown on the Drawings.

C. Sole responsibility for the proper height of all manholes necessary to reach the final grade at all locations belongs to CONTRACTOR. Caution: ENGINEER'S review of Shop Drawings for manhole components will be general in nature, provide an adequate supply of random length precast manhole riser sections to adjust any manhole to meet field conditions for final grading.

3.8 MANHOLE WATERTIGHTNESS

A. All manholes shall be free of visible leakage. Each manhole shall be tested for leaks and inspected, and all leaks shall be repaired in a manner subject to ENGINEER'S approval. Manhole testing shall conform to the requirements of Section 15051, Buried Piping Installation.

3.9 FLEXIBLE PIPE JOINT AT MANHOLE BASE

A. An approved flexible joint shall be provided between each pipe entering and exiting the manhole. This may be accomplished by the installation in the manhole base of the bell end of a pipe or by other means subject to approval of ENGINEER. Joints shall be similar to the approved pipe joints. The joint into the manhole base shall be completely watertight.

3.10 MANHOLE COVER AND FRAME INSTALLATION

A. Follow manufacturer's printed instructions and approved Shop Drawings.

B. Manhole lids shall be non-locking.

C. Set castings accurately to required location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Brace temporarily or anchor temporarily in formwork.

D. Protection from Dissimilar Materials:
   1. Coat all aluminum surfaces in contact with dissimilar materials such as concrete, masonry, steel and other metals as specified in Section 09900, Painting.

3.11 PROTECTION COATING SYSTEM

A. All manholes and sanitary sewer junction structures interior surface shall be lined with a corrosion resistant lining per specification 09910, Special Finishes.

END OF SECTION

SECTION 03100

CONCRETE FORMWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete formwork. The Work also includes:
      a. Providing openings in formwork to accommodate the Work under this and other Sections and building into the formwork all items such as sleeves, anchor bolts, inserts, and all other items to be embedded in concrete for which placement is not specifically provided under other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the formwork.
   2. Coordinate formwork Specifications herein with the requirements for finished surfaces specified in Section 03300, Cast-In-Place Concrete.

C. Related Sections:
   1. Section 03200, Concrete Reinforcement.
   2. Section 03251, Concrete Joints.
   3. Section 03300, Cast-In-Place Concrete.

1.2 QUALITY ASSURANCE

A. Standard Specifications and Details:
   1. CONTRACTOR shall conform to all applicable requirements of Section No. 505 of the Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments (MAG). Where there is conflict between MAG Standard Specifications and this Specification, provisions of this Specification shall govern.
   2. CONTRACTOR shall examine the substratum and the conditions under which concrete framework is to be performed, and notify the ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to the ENGINEER.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:

1. ACI 301, Specifications for Structural Concrete for Buildings.
2. ACI 347, Guide for Concrete Formwork.
3. US Product Standard, PS-1, latest edition.

C. Allowable Tolerances:
   1. Construct formwork to provide completed concrete surfaces complying with tolerances specified in ACI 347, Chapter 3.3, except as otherwise specified.

D. All items for permanent or temporary facilities shall be used in accordance with manufacturer's instructions.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Submit for information purposes the following:
      a. Copies of manufacturer's data and installation instructions for proprietary materials, including form coatings, manufactured form systems, ties, and accessories.

B. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. CONTRACTOR shall submit soft copies and hard copies per Specification 01300, Submittals. Soft copies shall be in DVD format and shall include all information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. On delivery to job site, place materials in area protected from weather.

B. Store materials above ground on framework or blocking. Cover wood for forms with protective waterproof covering. Provide for adequate air circulation or ventilation.

C. Handle materials to prevent damage.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

A. Forms for Exposed Finish Concrete:
   1. Unless otherwise shown or specified, construct formwork for exposed concrete surfaces with plywood, metal, metal-framed plywood-faced, or other panel type materials acceptable to ENGINEER, to provide continuous, straight, smooth as-cast surfaces. Furnish in largest practical sizes to minimize number of joints and to conform to joint system shown or specified. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.

B. Forms for Unexposed Finish Concrete:
   1. Form concrete surfaces that will be unexposed in the finished structure with plywood, lumber, metal, or other acceptable material. Provide lumber that is dressed on at least two edges and one side.

C. Cylindrical Columns and Supports:
   1. Form round section members with paper or fiber tubes, constructed of laminated plies using water-resistant type adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation.
      a. Provide manufacturer's seamless units to minimize spiral gaps or seams.
   2. Fiberglass or steel forms may be used for cylindrical columns if approved by ENGINEER.

D. Form Ties:
   1. Provide factory-fabricated, removable or snap-off metal form ties, designed to prevent form deflection, and to prevent spalling of concrete surfaces upon removal. Materials used for tying forms will be subject to approval of ENGINEER.
   2. Unless otherwise shown, provide ties so that portion remaining within concrete after removal of exterior parts is at least 1-inch from the outer concrete surface. Unless otherwise shown, provide form ties that will leave a hole no larger than 1-inch diameter in the concrete surface.
   3. Ties for exterior walls and walls subject to hydrostatic pressure shall have waterstops.

4. Provide wood or plastic cones for ties, where concrete is exposed in the finish structure and in the interior of tanks.
5. Wire ties are not acceptable.

E. Forms Coatings:
1. Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing compounds. For concrete surfaces that will be in contact with potable water, the form coating shall be a mineral oil base coating.

2.2 DESIGN OF FORMWORK

A. Design, erect, support, brace, and maintain formwork so that it shall safely support vertical and lateral loads that might be applied, until such loads can be supported by the concrete structure. Carry vertical and lateral loads to ground by formwork system or in-place construction that has attained adequate strength for this purpose. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation, and position.

B. Design forms and falsework to include values of live load, dead load, weight of moving equipment operated on formwork, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability, and other factors pertinent to safety of structure during construction.

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

D. Support form facing materials by structural members spaced sufficiently close to prevent significant deflection. Fit forms placed in successive units for continuous surfaces to accurate alignment, free from irregularities and within allowable tolerances. For long span members without intermediate supports, provide camber in formwork as required for anticipated deflections resulting from weight and pressure of fresh concrete and construction loads.

E. Design formwork to be readily removable without impact, shock, or damage to concrete surfaces and adjacent materials.

F. Provide formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide backup material at joints as required to prevent leakage and fins.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and his installer shall examine the substrate and the conditions under which Work is to be performed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 FORM CONSTRUCTION

A. Construct forms complying with ACI 347 to the exact sizes, shapes, lines, and dimensions shown as required to obtain accurate alignment, location, and grades to tolerances specified; and to obtain level and plumb work in finish structures. Provide for openings, offsets, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required. Use selected materials to obtain required finishes. Finish shall be as determined by approved mock-up or sample panel, if specified.

B. Fabricate forms for easy removal without damaging concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where the slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and ensure ease of removal.

C. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Brace temporary closures and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings on forms in locations as inconspicuous as possible, consistent with requirements of the Work. Form intersecting planes of openings to provide true, clean-cut corners, with edge grain of plywood not exposed as form for concrete.

D. Falsework:
   1. Erect falsework and support, brace, and maintain it to safely support vertical, lateral, and asymmetrical loads applied until such loads can be supported by in-place concrete structures. Construct falsework so that adjustments can be made for take-up and settlement.
   2. Provide wedges, jacks or camber strips to facilitate vertical adjustments. Carefully inspect falsework and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure; make necessary adjustments to produce finished work of required dimensions.

E. Forms for Exposed to View Concrete:
   1. Do not use metal cover plates for patching holes or defects in forms.

2. Provide sharp, clean corners at intersecting planes without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections.
3. Use extra studs, walers, and bracing to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Do not use narrow strips of form material that will produce bow.
4. Assemble forms so they may be readily removed without damage to exposed concrete surfaces.
5. Form molding shapes, recesses, rustication joints, and projections with smooth-finish materials, and install in forms with sealed joints to prevent displacement.

F. Corner Treatment:
1. Form exposed corners of beams, walls, foundations, bases, and columns to produce smooth, solid, unbroken lines, except as otherwise shown. Except as specified below for reentrant or internal corners, exposed corners shall be chamfered.
2. Form chamfers with 3/4-inch by 3/4-inch strips, unless otherwise shown, accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Use rigid PVC chamfers for all architecturally formed concrete. Extend terminal edges to required limit and miter chamfer strips at changes in direction.
3. Reentrant or internal corners and unexposed corners shall be formed chamfered.

G. Joints:
1. Refer to Section 03251, Concrete Joints, of these Specifications for treatment of joints. Locate as shown and specified.

H. Openings and Built-In Work:
1. Provide openings in concrete formwork shown or required by other Sections or other Contracts. Refer to Paragraph 1.1.B. herein for the requirements of coordination.
2. Accurately place and securely support items to be built into forms.

I. Cleaning and Tightening:
1. Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before concrete is to be placed. Retighten forms immediately after concrete placement as required to eliminate mortar leaks.

3.3 FORM COATINGS

A. Coat form contact surfaces with a non-staining form coating compound before reinforcement is placed. Do not allow excess form coating material to accumulate

in the forms or to come into contact with surfaces that will be bonded to fresh concrete. Apply in compliance with manufacturer's instructions.

B. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

3.4 INSTALLATION OF EMBEDDED ITEMS

A. Set and build into the formwork, anchorage devices, and other embedded items, shown, specified, or required by other Sections and other contracts. Refer to Paragraph 1.1.B. herein for the requirements of coordination. Use necessary setting drawings, diagrams, instructions, and directions.

B. Edge Forms and Screeds Strips for Slabs:
   1. Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in the finished slab surface. Provide and secure units to support screeds.

3.5 FIELD QUALITY CONTROL

A. Before concrete placement, CONTRACTOR shall check the formwork, including tolerances, lines, ties, tie cones, and form coatings. CONTRACTOR shall make corrections and adjustments to ensure proper size and location of concrete members and stability of forming systems.

B. During concrete placement CONTRACTOR shall check formwork and related supports to ensure that forms are not displaced and that completed Work shall be within specified tolerances.

C. If CONTRACTOR finds that forms are unsatisfactory in any way, either before or during placing of concrete, placement of concrete shall be postponed or stopped until the defects have been corrected, and reviewed by ENGINEER.

3.6 REMOVAL OF FORMS

A. Conform to the requirements of ACI 301, Section 2, and ACI 347, Chapter 3.7, except as specified below.
   1. Removal of Forms and Supports: Continue curing in accordance with Section 03300, Cast-In-Place Concrete, Paragraph 3.7.

	Temperature (F)				
	Over 95^{o}	70^{o}-95^{o}	60^{o}-70^{o}	50^{o}-60^{o}	Below 50^{o}
a. Walls	1 day	1 day	2 days	3 days	Do not remove
b. Columns	2 days	1 day	3 days	4 days	forms until site-cured

c. Beam Soffits	7 days	4 days	5 days	6 days	test cylinder develops
d. Slabs 5 in. Thick or Less	7 days	5 days	6 days	7 days	65% of 28 day strength.
e. Slabs over 5 in. Thick	7 days	6 days	7 days	7 days	

B. When high-early strength concrete is specified, a schedule for removal of forms will be developed in the field from the age/strength relationships established for the materials and proportions used by tests in accordance with ACI-301, Section 3.8.

C. Form facing material shall remain in place a minimum of four days after concrete placement, unless otherwise approved by ENGINEER or specified above.

D. Do not remove supporting forms or shoring until the members have acquired sufficient strength to safely support their weight and the load upon them. Results of suitable control tests may be used as evidence that the concrete has attained sufficient strength.

E. The time for removal of all forms will be subject to ENGINEER'S approval.

3.7 PERMANENT SHORES

A. Provide permanent shores as defined in ACI 347, Chapter 3.7.

B. Reshores will not be permitted.

3.8 RE-USE OF FORMS

A. Clean and repair surfaces of forms to be re-used in the Work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable. Apply new form coating compound material to concrete contact surfaces as specified for new formwork.

B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets. Do not use "patched" forms for exposed concrete surfaces. Form surfaces shall be subject to ENGINEER'S approval.

END OF SECTION

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete reinforcement.
   2. The extent of concrete reinforcement is shown.
   3. The Work includes fabrication and placement of reinforcement, including bars, ties and supports, and welded wire fabric for concrete, encasements, and fireproofing.

B. Related Sections:
   1. Section 03251, Concrete Joints.
   2. Section 03300, Cast-In-Place Concrete.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. Concrete Reinforcing Steel Institute, Manual of Standard Practice, includes ASTM Standards referred to herein.
   2. ACI 315, Manual of Engineering and Placing Drawings for Reinforced Concrete Structures.
   3. ACI 350, Code Requirements for Environmental Engineering Concrete Structures.

B. Allowable Placing Tolerances: Comply with ACI 350, Chapter 7 - Details of Reinforcement, except as specified below:
   1. Concrete surfaces which are in contact with liquids: 2-inch minimum coverage.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's specifications and installation instructions for all materials and reinforcement accessories.
   2. Drawings for fabrication, bending, and placement of concrete reinforcement. Comply with ACI 315, Parts A and B. For walls, show elevations to a minimum scale of 1/4-inch to 1 foot. For slabs, show top and bottom

reinforcing on separate plan views. Show bar schedules, stirrup spacing, diagrams of bent bars, arrangements, and assemblies, as required for the fabrication and placement of concrete reinforcement, unless otherwise noted. Splices shall be kept to a minimum. Splices in regions of maximum tension stresses shall be avoided whenever possible.

a. Drawings detailing the location of all construction and expansion joints as required under Section 03251, Concrete Joints, shall be submitted and approved before Shop Drawings for reinforcing steel are submitted.

B. Certificates:

1. Submit one copy of steel producer's certificates of mill analysis, tensile and bend tests for reinforcing steel.

C. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

D. CONTRACTOR shall submit soft copies and hard copies per Specification 01300, Submittals. Soft copies shall be in DVD format and shall include all information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

1.4 DELIVERY, HANDLING, AND STORAGE

A. Deliver concrete reinforcement materials to the site bundled, tagged and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings shown on placement diagrams.

B. Store concrete reinforcement material at the site to prevent damage and accumulation of dirt or excessive rust. Store on heavy wood blocking so that no part of it will come in contact with the ground.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforcing Bars: ASTM A 615 and as follows:
   1. Provide Grade 60 for all bars.

B. Low Alloy Steel Reinforcing Bars: ASTM A 706.

C. Mechanical Couplers: Reinforcement bars may be spliced with a mechanical connection. This connection shall be a full mechanical connection which shall develop in tension or compression, as required, at least 125% of specified yield strength (f_y) of the bar in accordance with ACI 318 Section 12.14.3.4. Location of the connections shall be approved by the ENGINEER.

D. Steel Wire: ASTM A 82.

E. Welded Smooth Wire Fabric: ASTM A 185.
   1. Furnish in flat sheets, not rolls.

F. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting and fastening reinforcement in place.
   1. Use wire bar type supports complying with CRSI recommendations, except as specified below. Do not use wood, brick, or other unacceptable materials.
   2. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.
   3. For all concrete surfaces where legs of supports are in contact with forms, provide supports complying with CRSI "Manual of Standard Practice" as follows:
      a. Either hot-dip galvanized, plastic protected or stainless steel legs.
   4. Over waterproof membranes, use pre-cast concrete chairs.
   5. For all polyvinyl chloride (PVC) lined concrete surfaces, where legs of supports are in contact with forms, provide supports complying with CRSI "Manual of Standard Practice" as follows:
      a. Either plastic or metal plastic protected legs.

2.2 FABRICATION

A. General: Fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with CRSI "Manual of Standard Practice". In case of fabricating errors, do not re-bend or straighten reinforcement in a manner that will injure or weaken the materials.

B. Unacceptable Materials: Reinforcement with any of the following defects will not be permitted in the Work:
   1. Bar lengths, bends, and other dimensions exceeding specified fabrication tolerances.
   2. Bends or kinks not shown on approved Shop Drawings.

3. Bars with reduced cross-section due to excessive rusting or other cause.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and his installer shall examine the substrate and the conditions under which concrete reinforcement is to be placed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 INSTALLATION

A. Comply with the applicable recommendations of specified codes and standards, and CRSI "Manual of Standard Practice", for details and methods of reinforcement placement and supports.

B. Clean reinforcement to remove loose rust and mill scale, earth, ice, and other materials which reduce or destroy bond with concrete.

C. Position, support, and secure reinforcement against displacement during formwork construction or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers as required.
   1. Place reinforcement to obtain the minimum concrete coverages, as shown and as specified in ACI 350. Arrange, space, and securely tie bars and bar supports together with 16 gage wire to hold reinforcement accurately in position during concrete placement operations. Set wire ties so that twisted ends are directed away from exposed concrete surfaces.
   2. Reinforcing steel shall not be secured to forms with wire, nails, or other ferrous metal. Metal supports subject to corrosion shall not touch formed or exposed concrete surfaces.

D. Install welded wire fabric in as long lengths as practical. Lap adjoining pieces at lease one full mesh and lace splices with 16 gage wire. Do not make end laps midway between supporting beams or directly over beams of continuous structures. Offset end laps in adjacent widths to prevent continuous laps.

E. Provide sufficient numbers of supports of strength required to carry reinforcement. Do not place reinforcing bars more than 2-inches beyond the last leg of any continuous bar support. Do not use supports as bases for runways for concrete conveying equipment or similar construction loads.

F. Splices:

1. Provide standard reinforcement splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements shown on Drawings for minimum lap of sliced bars.

G. Mechanical Couplers in Lieu of Lap Splicing:
   1. Mechanical butt splices shall be in accordance with the recommendation of the manufacturer of the mechanical splicing device. Butt splices shall develop 125% of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Bars shall be flame dried before butt splicing. Adequate jigs and clamps or other devices shall be provided to support, align, and hold the longitudinal centerline of the bars to be butt spliced in a straight line.
   2. Product and Manufacturer: Provide one of the following:
      a. BarLock (MBT) Coupler, as manufactured by BarLock (MBT) Coupler Systems.
      b. Dayton-Superior DBR Coupler. Allow for the reduction of bar area at threads.
      c. Or approved equal.

3.3 INSPECTION OF REINFORCEMENT

A. Concrete shall not be placed until the reinforcing steel is inspected and permission for placing concrete is granted by ENGINEER. All concrete placed in violation of this provision will be rejected.

END OF SECTION

SECTION 03251

CONCRETE JOINTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete joints.
   2. The types of concrete joints required include the following:
      a. Construction joints.
      b. Expansion joints and fillers.
      c. Waterstops.
      d. Control joints.

B. General: All joints subject to hydrostatic pressure shall be provided with continuous waterstop.

C. Related Sections:
   1. Section 03100, Concrete Formwork.
   2. Section 03200, Concrete Reinforcement.
   3. Section 03300, Cast-In-Place Concrete.

1.2 QUALITY ASSURANCE

A. Standard Specifications Details:
   1. CONTRACTOR shall conform to all applicable requirements of Sections No. 505 and 729 of the Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments (MAG).

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. ACI 301, Specifications for Structural Concrete for Buildings.
   2. ASTM A 36, Standard Specification for Structural Steel.
   3. ASTM D 1752, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
   4. CRD-C572, Corps of Engineers Specifications for Polyvinyl Chloride Waterstop.

C. All manufactured items shall be installed in accordance with manufacturer's instructions.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's specifications and installation instructions for all materials required.
   2. Layout of all construction joint locations prior to the submittal of steel reinforcing drawings.
   3. Detail for joining polyvinyl chloride to steel waterstops.

B. Samples: Submit for approval the following:
   1. Polyvinyl chloride for joints.
   2. Cork expansion joint fillers.

C. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

D. CONTRACTOR shall submit soft copies and hard copies per Specification 01300, Submittals. Soft copies shall be in DVD format and shall include all information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

PART 2 - PRODUCTS

2.1 WATERSTOPS

A. Polyvinyl Chloride:
   1. Reference Standard: CRD-C572.
   2. Construction Joints: Minimum of 3/8-inches thick.
      a. Width shall be as shown, or if not shown, as recommended by the manufacturer.
   3. Expansion Joints: Uniform minimum thickness of 1/4-inch by 9-inch minimum width. Center bulb shall be "O" or "U" shaped. The "O" shall

have an outside diameter of 3/4-inch minimum. The top of the "U" shall be jointed by a membrane that will tear when the expansion occurs.

4. Manufacturer: Provide polyvinyl chloride waterstops of one of the following:
   a. W. R. Meadows, Incorporated.
   b. A. C. Horn, Incorporated.
   c. Or approved equal.

B. Hypalon:
   1. Provide hypalon waterstops as shown, 40 mils thick.
   2. Waterstop shall be an integral part of a manufacturer's joint sealing system and shall be in accordance with the manufacturer's published recommendations.
   3. Product and Manufacturer: Provide one of the following:
      a. Sikadur Combiflex, as manufactured by Sika Corporation.
      b. Or approved equal.

C. Neoprene: General purpose high quality synthetic rubber sheet of 1/4-inch thickness, unless otherwise noted on Drawings, and durometer of ±60, as manufactured from polymer produced by E. I. DuPont Denemours and Company.

D. Hydrophilic:
   1. Provide hydrophilic waterstops where shown on the Drawings.
   2. Waterstop shall be an integral part of a manufacturer's joint sealing system and shall be in accordance with the manufacturer's published recommendations.
   3. Product and Manufacturer: Provide one of the following:
      a. Applied strip waterstops as manufactured by Greenstreak Plastic Products Company.
      b. Adeka Ultra Seal manufactured by Asahi Denka Kogyo.
      c. Or approved equal.

2.2 PREFORMED EXPANSION JOINT FILLER

A. Provide preformed expansion joint filler complying with ASTM D 1752, Type II, cork.

2.3 CONCRETE CONSTRUCTION JOINT ROUGHENER

A. Provide a water soluble non-flammable, surface-retardant roughener.

B. Product and Manufacturer: Provide one of the following:
   1. Rugasol-S, as manufactured by Sika Corporation for horizontal joints only.
   2. EAC-S, as manufactured by Preco Industries, Ltd., for horizontal joints only.
   3. Tuf-Cote (Deep Etch), as manufactured by Preco Industries Ltd., for vertical joints.

4. Or approved equal.

2.4 EPOXY BONDING AGENT

A. Provide an epoxy-resin bonding agent, two-component type.

B. Product and Manufacturer: Provide one of the following:
   1. Sikadur 32 Hi-Mod LPL, as manufactured by Sika Corporation.
   2. Eucopoxy LPL, as manufactured by the Euclid Chemical Company.
   3. Epoxtite Binder (Code #2390), as manufactured by A. C. Horn, Incorporated.
   4. Or approved equal.

2.5 RUBBER BONDING AGENT

A. Product and Manufacturer: Provide one of the following:
   1. Scotch-Grip 1300 Rubber Adhesive, as manufactured by 3M Company.
   2. Or approved equal.

2.6 NEOPRENE BEARING PADS

A. Product and Manufacturer: Provide one of the following:
   1. 65 Durometer, Sheet Neoprene No. 1200, as manufactured by Williams Products Company.
   2. Or approved equal.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and his installer shall examine the substrate and the conditions under which Work is to be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 CONSTRUCTION JOINTS

A. Comply with ACI 301 and as specified below.

B. Locate and install construction joints as shown. Additional construction joints shall be located as follows:
   1. In walls locate joints at a spacing of 40 feet maximum and approximately 12 feet from corners.
   2. In foundation slabs and slabs on grade locate joints at a spacing of approximately 40 feet. Place concrete in a strip pattern.

3. In mats and structural slabs and beams, at a spacing of approximately 40 feet. Locate joints in compliance with ACI 301.
4. Provide other additional construction joints as required to satisfactorily complete all Work.

C. Horizontal Joints:
1. Roughen concrete at the interface of construction joints by sandblasting to expose the aggregate and remove accumulated concrete on rebar immediately subsequent to form stripping, unless otherwise approved by ENGINEER. Immediately before placing fresh concrete, thoroughly clean the existing contact surface using a stiff brush or other tools and a stream of water under pressure. The surface shall be clean and wet, but free from pools of water at the moment the fresh concrete is placed.
2. Remove laitance, waste mortar, or other substance which may prevent complete adhesion.
3. Place a 2-inch thick coat of mortar, of similar proportions to the mortar in the concrete, over the contact surface of the old concrete. Place fresh concrete before the mortar has attained its initial set.

D. Vertical Joints:
1. Apply roughener to the form in a thin, even film by brush, spray or roller in accordance with the manufacturer's instructions. After roughener is dry, concrete may be placed.
2. When concrete has been placed and the form removed, wash loosened material off with high pressure water spray to obtain roughened surface subject to approval by ENGINEER.

3.3 EXPANSION JOINTS

A. Comply with ACI 301 and as specified below.

B. Locate and install expansion joints as shown. Install cork filler in accordance with manufacturer's instructions.

3.4 WATERSTOPS

A. General:
1. Comply with ACI 301 and as specified below. All joints shall be made in accordance with manufacturer's instructions.
2. Obtain ENGINEER'S approval for waterstop locations not shown.
3. Provide waterstops in all foundations, tanks and other substructures up to an elevation at least 12-inches above grade or to an elevation at least 12-inches above highest liquid level in tanks, whichever is higher, except where otherwise shown or noted.

B. Polyvinyl Chloride Waterstop:

1. Tie waterstop to reinforcement so that it is securely and rigidly supported in the proper position during concrete placement. Continuously inspect waterstops during concrete placement to ensure their proper positioning.
2. Waterstops shall be fused using equipment as supplied by or recommended by the manufacturer.

C. Hypalon Waterstop: Install in accordance with joint sealing system manufacturer's recommendations.

D. Neoprene Waterstop or Bearing Pad: Install with water insensitive adhesive in accordance with manufacturer's instructions.

E. Hydrophilic Waterstop: Install in accordance with joint sealing system manufacturer's recommendations.

3.5 BONDING WITH EPOXY ADHESIVE

A. Use Adhesive for the following:
1. Bonding of fresh concrete to concrete cured at least 45 days or to existing concrete.
2. Bonding of horizontal surfaces that will receive a topping.

B. Handle and store epoxy adhesive in compliance with the manufacturer's printed instructions, including safety precautions.

C. Mix the epoxy adhesive in complete accordance with the instructions of the manufacturer.

D. Before placing fresh concrete, thoroughly roughen and clean hardened concrete surfaces and coat with epoxy grout not less than 1/16-inch thick. Place fresh concrete while the epoxy material is still tacky, without removing the in-place grout coat, and as directed by the epoxy manufacturer.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install cast-in-place concrete.
   2. The Work includes providing concrete consisting of Portland cement, fine and coarse aggregate, water, and approved admixtures; combined, mixed, transported, placed, finished, and cured. The Work also includes:
      a. Providing openings in concrete to accommodate the Work under this and other Sections and building into the concrete all items such as sleeves, frames, anchor bolts, inserts, and all other items to be embedded.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed in the concrete.

C. Classes of Concrete:
   1. Class "A" (4,000 psi at 28 days) concrete shall be steel reinforced and shall be used for the following applications:
      a. All concrete, unless indicated otherwise.
   2. Class "B" concrete (3,000 psi at 28 days) shall be placed without forms or with simple forms, with little or no reinforcing, and includes the following:
      a. Duct banks.
      b. Unreinforced encasements.
      c. Curbs and gutters.
      d. Sidewalks.
      e. Thrust blocks.
   3. Class "C" (2,000 psi at 28 days) concrete shall be unreinforced and used where required as concrete fill under foundations, filling abandoned piping, and wherever "lean" concrete is required in the Drawings.

D. Related Sections:
   1. Section 02200, Earthwork, Excavation, and Backfill.
   2. Section 03100, Concrete Formwork.
   3. Section 03200, Concrete Reinforcement.
   4. Section 03251, Concrete Joints.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with the applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ACI 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.
   2. ACI 214, Recommended Practice for Evaluation of Strength Test Results of Concrete.
   3. ACI 301, Specifications for Structural Concrete for Buildings, (includes ASTM Standards referred to herein).
   4. ACI 304, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
   5. ACI 305, Hot Weather Concreting.
   6. ACI 309, Guide for Consolidation of Concrete.
   7. ACI 311, Guide for Concrete Inspection.
   8. ACI 350, Code Requirements for Environmental Engineering Concrete Structures.
   9. AASHTO M182, Burlap Cloth Made From Jute or Kenaf.

B. Concrete Testing Service:
   1. CONTRACTOR shall employ, at his own expense, a testing laboratory experienced in design and testing of concrete materials and mixes to perform material evaluation tests and to design concrete mixes.
      a. Testing agency shall meet the requirements of ASTM E329.
      b. Selection of a testing laboratory is subject to ENGINEER'S approval.
      c. Submit a written description of the proposed concrete testing laboratory giving qualifications of personnel, laboratory facilities and equipment, and other information which may be requested by ENGINEER.
   2. Materials and installed Work may require testing and retesting, as directed by ENGINEER, at any time during the progress of the Work. Allow free access to material stockpiles and facilities at all times. Tests not specifically indicated to be done at OWNER'S expense, including the retesting of rejected materials and installed Work, shall be done at CONTRACTOR'S expense.

C. Qualifications of Water-Reducing Admixture Manufacturer:
   1. Water-reducing admixtures shall be manufactured under strict quality control in facilities operated under a quality assurance program. CONTRACTOR shall furnish copy of manufacturer's quality assurance handbook to document the existence of the program. Manufacturer shall maintain a concrete testing laboratory which has been approved by the Cement and Concrete Reference Laboratory at the Bureau of Standards, Washington, D.C.
   2. Provide a qualified concrete technician employed by the admixture manufacturer to assist in proportioning the concrete for optimum use of the admixture. The concrete technician shall advise on proper addition of the admixture to the concrete and on adjustment of the concrete mix proportions to meet changing job site conditions.

D. Tests for Concrete Materials:
   1. Submit written reports to ENGINEER, for each material sampled and tested, prior to the start of Work.
   2. Provide the Project identification name and number, date of report, name of CONTRACTOR, name of concrete testing service, source of concrete aggregates, material manufacturer and brand name for manufactured materials, values specified in the referenced specification for each material, and test results. Indicate whether or not material is acceptable for intended use.

1.3 SUBMITTALS

A. Samples: Submit samples of materials as specified and as otherwise may be requested by ENGINEER, including names, sources, and descriptions.

B. Shop Drawings: Submit for approval the following:
   1. Manufacturer's specifications with application and installation instructions for proprietary materials and items, including admixtures and bonding agents.
   2. List of concrete materials and concrete mix designs proposed for use. Include the results of all tests performed to qualify the materials and to establish the mix designs.
   3. The following information, if ready-mixed concrete is used.
      a. Physical capacity of mixing plant.
      b. Trucking facilities available.
      c. Estimated average amount which can be produced and delivered to the site during a normal eight hour day, excluding the output to other customers.

C. Laboratory Test Reports: Submit copies of laboratory test reports for concrete cylinders, materials and mix design tests. ENGINEER'S review will be for general information only. Production of concrete to comply with specified requirements is the responsibility of CONTRACTOR.

D. Submit notarized certification of conformance to referenced standards when requested by ENGINEER.

E. Delivery Tickets: Furnish to ENGINEER copies of all delivery tickets for each load of concrete delivered to the site. Provide items of information as specified in ASTM C94, Section 16.
   1. Provide batch tickets for each batch of job site mixed concrete, as specified.

F. The CONTRACTOR shall submit Portland cement submittals to the ENGINEER by a well known manufacturer and supplied by one plant.

G. CONTRACTOR may provide Portland cement from a second plant to be used in emergency situations only. CONTRACTOR must provide second submittal within 30 days of receipt of first submittal.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. All materials used for concrete must be kept clean and free from all foreign matter during transportation and handling and kept separate until measured and placed in the mixer. Bins or platforms having hard clean surfaces shall be provided for storage. Suitable means shall be taken during hauling, piling, and handling to insure that segregation of the coarse and fine aggregate particles does not occur and the grading is not affected.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Cement:
   1. Portland cement, ASTM C150, Type II.
   2. Use Portland cement made by a well-known acceptable manufacturer and produced by not more than one plant.
   3. Do not use cement which has deteriorated because of improper storage or handling.

B. Aggregates: ASTM C33 and as herein specified.
   1. Do not use aggregates containing soluble salts or other substances such as iron sulfides, pyrite, marcasite, ochre, or other materials that can cause stains on exposed concrete surfaces.
   2. Fine Aggregate: Clean, sharp, natural sand free from loam, clay, lumps, or other deleterious substances.
      a. Dune sand, bank run sand, and manufactured sand are not acceptable.
   3. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter as follows:
      a. Crushed stone, processed from natural rock or stone.
      b. Washed gravel, either natural or crushed. Use of slag and pit or bank run gravel is not permitted.
      c. Coarse Aggregate Size: Size to be ASTM C33, Nos. 57 or 67, except that No. 467 may be used for footings, foundation mats, and walls 16-inches or greater in thickness.

C. Water: Clean, potable, free from injurious amounts of oils, acids, alkalis, organic materials, or other substances that may be deleterious to concrete or steel.

2.2 CONCRETE ADMIXTURES

A. Provide admixtures produced by established reputable manufacturers and use in compliance with the manufacturer's printed instruction. Do not use admixtures which have not been incorporated and tested in the accepted mixes, unless otherwise authorized in writing by ENGINEER.

B. Water-Reducing Admixture: ASTM C494, Type A.
   1. Proportion all Class "A" and Class "B" concrete with non-air entraining, normal setting, water-reducing, aqueous solution of a modification of the salt of polyhydroxylated organic acids. The admixture shall not contain any lignin, nitrates, or chlorides added during manufacture.
   2. Product and Manufacturer: Provide one of the following:
      a. Eucon WR-75, as manufactured by The Euclid Chemical Company.
      b. Pozzolith, as manufactured by Master Builders, Inc.
      c. WRDA-15, as manufactured by W.R. Grace & Conn.
      d. Or approved equal.

C. Pozzolanic Admixtures:
   1. Mineral admixtures, when used, shall meet the requirements of ASTM C618, Class F, except as follows:
      a. The loss on ignition shall be a maximum of 4%.
      b. The maximum percent of sulfur trioxide (SO3) shall be 4.0.
   2. A substitution by weight, of the Portland cement, by pozzolan, so that the total tricalcium aluminate content of the resulting cement plus pozzolan is not greater than 8%, will be considered. However, the pozzolan shall not exceed 20% by weight of the cement, plus pozzolan.

D. Set-Control Admixtures: ASTM C494, as follows:
   1. Type B, Retarding.
   2. Type C, Accelerating.
   3. Type D, Water-reducing and Retarding.
   4. Type E, Water-reducing and Accelerating.

E. Calcium Chloride: Do not use calcium chloride in concrete unless otherwise authorized in writing by ENGINEER. Do not use admixtures containing calcium chloride where concrete is placed against galvanized steel.

2.3 PROPORTIONING AND DESIGN OF MIXES

A. Prepare concrete design mixes subject to the following limitations:

Class	Coarse Aggregate[1] Size A	Size B	Minimum Cementitious (lbs./cu yd)	Maximum W/C	Slump[2]	Air %	Min. Comp Strength[3] (psi)
Class "A"	#57 or #67		564	0.45	4" Max.	6+/-1	4,000
Class "B"	#57 or #67		517	0.55	4" Max.	6+/-1	3,000
Class "C"	Any ASTM C33		No requirements				2,000

1. Coarse aggregate size numbers refer to ASTM C33. Where a size A and B are listed, it is intended that the smaller size B aggregate is to be added, replacing a portion of the coarse and /or fine aggregate, in the minimum amount necessary to make a workable and pumpable mix with a sand content not exceeding 41% of total aggregate.
2. The slumps listed are prior to the addition of high range water reducer (super plasticizer).
3. Mix designs shall be made for all but Class "C", which does not require a trial batch, so that the compressive strength achieved for the laboratory trial batches will be no less than 125% of the specified design strength. This is to assure meeting the design strength for all concrete batched during the Project.
4. The quantity of water to be used in the determination of the water-cementitious materials ratio shall include free water on aggregates in excess of SSD and the water portion of admixtures.

B. Use an independent testing facility acceptable to ENGINEER for preparing and reporting proposed mix designs.
   1. The testing facility shall not be the same as used for field quality control testing.

C. Proportion mixes either by laboratory trial batch or field experience methods, using materials to be employed on the Project for concrete required. Comply with ACI 211.1 and report to ENGINEER the following data:
   1. Complete identification of aggregate source of supply.
   2. Tests of aggregates for compliance with specified requirements.
   3. Scale weight of each aggregate.
   4. Absorbed water in each aggregate.
   5. Brand, type, and composition of cement.
   6. Brand, type, and amount of each admixture.
   7. Amounts of water used in trial mixes.
   8. Proportions of each material per cubic yard.
   9. Gross weight and yield per cubic yard of trial mixtures.
   10. Measured slump.
   11. Compressive strength developed at 7 days and 28 days, from not less than three test cylinders cast for each 7 day and 28 day test, and for each design mix.

D. Submit written reports to ENGINEER of proposed mix of concrete at least 15 days prior to start of Work.

E. Laboratory Trial Batches: When laboratory trial batches are used to select concrete proportions, prepare test specimens and conduct strength tests as specified in ACI 301, Section 4, Proportioning.

F. Field Experience Method: When field experience methods are used to select concrete proportions, establish proportions as specified in ACI 301, Section 4.

G. Adjustment to Concrete Mixes: Mix design adjustments may be requested by CONTRACTOR when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to the OWNER and as accepted by ENGINEER. Laboratory test data for revised mix designs and strength results must be submitted to and accepted by ENGINEER before using the revised mixes.

H. Admixtures:
   1. Use amounts of admixtures as recommended by the manufacturer for climatic conditions prevailing at the time of placing. Adjust quantities and types of admixtures as required to maintain quality control.

I. Slump Limits:
   1. A slump of up to 5-inches will be allowed for Class "C" concrete. See the General Structural Notes in the Drawings for allowable slumps for other mixes.
   2. Slump tolerances for all concrete shall meet the requirements of ACI 301 and ACI 117.

J. Red Dye:
   1. Add red dye to all concrete used for electrical duct bank encasement.

2.4 EPOXY BONDING AGENT

A. Provide an epoxy-resin bonding agent, two-component type.

B. Product and Manufacturer: Provide one of the following:
   1. Sikadur 32 Hi-Mod LPL, as manufactured by Sika Corporation.
   2. Euco 452 MV, as manufactured by the Euclid Chemical Company.
   3. MasterEmaco AHD 326, as manufactured by BASF.
   4. Or approved equal.

2.5 CONCRETE CURING MATERIALS

A. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 10 ounces per square yard and complying with AASHTO M182, Class 3.

B. Moisture-Retaining Cover: Comply with ASTM C171.
   1. Transguard 4000 or approved equal.

C. Curing Compound: ASTM C309 Type 1-D (water retention requirements):
   1. Product and Manufacturer: Provide one of the following:
      a. Super Aqua Cure VOX, as manufactured by The Euclid Chemical Company.
      b. Sealtight 1100, as manufactured by W.R. Meadows, Incorporated.

c. MasterKure, as manufactured by Master Builders, Inc.
d. Or approved equal.

2. Provide fugitive dye when requested by ENGINEER.

2.6 EMBEDDED ITEMS

A. Items such as plates, angles, inserts, bolts, and similar items not specified elsewhere shall be provided and installed under this Section. All embedded items shall be hot-dip galvanized after fabrication. After galvanizing, coat with zinc chromate paint. Stainless steel items shall not be galvanized.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and his installer shall examine the substrate and the conditions under which Work is to be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 CONCRETE MIXING

A. General:
1. Concrete may be produced at batch plants or it may be produced by the ready-mixed process. Batch plants shall comply with the recommendations of ACI 304 and shall have sufficient capacity to produce concrete of the qualities specified, in quantities required to meet the construction schedule. All plant facilities are subject to testing laboratory inspection and acceptance of ENGINEER.
2. Mixing:
a. Mix concrete with an approved rotating type batch machine, except where hand mixing of very small quantities may be permitted.
b. Remove hardened accumulations of cement and concrete frequently from drum and blades to assure acceptable mixing action.
c. Replace mixer blades when they have lost 10% of their original height.
d. Use quantities such that a whole number of bags of cement is required, unless otherwise permitted.
3. Job Site Mixing: Is not permitted.

B. Ready-Mix Concrete:
1. Comply with the requirements of ASTM C94 and as herein specified. Proposed changes in mixing procedures, other than herein specified, must be accepted by ENGINEER before implementation.
a. Plant Equipment and Facilities: Conform to National Ready-Mix Concrete Association "Plant and Delivery Equipment Specification".

b. Mix concrete in revolving type truck mixers which are in good condition and which produce thoroughly mixed concrete of the specified consistency and strength.
c. Do not exceed the proper capacity of the mixer.
d. Mix concrete for a minimum of two minutes after arrival at the job site or as recommended by the mixer manufacturer.
e. Mix at proper speed until concrete is discharged.
f. Maintain adequate facilities at the job site for continuous delivery of concrete at the required rates.
g. Provide access to the mixing plant for ENGINEER at all times.

2. Provide a batch ticket for each batch discharged and used in the Work, indicating the Project identification name and number, date, mix type, mix time, quantity, and amount of water introduced.

C. Maintain equipment in proper operating condition, with drums cleaned before charging each batch. Schedule rates of delivery in order to prevent delay of placing the concrete after mixing, or holding dry-mixed materials too long in the mixer before the addition of water and admixtures.

3.3 TRANSPORTING CONCRETE

A. Transport and place concrete not more than 90 minutes after water has been added to the dry ingredients.

B. Take care to avoid spilling and separation of the mixture during transportation.

C. Do not place concrete in which the ingredients have been separated.

D. Do not retemper partially set concrete.

E. Use suitable and approved equipment for transporting concrete from mixer to forms.

3.4 CONCRETE PLACEMENT

A. General: Place concrete continuously so that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, provide construction joints as specified in Section 3.4.E of these Specifications only as approved by ENGINEER. Deposit concrete as nearly as practical in its final location to avoid segregation due to rehandling or flowing. Do not subject concrete to any procedure which will cause segregation.
1. Screed concrete which is to receive other construction to the proper level to avoid excessive skimming or grouting.
2. Do not use concrete which becomes non-plastic and unworkable, or does not meet the required quality control limits, or which has been contaminated by

foreign materials. Do not use retempered concrete. Remove rejected concrete from the job site and dispose of it in an acceptable location.

3. Do not place concrete until all forms, bracing, reinforcement, and embedded items are in final and secure position.
4. Unless otherwise approved, place concrete only when ENGINEER is present.
5. Allow a minimum of 24 hours before placing concrete against a slab or wall already in place.

B. Concrete Conveying:
   1. Handle concrete from the point of delivery and transfer to the concrete conveying equipment and to the locations of final deposit as rapidly as practical by methods which will prevent segregation and loss of concrete mix materials.
   2. Provide mechanical equipment for conveying concrete to ensure a continuous flow of concrete at the delivery end. Provide runways for wheeled concrete conveying equipment from the concrete delivery point to the locations of final deposit. Keep interior surfaces of conveying equipment, including chutes, free of hardened concrete, debris, water, snow, ice, and other deleterious materials.
   3. Do not use chutes for distributing concrete unless approved in writing by ENGINEER.
      a. Provide sketches showing methods by which chutes will be employed when requesting such approval.
      b. Design chutes, if permitted, with proper slopes and supports to permit efficient handling of the concrete.
   4. Pumping concrete is permitted, however do not use aluminum pipe for conveying.

C. Placing Concrete into Forms:
   1. Deposit concrete in forms in horizontal layers not deeper than 18-inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place concrete at such a rate that concrete which is being integrated with fresh concrete is still plastic.
   2. Do not permit concrete to free-fall within the form from a distance exceeding 4 feet. Use "elephant trunks" to prevent free fall and excessive splashing on forms and reinforcement.
   3. Remove temporary spreaders in forms when concrete placing has reached the elevation of such spreaders.
   4. Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete in accordance with the applicable recommended practices of ACI 309. Vibration of forms and reinforcing will not be permitted, unless otherwise accepted by ENGINEER.
   5. Do not use vibrators to transport concrete inside of forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate

the layer of concrete and at least 6-inches into the preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit the duration of vibration to the time necessary to consolidate the concrete and complete embedment of reinforcement and other embedded items without causing segregation of the mix.

6. Do not place concrete in beam and slab forms until the concrete previously placed in columns and walls is no longer plastic.
7. Force concrete under pipes, sleeves, openings, and inserts from one side until visible from the other side to prevent voids.

D. Placing Concrete Slabs:
   1. Deposit and consolidate concrete slabs in a continuous operation, within the limits of construction joints, until the placing of a panel or section is completed.
   2. Consolidate concrete during placing operations using mechanical vibrating equipment, so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.
   3. Consolidate concrete placed in beams and girders of supported slabs, and against bulkheads of slabs on ground, as specified for formed concrete structures.
   4. Bring slab surfaces to the correct level. Smooth the surface, leaving it free of humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations.

E. Bonding for Next Concrete Pour: Roughen surfaces of set concrete at all joints, except where bonding is obtained by use of a concrete bonding agent. Construction joints shown on the Drawings are specified in Section 03251, Concrete Joints, of these Specifications. Clean surfaces of laitance, coatings, loose particles, and foreign matter. Roughen surfaces in a manner to expose bonded aggregate uniformly and to not leave laitance, loose particles of aggregate, or damaged concrete at the surface.
   1. Prepare for bonding of fresh concrete to new concrete that has set but is not fully cured, as follows:
      a. Thoroughly wet the surface but allow no freestanding water.
      b. For horizontal surfaces, place a 2-inch layer of mortar, one part sand and one part cement with water, over the hardened concrete surface.
      c. Place fresh concrete before the mortar has attained its initial set.
   2. Bonding of fresh concrete to fully-cured hardened concrete or existing concrete and horizontal surfaces which will receive a topping shall be accomplished by using an epoxy-resin bonding agent as specified in Section 03251, Concrete Joints, of these Specifications.

F. Quality of Concrete Work:
   1. Make all concrete solid, compact and smooth, and free of laitance, cracks, and cold joints.

2. All concrete for liquid retaining structures, and all concrete in contact with earth, water, or exposed directly to the elements shall be watertight.
3. Cut out and properly replace to the extent ordered by ENGINEER, or repair to the satisfaction of ENGINEER, surfaces which contain cracks or voids, are unduly rough, or are in any way defective. Thin patches or plastering will not be acceptable.
4. All leaks through concrete and cracks, holes, or other defective concrete in areas of potential leakage, shall be repaired and made watertight by CONTRACTOR.
5. Repair, removal, and replacement of defective concrete as ordered by ENGINEER shall be at no additional cost to OWNER.

G. Cold Weather Placing:
1. Protect all concrete Work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures, in compliance with the requirements of ACI 306 and as herein specified.
2. When the air temperature has fallen to or may be expected to fall below 40° F, provide adequate means to maintain the temperature, in the area where concrete is being placed, at between 50° F and 70° F for at least 7 days after placing. Provide temporary housings or coverings including tarpaulins or plastic film. Maintain the heat and protection, if necessary, to insure that the ambient temperature does not fall more than 30° F in the 24 hours following the seven-day period. Avoid rapid dry-out of concrete due to overheating, and avoid thermal shock due to sudden cooling or heating.
3. When air temperature has fallen to or is expected to fall below 40° F, uniformly heat all water and aggregates before mixing as required to obtain a concrete mixture temperature of not less than 55° F and not more than 85° F at point of placement.
4. Do not use frozen materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials. Ascertain that forms, reinforcing steel, and adjacent concrete surfaces are entirely free of frost, snow and ice before placing concrete.
5. Do not use salt and other materials containing antifreeze agents or chemical accelerators, or set-control admixtures, unless approved by ENGINEER, in mix designs.

H. Hot Weather Placing:
1. When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
2. Cool ingredients before mixing to maintain concrete temperature at time of placement below 80° F when the temperature is rising and below 85° F when the temperature is falling. Mixing water may be chilled. Chopped ice or liquid nitrogen may be used to control the concrete temperature provided the water equivalent of the ice is calculated in the total amount of mixing water.

3. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
4. Wet forms thoroughly before placing concrete.
5. Do not place concrete at a temperature so as to cause difficulty from loss of slump, flash set, or cold joints.
6. Do not use set-control admixtures unless approved by ENGINEER in mix designs.
7. Obtain ENGINEER'S approval of other methods and materials proposed for use.

3.5 FINISH OF FORMED SURFACES

A. Rough Form Finish:
   1. Standard rough form finish shall be the concrete surface having the texture imparted by the form material used, with tie holes and defective areas repaired and patched with mortar of one part cement to 1-1/2 parts sand. All fins and other projections exceeding 1/4-inch in height are to be rubbed down or chipped off.
   2. Use rough form finish for the following:
      a. Exterior vertical surfaces up to 1 foot below grade.
      b. Interior exposed vertical surfaces of liquid containers up to 1 foot below liquid level.
      c. Interior and exterior exposed beams and undersides of slabs.
      d. Other areas shown.

B. Smooth Form Finish:
   1. Produce smooth form finish by selecting form materials which will impart a smooth, hard, uniform texture. Arrange panels in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective areas as above with all fins or other projections completely removed and smoothed.
   2. Use smooth form finish for surfaces that are to be covered with a coating material. The material may be applied directly to the concrete or may be a covering bonded to the concrete such as waterproofing, damp proofing, painting or other similar system.

C. Smooth Rubbed Finish:
   1. Provide smooth rubbed finish to concrete surfaces which have received smooth form finish as follows:
      a. Rubbing of concrete surfaces not later than the day after form removal.
      b. Moistening of concrete surfaces and rubbing with carborundum brick or other abrasive until a uniform color and texture is produced. Do not apply cement grout other than that created by the rubbing process.
   2. Except where surfaces have been previously covered as specified above, use smooth rubbed finish as follows:
      a. Repair all defects and patch all tie holes prior to rubbed finish.

b. Grind all form finish and joint lines until smooth. Remove all curing compound and form oil.
c. Combine one part Portland cement to 1-1/2 parts fine sand by volume and mix with water to a consistency of thick paint. Blend standard Portland cement with white Portland cement in amounts determined by trial patches. Final color of dried grout to match color of adjacent concrete surfaces.
d. Thoroughly wet concrete surface with bonding agent and water mix. Apply grout uniformly by rubber or cork float. Fill all surface holes. Remove excess grout by rubbing with clean wet burlap to remove any visible grout film.
e. Provide sample panel for approval, prior to start of Work.

D. Related Unformed Surfaces:
1. At tops of walls, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, strike off smooth and finish with a texture matching the adjacent formed surfaces. Continue the final surface treatment of formed surfaces uniformly across the adjacent unformed surfaces, unless otherwise shown.

3.6 MONOLITHIC SLAB FINISHES

A. Float Finish:
1. After placing concrete slabs, do not work the surface further until ready for floating. Begin floating when the surface water has disappeared or when the concrete has stiffened sufficiently. Check and level the surface plane to a tolerance not exceeding 1/4-inch in 10 feet when tested with a 10 foot straightedge placed on the surface at not less than two different angles. Cut down high spots and fill all low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat the surface to a uniform, smooth, granular texture.
2. Use float finish for the following:
a. Interior exposed horizontal surfaces of liquid containers, except those to receive grout topping.
b. Exterior below grade horizontal surfaces.
c. Surfaces to receive additional finishes, except as shown or specified.

B. Trowel Finish:
1. After floating, begin the first trowel finish operation using a power-driven trowel. Begin final troweling when the surface produces a ringing sound as the trowel is moved over the surface.
2. Consolidate the concrete surface by the final hand troweling operation. Finish shall be free of trowel marks, uniform in texture and appearance, and with a surface plane tolerance not exceeding 1/8-inch in 10 feet when tested with a 10 foot straightedge. Grind smooth surface defects that would telegraph through applied floor covering system.
3. Use trowel finish for the following:

a. Interior exposed slabs unless otherwise shown or specified.
b. Slabs to receive resilient floor finishes.

C. Non-Slip Broom Finish:
1. Immediately after float finishing, slightly roughen the concrete surface by brooming in the direction perpendicular to the main traffic route. Use fiber bristle broom unless otherwise directed. Coordinate the required final finish with ENGINEER before application.
2. Use non-slip broom finish for the following:
a. Exterior exposed horizontal surfaces subject to light foot traffic.
b. Interior and exterior concrete steps and ramps.
c. Horizontal surfaces which will receive a grout topping or a concrete equipment base slab.

3.7 CONCRETE CURING AND PROTECTION

A. General:
1. Protect freshly placed concrete from premature drying and excessive cold or hot temperature, and maintain without drying at a relatively constant temperature for the period of time necessary for hydration of the cement and proper hardening of the concrete.
2. Start initial curing after placing and finishing concrete as soon as free moisture has disappeared from the concrete surface. Keep continuously moist for not less than 72 hours.
3. Begin final curing procedures immediately following initial curing and before the concrete has dried. Continue final curing for at least seven days and in accordance with ACI 301 procedures. For concrete sections over 30-inches thick, continue final curing for an additional seven days, minimum. Avoid rapid drying at the end of the final curing period.

B. Final Curing Methods:
1. Perform curing of concrete by moist curing, or by moisture-retaining cover curing, or curing compound.
a. For curing, use water that is free of impurities which could etch or discolor exposed, natural concrete surfaces.
2. Provide moisture curing by any of the following methods:
a. Keeping the surface of the concrete continuously wet by covering with water.
b. Continuous water-fog spray.
c. Covering the concrete surface with the specified absorptive cover, thoroughly saturating the cover with water, and keeping the absorptive cover continuously wet with sprinklers or porous hoses. Cover shall be Transguard 4000 or approved equal.
d. Place absorptive cover so as to provide coverage of the concrete surfaces and edges, with a 4-inch lap over adjacent absorptive covers.
3. Provide moisture retaining cover curing as follows:

a. Cover the concrete surfaces with the specified moisture retaining cover for curing concrete, placed in the widest practical width with sides and ends lapped at least 3-inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during the curing period using cover material and waterproof tape.

4. Provide liquid curing compound as follows:
   a. Apply the specified curing compound to all concrete surfaces when permitted by ENGINEER. Slabs to receive terrazzo floors, chemical resistant heavy-duty concrete topping or ceramic tile, shall not be cured with liquid curing compound, but shall be moisture cured. The compounds shall be applied immediately after final finishing in a continuous operation by power spray equipment in accordance with the manufacturer's directions. Recoat areas which are subjected to heavy rainfall within three hours after initial application. Maintain the continuity of the coating and repair damage to the coat during the entire curing period. For concrete surfaces which will be in contact with raw or potable water, the manufacturer shall certify that the curing compound used is EPA approved.

C. Curing Formed Surfaces:
   1. Cure formed concrete surfaces, including the undersides of girders, beams, supported slabs, and other similar surfaces with the forms in place for the full curing period. If forms are removed earlier, continue curing by methods specified above, as applicable.

D. Curing Unformed Surfaces:
   1. Final cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by using the appropriate method specified above.

E. Temperature of Concrete During Curing:
   1. When the atmospheric temperature is 40° F and below, maintain the concrete temperature between 50° F and 70° F continuously throughout the curing period. When necessary, make arrangement before concrete placing for heating, covering, insulation or housing as required to maintain the specified temperature and moisture conditions continuously for the concrete curing period. Provide cold weather protection complying with the requirements of ACI 306.
   2. When the atmospheric temperature is 80° F and above, or during other climatic conditions which will cause too rapid drying of the concrete, make arrangements before the start of concrete placing for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or moisture-retaining covering. Protect the concrete continuously for the concrete curing period. Provide hot weather protection complying with the requirements of ACI 305, unless otherwise specified.

3. Maintain concrete temperature as uniformly as possible, and protect from rapid atmospheric temperature changes. Avoid temperature changes in concrete which exceed 5° F in any one hour and 50° F in any 24 hour period.

F. Protection from Mechanical Injury:
   1. During the curing period, protect concrete from damaging mechanical disturbances including load stresses, heavy shock, excessive vibration, and from damage caused by rain or flowing water. Protect all finished concrete surfaces from damage by subsequent construction operations.

3.8 FIELD QUALITY CONTROL

A. CONTRACTOR shall employ a testing laboratory to perform field quality control testing. ENGINEER will make slump tests and will direct the number of tests and cylinders required. CONTRACTOR shall make standard compression test cylinders and entrained air tests as specified below, under the direct inspection by ENGINEER. CONTRACTOR shall furnish all necessary assistance required by ENGINEER. CONTRACTOR shall also furnish all labor, material, and equipment required, including cones, rods, molds, air tester, thermometer, curing in a heated storage box, and all other incidentals required. Above will be subject to approval by ENGINEER. CONTRACTOR shall furnish all necessary storage, curing, and transportation required by the testing.

B. Quality Control Testing During Construction:
   1. Perform sampling and testing for field quality control during the placement of concrete, as follows:
      a. Sampling Fresh Concrete: ASTM C172.
      b. Slump: ASTM C143; one test for each concrete load at point of discharge; and one for each set of compressive strength test specimens.
      c. Air Content: ASTM C231; one for every other concrete load at point of discharge, or when required by an indication of change.
      d. Compressive Strength Tests: ASTM C39; one set of compression cylinders for each 50 cubic yards or fraction thereof, of each mix design placed in any one day or for each 2,500 square feet of surface area placed; two specimens tested at seven days, and two specimens tested at 28 days.
         1) Adjust mix if test results are unsatisfactory and resubmit for ENGINEER'S approval.
         2) Concrete which does not meet the strength requirements is subject to rejection and removal from the Work, or to other such corrective measures as directed by ENGINEER, at the expense of CONTRACTOR.
      e. Compression Test Specimens: ASTM C31; make one set of three standard cylinders for each compressive strength test, unless otherwise directed.
         1) Cast, store, and cure specimens as specified in ASTM C31.

f. Concrete Temperature: Test hourly when air temperature is 40° F and below, and when 80° F and above; and each time a set of compression test specimens is made.

2. The testing laboratory shall submit certified copies of test results directly to ENGINEER and CONTRACTOR within 24 hours after tests are made.

C. Evaluation of Quality Control Tests:
1. Do not use concrete delivered to the final point of placement which has slump or total air content outside the specified values.
2. Compressive strength tests for laboratory-cured cylinders will be considered satisfactory if the averages of all sets of three consecutive compressive strength tests results equal or exceed the 28 day design compressive strength of the type or class of concrete; and, no individual strength test falls below the required compressive strength by more than 500 psi.
   a. Where questionable field conditions may exist during placing concrete or immediately thereafter, strength tests of specimens cured under field conditions will be required by ENGINEER to check the adequacy of curing and protecting of the concrete placed. Specimens shall be molded at the same time and from the same samples as the laboratory cured specimens.
      1) Provide improved means and procedures for protecting concrete when the 28 day compressive strength of field-cured cylinders is less than 85% of companion laboratory-cured cylinders.
      2) When laboratory-cured cylinder strengths are appreciably higher than the minimum required compressive strength, field-cured cylinder strengths need not exceed the minimum required compressive strength by more than 500 psi even though the 85% criterion is not met.
      3) If individual tests of laboratory-cured specimens produce strengths more than 500 psi below the required minimum compressive strength, or if tests of field-cured cylinders indicate deficiencies in protection and curing, provide additional measures to assure that the load-bearing capacity of the structure is not jeopardized. If the likelihood of low-strength concrete is confirmed and computations indicate the load-bearing capacity may have been significantly reduced, tests of cores drilled from the area in question will be required at CONTRACTOR'S expense.
   b. If the compressive strength tests fail to meet the minimum requirements specified, the concrete represented by such tests will be considered deficient in strength and subject to replacement, reconstruction or to other action approved by ENGINEER.

D. Testing Concrete Structure for Strength:
1. When the OWNER employed testing laboratory results indicate that the strength of the in-place concrete does not meet Specification requirements, CONTRACTOR shall employ, at his expense, the services of a concrete

testing service to take cores drilled from hardened concrete for compressive strength determination following requirements of ACI 350. Tests shall comply with ASTM C42 and the following:

a. Take at least three representative cores from each member or suspect area at locations directed by ENGINEER.
b. Strength of concrete for each series of cores will be considered satisfactory if their average compressive strength is at least 85% and no single core is less than 75% of the 28 day required compressive strength.
c. Report test results in writing to ENGINEER on the same day that tests are made. Include in test reports the Project identification name and number, date, name of CONTRACTOR, name of concrete testing service, location of test core in the structure, type, or class of concrete represented by core sample, nominal maximum size aggregate, design compressive strength, compression breaking strength and type of break (corrected for length-diameter ratio), direction of applied load to core with respect to horizontal plane of the concrete as placed, and the moisture condition of the core at time of testing.

2. Fill core holes solid with non-shrink, high strength grout, and finish to match adjacent concrete surfaces.
3. Conduct static load test and evaluations complying with ACI 350 if the results of the core tests are unsatisfactory, or if core tests are impractical to obtain, as directed by ENGINEER.
4. OWNER, at his own expense, may also conduct the same tests using the laboratory of OWNER'S choice when the test results show that the concrete does not meet the Specifications. The CONTRACTOR shall coordinate with the OWNER and ENGINEER prior to taking any representative samples and beginning the testing process.

3.9 MISCELLANEOUS CONCRETE ITEMS

A. Filling-In:
   1. Fill-in holes and openings left in concrete structures for the passage of work by other contractors, unless otherwise shown or directed, after the work of other contractors is in place. Mix, place and cure concrete as herein specified, to blend with in-place construction. Provide all other miscellaneous concrete filling shown or required to complete the Work.

B. Curbs:
   1. Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
   2. Exterior curbs shall have rubbed finish for vertical surfaces and a broomed finish for top surfaces.

C. Equipment Bases:

1. Unless specifically shown otherwise, provide concrete bases for all pumps and other equipment. Construct bases to the dimensions shown, or as required to meet manufacturer's requirements and drawing elevations. Where no specific elevations are shown, bases shall be 6-inches thick and extend 3-inches outside the metal equipment base or supports. Bases to have smooth trowel finish, unless a special finish such as terrazzo, ceramic tile or heavy-duty concrete topping is required. In those cases, provide appropriate concrete finish.
2. Include all concrete equipment base work not specifically included under other Sections or other contracts.
3. In general, place bases up to 1-1/2-inches below the metal base. Properly shim equipment to grade and fill 1-1/2-inch void with non-shrink grout, as specified in Section 03600, Grout.

3.10 CONCRETE ENCASEMENT OF ELECTRICAL DUCT BANKS

A. Mix red dye into concrete to be used for encasement.

B. Provide a minimum covering of 3-inches of concrete over the top and sides of the conduit and conduit supports.

C. Conduit shall be firmly fixed in place before pouring concrete. Vibrate the concrete to ensure filling of all spaces between conduits.

D. Where duct banks pass under paved or unpaved roadways, concrete encasement shall be reinforced with No. 4 longitudinal steel bars placed at each "corner" and at 18-inches o.c. along the top and sides of the duct bank. Place No. 3 tie-bars placed transversely at 18-inches o.c. Maintain a minimum cover of 2-inches of concrete over the reinforcing bars.

E. Install a bare stranded copper duct bank ground in each duct bank. Make the ground electrically continuous throughout the entire duct bank system and connect to switchgear and motor control center ground busses and to steel conduit extension of the underground duct system.

3.11 CONCRETE REPAIRS

A. Repair of Formed Surfaces:
   1. Repair exposed-to-view formed concrete surfaces that contain defects which adversely affect the appearance of the finish. Surface defects that require repair include: color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, holes left by the rods and bolts, fins and other projections on the surface, and stains or other discolorations that cannot be removed by cleaning.
   2. Repair concealed formed concrete surfaces that may contain defects that adversely affect the durability of the concrete. Surface defects that require

repair include: cracks in excess of 0.01-inch wide, cracks of any width, other surface deficiencies which penetrate to the reinforcement or completely through non-reinforced sections, honeycomb, rock pockets, holes left by tie rods and bolts, and spalls except minor breakage at corner.

B. Repair structural cracks and cracks in water-holding structures. Method of Repair of Formed Surfaces:
   1. Repair and patch defective areas with cement mortar immediately after removal of forms and as directed by ENGINEER.
   2. Cut out honeycomb, rock pockets, voids over 1/2-inch diameter, and holes left by tie rods and bolts, down to solid concrete but, in no case, to a depth of less than 1-inch. Make edges of cuts perpendicular to the concrete surface. Before placing the cement mortar thoroughly clean, dampen with water, and brush-coat the area to be patched with the specified bonding agent.
      a. For exposed-to-view surfaces, blend white Portland cement and standard Portland cement so that, when dry, the patching mortar color will match the color of the surrounding concrete. CONTRACTOR shall impart texture to repaired surfaces to match texture of existing adjacent surfaces. Provide test areas at inconspicuous locations to verify mixture, texture and color match before proceeding with the patching. Compact mortar in place and strike off slightly higher than the surrounding surface.
   3. Cracks which require repair shall be pressure grouted using one of the following. Apply in accordance with the manufacturer's directions and recommendations.
      a. Sikadur 35, Hi-Mod L.V. or Sikadur 55 SLV, with Sikadur 31, Hi-Mod Gel, as manufactured by Sika Corporation Company.
      b. Euco Epoxy #452 Gel Epoxy System with Dural 335 Ulta-low V or EucoPoxy Injection Resin, as manufactured by The Euclid Chemical Company.
      c. Or approved equal.
   4. Fill holes extending through concrete by means of a plunger-type gun or other suitable device from the least exposed face, using a flush stop held at the exposed face to ensure complete filling.
   5. Sandblast exposed-to-view surfaces that require removal of stains, grout accumulations, sealing compounds, and other substances marring the surfaces. Use sand finer than No. 30 and air pressure from 15 to 25 psi.

C. Repair of Unformed Surfaces:
   1. Test unformed surfaces, such as monolithic slabs, for smoothness and to verify surface plane to the tolerances specified for each surface and finish. Correct low and high areas as herein specified.
   2. Test unformed surfaces sloped to drain for trueness of slope, in addition to smoothness, using a template having the required slope. Correct high and low areas as herein specified.

3. Repair finish of unformed surfaces that contain defects which adversely affect the durability of the concrete. Surface defects as such, include crazing, cracks in excess of 0.01-inch wide or which penetrate to the reinforcement or completely through non-reinforced sections regardless of width, spalling, pop-outs, honeycomb, rock pockets, and other objectionable conditions.
4. Repair structural cracks and cracks in water-holding structures.

D. Methods of Repair of Unformed Surfaces:
   1. Correct high areas in unformed surfaces by grinding, after the concrete has cured sufficiently so that repairs can be made without damage to adjacent areas.
   2. Correct low areas in unformed surfaces during, or immediately after completion of surface finishing operations by cutting out the low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. Use one of the following. Apply in accordance with the manufacturer's directions and recommendations.
      a. Tammspatch II, as manufactured by The Euclid Chemical Company.
      b. Sikatop 122 Plus, as manufactured by Sika Corporation.
      c. Or approved equal.
   3. Repair defective areas, except random cracks and single holes not exceeding 1-inch diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts, and expose reinforcing steel with at least 3/4-inch clearance all around. Dampen all concrete surfaces in contact with patching concrete and brush with the specified bonding agent. Place patching concrete before grout takes its initial set. Mix patching concrete of the same materials and proportions to provide concrete of the same type or class as the original adjacent concrete. Place, compact and finish as required to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.
   4. Repair isolated random cracks and single holes not over 1-inch diameter, by the dry-pack method. Groove the top of cracks, and cut out holes to sound concrete and clean of dust, dirt and loose particles. Dampen all cleaned concrete surfaces and brush with the specified bonding agent. Place dry pack before the cement grout takes its initial set. Mix dry-pack, consisting of one part Portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Compact dry pack mixture in place and finish to match adjacent concrete. Keep patched areas continuously moist for not less than 72 hours.
   5. Cracks which require repair shall be pressure grouted using one of the following. Apply in accordance with the manufacturer's directions and recommendations.
      a. Sikadur 35, Hi-Mod L.V. or Sikadur 55 SLV, with Sikadur 31, Hi-Mod Gel, as manufactured by Sika Corporation Company.
      b. Euco Epoxy #452 Gel Epoxy System with Dural 335 Ulta-low V or EucoPoxy Injection Resin, as manufactured by The Euclid Chemical Company.

c. Or approved equal.

6. Assure that surface is acceptable for flooring material to be installed in accordance with manufacturer's recommendations.

E. Other Methods of Repair:

1. Repair methods not specified above may be used if approved by ENGINEER.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. All specialty metal items required to complete the Work in accordance with the intent of the Drawings and Specifications shall be furnished and installed, regardless of whether or not specifically shown or described. Such items include loose or embedded items of structural shapes, plates and bars, welded plate inserts, fabrications, and similar items. Bolts, expansion shields, and other fastening devices, which may or may not be provided with the indicated or specified items, shall also be furnished and installed as required for attachment and support.

1.2 SECTION INCLUDES

A. Pipe supports, hangers, and brackets.

B. Access hatches.

C. Anchor bolts.

D. Stainless steel rods, nuts, bolts, and washers.

E. Fasteners for aluminum.

F. Fasteners.

G. Pipe bollards.

H. Corrosion protection.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Letters of Certification of Compliance on materials, equipment, etc.
   2. Final Certified Drawings showing outline dimensions, foundation layout or mounting information, and other pertinent dimensions.
   3. Field erection instructions, assembly drawings and/or diagrams, detailed reference drawing lists, and lists of erection details.
   4. Shop detail drawings showing individual sub-assemblies and fabricated pieces with material specifications and other applicable data.

5. General bulletins and product literature describing complete apparatus including operating principles and fundamentals.
6. Materials of construction of all components.
7. Material gradation, design mix, job formula, and/or material analysis.
8. All welds, both shop and field, shall be indicated by AWS Welding Symbols.
9. Show all types of paint.
10. Submit certified copies of the qualification records of each welder prepared within six months of the time of Contract award.

B. Operation and Maintenance Manuals: Submit complete Operation and Maintenance Manuals in conformance with the Operation and Maintenance Manuals Section of Section 01300, Submittals.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A36.

B. Aluminum:
1. Alloy and Temper: Provide alloy and temper as shown on the Drawings or specified, or as otherwise recommended by the aluminum producer or finisher.
2. Extruded Shapes and Tubes: ASTM B221.
3. Plate and Sheet: ASTM B209.
4. Bars, Rods, and Wire: ASTM B211.

C. Stainless Steel Plates, Sheets, Bars and Bolts: ASTM A240 or A276, or A320; Type 316 stainless steel.
1. Submerged or Intermittently Submerged: Type 316 stainless steel.
2. Non-Submerged: Type 316 stainless steel.

D. Stainless Steel Fasteners and Fittings: ASTM A320.

2.2 PROCESS PIPE SUPPORTS, HANGERS, AND BRACKETS

A. Process Piping:
1. All process piping shall be supported as detailed on the Drawings and specified herein. Process piping includes, but is not limited to, the following:
   a. Ductile iron pipe.
   b. Stainless steel pipe.
   c. PVC pipe.
   d. Steel pipe.
   e. Fiberglass reinforced plastic (FRP) pipe.
   f. Copper pipe.

2. All process pipe supports, hangers, and brackets shall be as manufactured by B-Line Systems, Grinnell, or Unistrut, as detailed on the Drawings. Supports for stainless steel piping shall be Type 316 stainless steel.
3. All appurtenances required for proper installation of the pipe supports, brackets, and hangers shall be supplied by the manufacturer and shall be Type 316.
4. Anchor bolts for pipe supports, hangers and brackets shall be of the sizes as recommended by the manufacturers of the pipe supports, hangers, and brackets. Anchor bolt type and materials shall be as specified under Section 2.4 of this Specification.

2.3 ACCESS HATCHES

A. Access hatches shall be manufactured by Halliday, Inc., Syracuse Castings, or approved equal.

B. Each hatch shall be designed to combine covering of the opening per OSHA Standard 1910.23 and controlled confine space entry with a safety grate per OSHA Standard 1910.146.

C. The safety grate shall be made of 6061-T6 aluminum with a minimum ultimate strength of 38,000 psi and a minimum yield strength of 35,000 psi, as per ASTM B221. Grate design shall use safety factors as defined in the "Specifications for Aluminum Structures" by the Aluminum Association, Inc., 5th addition, for "Bridge Type Structures".

D. Grating shall be designed to withstand a minimum live load of 300 lbs per square foot. Deflection shall not exceed 1/150th of the span.

E. Grate openings shall be 4-inches by 4-inches, which will allow for visual inspection, limited maintenance, and float adjustments while the safety grate fall-through protection is left in place.

F. Design must assure that the fall-through protection is in place before the doors can be closed, thereby protecting the next operator.

G. Each grate shall be provided with a permanent hinging system, which will lock the grate in the 90 degree position once opened. Grate shall be coated with an OSHA type safety orange color and shall receive a two-coat powder coat system, applied by electrostatic spray process. The base coat is a thermosetting epoxy powder coat finish with a minimum thickness of 2 mils to 4 mils. The top coat is a mar-resistant, TGIC polyester powder coating with a minimum thickness of 2 mils to 4 mils. Each coat shall be baked at 350° F to 375° F until cured. Each grate shall have an opening arm, with a red vinyl grip handle. The opening arm shall also be equipped with a controlled confined space entry lock (lock provided by others).

H. Welding shall be in accordance with ANSI/AWS D1.2 Structural Welding Code for Aluminum.

I. Access hatches shall be sized as shown on the Drawings or as specified in related Sections. All hatches shall be aluminum with anodized finish, use 316 stainless steel hardware, and pedestrian traffic rated for a load of 300 lbs. per square foot, as indicated on the Plans or as specified in related Sections. The hatches shall be supplied with safety chains, stainless steel compression springs for lift assistance, and a recessed, tamper resistant padlock assembly.

J. Access hatches shall come with a minimum five year warranty on all parts and workmanship.

K. See Specification herein on aluminum coating in contact with grout or concrete.

2.4 ANCHOR BOLTS

A. Cast-In-Place Bolt-Type Anchors:
   1. Cast-in-place anchor bolts, nuts, and washers shall be ANSI Type 316 stainless steel, which meet the requirements of ASTM F593 and ASTM A666.
   2. Cast-in-place anchor bolts shall have a flat plate configuration bent shanks L or J configuration shall not be allowed.

B. Adhesive (Epoxy) Anchors:
   1. Adhesive anchors shall consist of all-thread anchor rod, nut, washer, and epoxy adhesive. Anchor rods shall be manufactured from ASTM A666 AISI Type 316 stainless steel which meets the requirements of ASTM F593. The adhesive shall be approved for both cracked concrete and masonry; Hilti HIT-HY 200 or Simpson SET-XP or other Equal with an approved ICC-Evaluation Report or Equal approval.
   2. Post-installed anchors shall be installed by qualified personnel in accordance with the Manufacturer's Printed Installation Instructions (MPII). Special Inspection shall be per IBC requirements along with those of the ICC Evaluation Service Reports or other approved evaluation reports.

2.5 STAINLESS STEEL RODS, NUTS, BOLTS, AND WASHERS

A. Stainless steel rods, nuts, bolts, and washers shall be ASTM A666, Type 316 stainless steel. Only non-gall lubricants shall be used on stainless steel rods, nuts, and bolts.

2.6 FASTENERS FOR ALUMINUM

A. Unless otherwise specified, all nuts, bolts, screws, washers, and other fastener material for aluminum fabrications shall be Type 316 stainless steel.

2.7 FASTENERS

A. Unless otherwise specified or required, all fasteners provided for this Project shall be at a minimum Grade 5, ASTM A449 Type 1, SAE J429. Grade marking shall appear on all bolts and nuts.

2.8 PIPE BOLLARDS

A. Fabricate pipe bollards from Schedule 80 steel pipe, with stud anchors.

B. Pipe Diameter: 6-inch outside diameter, unless noted otherwise.

2.9 CORROSION PROTECTION

A. Corrosion Protection: Prepare and coat all concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
   1. Surface must be clean, dry, and free of oil, grease, and other contaminants. Surface preparation with SSPC-SP7 brush-off abrasive blast cleaning. Apply two coats of Tnemec Series 20 Pota-Pox or approved equal; each coat shall be 3-5 mils. Coating must be NSF 61 approved.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items plumb and level, accurately fitted, free from distortion or defects.

B. All bolting holes provided in equipment, valves, gates, pipe supports and hangers, handrails, ladders, and other items which require mounting shall be used as specified and intended.

C. Allow for erection loads and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.
   1. Field weld components indicated on Drawings.
   2. Perform field welding in accordance with AWS D1.1.
   3. The ENGINEER'S approval prior to site cutting or making adjustments not scheduled.

3.2 INSTALLING PIPE BOLLARDS

A. Anchor bollards in concrete with pipe sleeves pre-set and anchored into concrete. After bollards have been inserted into sleeves, fill annular space between bollard and sleeve solidly with non-shrink, non-metallic grout, mixed and placed to comply with grout manufacturer's directions.

B. Fill bollards solidly with concrete and strike flush with top of bollard, unless indicated otherwise.

END OF SECTION

SECTION 09900

PAINTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, services and incidentals required to furnish and install all painting work for aluminum and ferrous metals, masonry surfaces, fiberglass, CPVC, PVC, galvanized metals, and other surfaces as specified herein or as indicated on the Drawings.
   2. The extent of painting work is specified and/or shown.
   3. The Work includes the painting and finishing of all items and surfaces throughout the Project included in the Specifications.
      a. Surface preparation, priming, and coats of paint specified are in addition to shop priming and surface treatment specified under other Sections of the Work.
   4. The term "paint" as used herein means all coating systems materials, which includes pretreatments, primers, emulsions, enamels, stain, sealers, and fillers, and other applied materials, whether used as prime, intermediate or finish coat.
   5. Paint all exposed surfaces whether or not colors are designated in any schedule, except where the natural finish of the material is specifically noted as a surface not to be painted. The term "exposed" as used herein means all items not covered with concrete. Ducts, conduits, and other materials with corrosion resistant surfaces, which are in chases, above, finished ceilings, or other inaccessible areas shall not require field painting, unless otherwise specified or otherwise shown. Where items or surfaces are not specifically mentioned, paint these the same as adjacent similar materials or areas. If the schedules do not indicate color or finish that is mentioned, the ENGINEER will select from standard colors and finishes available.
   6. Structural and miscellaneous metals covered with concrete, shall only receive a primer compatible with the covering material.
   7. Pre-applied coatings to all items delivered to the job site and not requiring field sand blasting shall be done in accordance with the approved painting submittal under this Section. All items delivered to the job site with pre-applied coatings will be inspected by the ENGINEER and shall be repaired by the CONTRACTOR if, in the judgment of the ENGINEER, the coating is damaged. The CONTRACTOR shall then apply a final coat of the approved protective coating to the equipment in the field.
   8. Where required in these Specifications, ferrous metal surfaces to be painted including above ground and below ground piping, fittings, valves, etc.,

supplied under Division 15, Mechanical, shall be prepared by field blast cleaning as specified herein.

9. Pipe identification markers, as specified.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be field painted in this Section.
   2. Coordinate the painting of areas that are inaccessible once equipment has been installed.
   3. Ensure pre-applied prime coats not to be sand blasted are done in accordance with the approved painting submittals under this Section. CONTRACTOR shall be responsible to ensure all coating systems are provided in accordance with the approved painting and protective coating submittals under this Section.
   4. Provide finish coats that are compatible with the prime paints used. Review other Sections of these Specifications in which prime paints are to be provided to ensure compatibility of the total coatings system for the various substrates. CONTRACTOR shall be responsible for the compatibility of all shop primed and field painted items. Furnish information on the characteristics of the finish materials proposed to use, to ensure that compatible prime coats are used. Provide barrier coats over incompatible primers or remove and re-prime as required. Notify ENGINEER, in writing, of anticipated problems using the coating systems as specified with substrates primed by others.

C. Painting Not Included: The following categories of Work are not included as part of the field-applied finish work or included in other Sections of these Specifications.
   1. Shop Priming: Unless otherwise specified, shop priming of structural metal, miscellaneous metal fabrications, other metal items and such fabricated components as shop-fabricated or factory-built heating and ventilating, instrumentation and electrical equipment or accessories shall conform to applicable requirements of Section 09900, Painting, but is included under the appropriate Sections of this Specification.
   2. Pre-Finished Items:
      a. Pre-finished items include, but are not limited to, the following factory-finished components:
         1) Architectural woodwork and casework.
         2) Motor nameplates.
         3) Instrumentation and electrical mounting hardware such as nuts, bolts, screws, u-bolts, handles, latches, and hinges.
         4) Analyzers, probes, nuts, bolts, and screws or any mounting hardware.
         5) Metal toilet enclosures.
         6) Acoustical ceiling panels.
         7) Metal lockers.

8) tile, windows, glass, resilient flooring; other architectural features, such as "finish" hardware, furnished in aluminum, bronze or plated ferrous metal, prefinished panels, or other items installed prefinished.
9) Finished mechanical and electrical equipment, except as indicated in the Specifications or on the Plans.
10) Light fixtures.
11) Interior distribution cabinets and switch gear, except as indicated.
12) Items such as baked-on enamel, porcelain, polyvinylfluoride or other similar finishes, where specified, or noted on the Drawings.

3. Concealed Surfaces:
   a. These include walls or ceilings in the following generally inaccessible spaces:
      1) Foundation spaces, unless noted otherwise.
      2) Surfaces behind furred areas.
      3) Ceiling plenums.
      4) Pipe spaces.
      5) Duct shafts.
4. Metal surfaces of anodized aluminum, stainless steel, chromium plate, bronze, and copper will not require finish painting, unless shown or specified otherwise.
5. Operating Parts:
   a. Operating parts include moving parts of operating equipment and the following:
      1) Valve and damper operators or handles.
      2) Linkages.
      3) Sensing devices.
      4) Motor and fan shafts.
6. Labels:
   a. Do not paint over any code-required labels, such as Underwriters Laboratories (UL), Factory Mutual (FM), fire rating labels, equipment serial number and capacity labels or other code-required labels or equipment name, identification, performance rating, nomenclature plates and equipment identification plates.
7. Sealants.
8. Protective coating of concrete.

1.2 DEFINITIONS

A. General: Standard coating terms defined in ASTM D16 apply to this Section.
   1. Flat refers to a lusterless or matte finish with a gloss range below 15 when measured at an 85 degree meter.
   2. Eggshell refers to low-sheen finish with a gloss range between 5 and 20 when measured at a 60 degree meter.
   3. Satin refers to low-sheen finish with a gloss range between 15 and 35 when measured at a 60 degree meter.

4. Semi-gloss refers to medium-sheen finish with a gloss range between 30 and 65 when measured at a 60 degree meter.
5. Full gloss refers to high-sheen finish with a gloss range more than 65 when measured at a 60 degree meter.
6. Buried refers to covered with earth.
7. Exposed or exposed surfaces refer to areas visible when permanent or built-in fixtures, grilles, and similar components are in place. Extend coatings in these areas, as required, to maintain the system integrity and provide desired protection.
8. Submerged refers to materials which are permanently or intermittently below the maximum water or liquid surface elevation in open top structures unless otherwise noted or otherwise shown; materials within liquid or residual solids carrying structures that are covered, including materials on the underside of the covers, whether in contact with liquids or not, unless otherwise noted or otherwise shown; materials within an enclosed process structure, whether in contact with liquids or not.

1.3 QUALITY ASSURANCE

A. Applicator Qualifications:
   1. CONTRACTOR shall submit to the ENGINEER the name and experience record of the painting subcontractor. Include a list of utility or industrial installations painted, responsible officials, architects, or engineers concerned with the Project and the approximate Contract price.
   2. Painting subcontractors whose submissions indicate that they have not had the experience required to perform the Work shall not be approved. Qualifying experience shall include at least four previous water/wastewater treatment plant projects of similar magnitude and complexity to this Project that have been completed not less than three years prior to submission of qualifications to ENGINEER.

B. All materials specified by name, brand, or manufacturer shall be delivered unopened to the job in their original containers. The paint shall be applied in strict accordance with the recommendations of the manufacturer using equipment approved for the duty.

C. Source Quality Control:
   1. Provide the services of a qualified manufacturer's representative at the Project site for a minimum of two trips and two, eight hour workdays at the commencement of Work to advise on materials, installation, and finishing techniques.
   2. Certify long-term compatibility of all coatings with all substrates.
   3. Provide the services of a qualified manufacturer's representative at the Project site for a minimum of two trips and four, eight hour workdays at completion of the Work to inspect the Work. Within seven calendar days after inspection by the manufacturer, the CONTRACTOR shall provide a

written report from the manufacturer certifying the coatings have been applied properly and in accordance with the manufacturer's recommendations and requirements. Deficiencies in the coatings system, if any noted by the manufacturer during final inspection shall be defined in the manufacturer's report including corrective measures to be implemented by the CONTRACTOR at the CONTRACTOR'S expense. Following corrective measures by the CONTRACTOR, the manufacturer shall re-inspect the work, at the CONTRACTOR'S expense and the CONTRACTOR shall, within seven days after re-inspection, provide a written report from the manufacturer certifying the coatings have been applied properly and in accordance with the manufacturer's recommendations and requirements.

D. Reference Regulations: Surface preparation and application of coatings shall be performed by the CONTRACTOR in compliance with all applicable Federal, State, and local occupational Safety, Health and Air Pollution Control Regulations. The CONTRACTOR shall obtain and comply with all safety precautions recommended by the paint manufacturer in printed instructions or special bulletins, and as required by applicable regulations. The CONTRACTOR shall provide forced ventilation in all areas where inadequate ventilation exists.

1.4 SUBMITTALS

A. Letters of Certification of Compliance on materials, equipment, etc.

B. The CONTRACTOR shall be required to submit his proposed protective coating systems prior to any other equipment, piping, or hardware submittals that require protective coatings. After review of the protective coating submittals by the ENGINEER to indicate no further submittals are required, the CONTRACTOR shall be required to furnish only the approved protective coatings throughout the Project.

C. Submit product data and marker sample for each type of pipe identification required.

D. List each material and cross-reference to the specific paint and finish system and application. Identify by manufacturer's catalog number and general classification.

E. Manufacturer's Information: Provide manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each coating material proposed for use.
   1. Identify manufacturer's recommended, published spreading rate and dry film thickness of each coating material proposed for use.
   2. Indicate manufacturer's instructions on surface and special surface preparation procedures.
   3. Include the following: Mixing instructions, shelf life, method of application, recommended number of coats, drying time of each coat including prime

coat, required prime coat, compatible and non-compatible prime coats, and recommended thinners when required.

F. Copies of CONTRACTOR'S proposed protection procedures in each area of the Work.

G. Copies of manufacturer's complete color charts for each coating system.

H. Maintenance Manual: Upon completion of the Work, furnish copies of a detailed maintenance manual including the following information:
   1. Product name and number.
   2. Name, address, and telephone number of manufacturer and local distributor.
   3. Detailed procedures for routine maintenance and cleaning.
   4. Detailed procedures for light repairs such as dents, scratches, and staining.

I. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each type of finish-coat material indicated. Submit two paper chip samples, 3-inch by 3-inch in size.

J. Before supplying any material to the site, the painting subcontractor and the paint manufacturer's area representative shall prepare a complete schedule showing the materials proposed to be used for each treatment specified, and submit same to ENGINEER for approval.

K. Include list of completed projects with project names and addresses, names and addresses of Engineers or Owners, and other information specified.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery of Materials: Deliver all materials to the job site in original, new and unopened packages and containers bearing manufacturer's name and label, and the following information:
   1. Name or title of material.
   2. Manufacturer's stock number and date of manufacture.
   3. Manufacturer's name.
   4. Contents by volume, for major pigment and vehicle constituents.
   5. Thinning instructions where recommended.
   6. Application instructions.
   7. Color name and number.

B. Storage of Materials:
   1. Store only acceptable project materials on Project site.
   2. Store in a suitable location approved by ENGINEER. Keep area clean and accessible.
   3. Restrict storage to paint materials and related equipment.

4. Comply with health and fire regulations including the Occupational Safety and Health Act of 1970.

C. Handling of Materials:
   1. Handle materials carefully to prevent inclusion of foreign materials.
   2. Do not open containers or mix components until necessary preparatory Work has been completed and application Work will start immediately.

1.6 JOB CONDITIONS

A. Existing Conditions:
   1. Before painting is started in any area, it shall be broom cleaned and excessive dust shall be removed.
   2. After painting operations begin in a given area, broom cleaning will not be allowed; cleaning shall then be done only with commercial vacuum cleaning equipment.

B. Environmental Requirements:
   1. Apply water-based paints only when the temperature of surfaces to be painted and the surrounding air temperatures are between 55° F and 90° F, unless otherwise permitted by the paint manufacturer's printed instructions.
   2. Apply other paints only when the temperature of surfaces to be painted and the surrounding air temperatures are between 65° F and 95° F and the temperature is 5° F above the dew point, unless otherwise permitted by the paint manufacturer's printed instructions and approved by the ENGINEER.
   3. Do not apply paint in rain, fog, or mist, or when the relative humidity exceeds 80%, or to damp or wet surfaces.
   4. Painting may be continued during inclement weather only if the areas and surfaces to be painted are enclosed and heated within the temperature limits specified by the paint manufacturer during application and drying periods.
   5. Adequate illumination and ventilation shall be provided in all areas where painting operations are in progress.
   6. Surface preparation and application of coatings shall be performed by the CONTRACTOR in compliance with all applicable Federal, State, and local Occupational Safety, Health and Air Pollution Control Regulations. The CONTRACTOR shall obtain and comply with all safety precautions recommended by the paint manufacturer in printed instructions or special bulletins.
   7. Install piping markers only after all painting and finish work has been completed.

C. Protection: Cover or otherwise protect finished work of other trades and surfaces not being painted concurrently or not to be painted.

D. Spent abrasive containing lead and/or chromate paint resulting from the blasting of the "affected surfaces" may be classified as a hazardous waste. "Spent

abrasive" shall be understood to mean the abrasive generated during the blasting operation, including the spent water imposed over the abrasive flow, paint residue, and any other debris.

E. Care shall be exercised to prevent spent abrasive, water, or dust from falling on surrounding buildings, unprotected vegetation, walkways, soils, structures and equipment by covering these areas with non-tearing tarps. Spent abrasive collecting on the ground shall be vacuumed regularly to prevent it from becoming wind blown. The site shall at all times be kept as clean as possible. At the end of the Work day, all spent abrasive shall be thoroughly vacuumed and the site left with a neat appearance.

F. Spent abrasive resulting from the blasting of the "affected surfaces" shall be captured. Non-tearing tarps or plastic sheathing, platforms, partial or total enclosures, temporary barriers or structures, or similar containment methods may be employed for this purpose. These methods must be reviewed by the ENGINEER prior to start of Work. A detailed procedure describing the proposed blast cleaning operation, abrasive capture, and containment techniques, and safety measures to avoid the contamination of the natural environment or surrounding structures.

G. Spent abrasive resulting from the blasting of the "affected surfaces" shall be collected and legally disposed off by the CONTRACTOR in a legal and responsible manner. Such disposal shall also be in conformance with all applicable codes, ordinances, and regulations for hazardous waste disposal. All other waste, including spent abrasive generated by the blasting of non-affected surfaces, shall be disposed by the CONTRACTOR.

H. All materials, including painting equipment, shall be stored in accordance with local, State, and Federal requirements for paints, toxic materials, and hazardous materials. All rags shall be removed from the premises. All possible precautions shall be taken to prevent spontaneous fires.

I. All reasonable care shall be taken to protect against paint splatter and over spray. CONTRACTOR shall be responsible for any damage incurred to surrounding property resulting from his Work.

J. Signs shall be posted, as required, to alert the public of any risks associated with sandblasting debris, painting over spray, etc. All efforts shall be made to prevent debris from becoming wind blown.

K. CONTRACTOR shall be responsible for obtaining any and all permits required to perform the Work.

L. Spent water, resulting from the cleaning operation of "affected surfaces" due to wet sandblasting, may contain hazardous particulates. Spent water shall be handled and disposed off in a legal and responsible manner.

PART 2 - PRODUCTS

2.1 MATERIAL QUALITY

A. Provide manufacturer's best grade of the various types of coatings suitable for use in this Project. Materials not displaying the manufacturer's identification as a standard, best-grade product will not be acceptable.

B. Provide primers produced by the same manufacturer as the finish coats. Use only thinners recommended by the paint manufacturer and use only to manufacturer's recommended limits.

C. Provide paints, and pipe markers of durable and washable quality. Use materials which will withstand normal washing, as required to remove grease, oil, chemicals, etc., without showing discoloration, loss of gloss, staining, or other damage.

D. Product and Manufacturer: Provide one of the following:
   1. Tnemec Company, Incorporated.
   2. Carboline.
   3. Or approved equal.

2.2 SUBSTITUTIONS

A. No product shall be considered that decreases the film thickness, the number of coats, percent solids, the surface preparation or the generic type and formulation of coating(s) specified.

B. All "or equal" products shall be submitted with direct comparison to products specified, including information on durability, color and gloss retention, percent solids, VOCs per gallon and recoatability after curing.

C. Approved manufacturers shall furnish the same color selection as the manufacturers specified, including intense chroma and custom pigmented colors in all painting systems.

2.3 COLORS AND FINISHES

A. Surface treatments and finishes are specified under "Painting Systems" below. All substrates referenced under "Painting Systems" shall be painted whether or

not shown or scheduled, unless an item is specifically scheduled as not requiring the painting system scheduled below.

B. Color Selection:
   1. Color Schedule: The ENGINEER will provide a complete schedule of colors. Colors may be selected from various manufacturers' standards. The paint manufacturer supplying for this Project shall match these colors. Well in advance of commencing Work, the painting CONTRACTOR shall obtain the schedule from the ENGINEER, and proceed to prepare duplicate sets of samples of treatment for all major surfaces.
   2. Colors: All colors as selected by ENGINEER from manufacturer's standards except as follows:
      a. Color of bollards matches PPG 6-330 Safety Yellow.
   3. A maximum of 20 different colors shall be selected for the Project, in addition to the color coding of all piping and ducts.
   4. ENGINEER reserves the right to select non-standard colors for all paint systems specified within the ability of the manufacturer to produce such non-standard colors. Selection of non-standard colors shall not be the cause for CONTRACTOR rejecting ENGINEER'S color selections and CONTRACTOR shall provide such colors at no additional expense to OWNER.

C. After approval of submittals and prior to beginning Work, ENGINEER will select color schedules for surfaces to be painted listed in the painting systems below.

D. Piping and Sign Color Coding: In general, and unless otherwise specified, all color coding of piping, ducts and equipment shall comply with applicable standards of ANSI A13.1 and OSHA 1910.144.

E. Alternate color bands on piping shall be spaced every 2 feet along the length of the pipeline.

F. Use representative colors when preparing samples for ENGINEER'S review.

G. Color Pigments: Pure, non-fading, applicable types to suit the substrates and service indicated.
   1. All color pigments shall be lead free.
   2. Submit proposed application techniques to ENGINEER and submit proof of acceptability, of technique proposed, by the paint manufacturer selected with the required submittals.
   3. Material Compatibility: Provide block fillers, primers, undercoats, and finish-coat materials that are compatible with one another and the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

4. Material Quality: Provide manufacturer's best quality paint material of various coating types specified. Paint material containers not displaying manufacturer's product identification will not be acceptable.
    a. Proprietary Names: Use of manufacturer's proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Furnish manufacturer's material data and certificates of performance of proposed substitutions.

2.4 PAINTING SYSTEMS

A. Concrete Block Walls: Interior:
    1. Surface Preparation: Remove grease, oil and all foreign matter as specified in Paragraph 3.2.E.1.
    2. Product and Manufacturer: Provide one of the following:
        a. Tnemec:
            1) Primer: Series N69 H.B. Expoxoline II - one coat, 10.0 dry mils, pinhole free.
            2) Finish: Series N69 H.B. Epoxoline II - two coats, 4.0-5.0 dry mils per coat.
        b. Or approved equal.

B. Ferrous Metals including all Structural Steel, Miscellaneous Ferrous Metals, and all Ferrous Piping; Interior Non-submerged:
    1. Surface Preparation: SSPC-SP6 Commercial Blast Cleaning as specified in Paragraph 3.2.B. and/or as required in accordance with Paragraph 3.2.C.
    2. Interior non-submerged applies to areas that are housed within a building and/or within a non-process, enclosed structure.
    3. Product and Manufacturer: Provide one of the following:
        a. Tnemec:
            1) Shop Primer: 66 H.B. Epoxoline - two coats, 2.0-3.0 dry mils per coat.
            2) Field Primer or Field Touchup: Series N69 H.B. Epoxoline II - one coat, 2.0-3.0 dry mils per coat.
            3) Finish: N69 H.B. Epoxoline II - two coats, 4.0-5.0 dry mils per coat.
        b. Or approved equal.

C. Ferrous Metals, Including all Ferrous Piping; Exterior Non-submerged:
    1. Surface Preparation: SSPC-SP6 Commercial Blast Cleaning as specified in Paragraph 3.2.B. and/or as required in accordance with Paragraph 3.2.C.
    2. Exterior non-submerged applies to areas that are not housed within a building or structure, and that are not located within process and/or water carrying structures or tanks.
    3. Product and Manufacturer: Provide one of the following:
        a. Tnemec:

1) Primer: 66 H.B. Epoxoline - two coats, 4.0-6.0 dry mils per coat.
2) Intermediate: N69 H.B. Epoxoline II - one coat, 4.0-5.0 dry mils.
3) Finish: 1075 Endura-Shield II - two coats, 1.5-2.0 dry mils per coat.

b. Or approved equal.

D. Galvanized Metal and Non-Ferrous Metal; Interior Non-Submerged:
1. Surface Preparation: SSPC-SP 1 Solvent Cleaning, as specified in Paragraph 3.2.D. and Paragraph 3.2.F.
2. Interior non-submerged applies to areas that are housed within a building and/or within a non-process, enclosed structure.
3. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Primer: Series N69 H.B. Epoxoline II - one coat, 3.0-4.0 dry mils.
      2) Finish: Series N69 H.B. Epoxoline II - one coat, 4.0-5.0 dry mils.
   b. Or approved equal.

E. All Aluminum in Contact with Dissimilar Materials:
1. Surface Preparation: Remove all foreign matter.
2. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Series N69 H.B. Epoxoline II - one coat, 4.0-6.0 dry mils per coat.
   b. Or approved equal.

F. PVC Piping, CPVC Piping, Fiberglass, Fiberglass Insulation Covering; Exterior:
1. Surface Preparation: Sand as specified in Paragraph 3.2.G.
2. Exterior applies to areas that are not housed within a building and/or within an enclosed structure.
3. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Primer/Intermediate: Series N69 H.B. Epoxoline II - one coat each, 2.0-3.0 dry mils per coat.
      2) Finish: 1075 Endura-Shield II - one coat, 3.0 dry mils.
   b. Or approved equal.

G. PVC Piping, CPVC Piping, Fiberglass, Fiberglass Insulation Covering; Interior Non-Submerged:
1. Surface Preparation: Sand, as Specified in Paragraph 3.2.G.
2. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Primer/Intermediate/Finish: Series N69 H.B. Epoxoline II - one coat each, 2.0-3.0 dry mils per coat.
   b. Or approved equal.

H. Steel and Galvanized Steel Pipe; Buried Exterior:

1. Surface Preparation: SSPC-SP 10, Near-White Blast, as specified in Paragraph 3.2.D.
2. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Primer: Series N69 Epoxoline II - two coats, 3.0-4.0 dry mils per coat.
      2) Field Primer or Field Touchup: Surface preparation as specified.
      3) Finish: 46-413 Tneme-Tar - two coats, 10.0 dry mils per coat.
   b. Or approved equal.

I. Submerged or Intermittently Submerged Ferrous Metals; Interior and Exterior:
1. Definition: Submerged shall apply to all metals below the maximum water surface elevation in open top structures unless otherwise noted or otherwise shown; and to all metals within liquid or residual solids carrying structures that are covered, including all metals on the underside of the covers unless otherwise noted or otherwise shown; and to all metals within an enclosed process structure. This shall apply to all metals whether intermittently or continuously submerged.
2. Surface Preparation: SSPC-SP 10 Near-White Blast cleaning as specified in Paragraph 3.2.D.
3. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Primer: Series N69-1211 (red) - one coat, 3.0-4.0 dry mils per coat.
      2) Intermediate: Series N69 H.B - one coat, 6.0-8.0 dry mils per coat.
      3) Finish: Series N69 - one coat, 6.0-8.0 dry mils per coat.
   b. Or approved equal.

J. Special Requirements for Aluminum:
1. Aluminum surfaces bearing in or embedded in concrete and faying surfaces of bolted aluminum joints, except anchor bolts, shall be given two coats of N69 H.B. Epoxoline II Primer, or approved equal. The primer shall be allowed to dry between coats and before concrete is poured against it.
2. Where aluminum metals are placed in contact with or fastened to ferrous or stainless steel metals, the contact surfaces of each shall receive the protective coating specified for that metal and a gasket shall be placed between the two contact surfaces. The gasket material shall be non-conductive commercial grade neoprene, 60 durometer, 0.03-inch in thickness unless otherwise specified. Bolts shall be isolated using one piece non-conductive sleeves and washers as manufactured by PSI Products, Inc., Burbank, California; Parker Seal Col, Culvert City, California, or approved equal.

K. Galvanizing: All galvanizing, where called for in the Contract Documents, shall be hot-dip process conforming to ASTM A123.

L. Gypsum Wallboard and Stucco:

1. Surface Preparation: Remove grease, oil and all foreign matter as specified in Paragraph 3.2.E.1.
2. Product and Manufacturer: Provide one of the following (semi-gloss or flat as scheduled):
    a. Tnemec:
        1) Primer: Series 51-792 PVA Sealer - one coat, 1.0-2.5 dry mils.
        2) Finish: Series 6 Tnemec - Cryl - two coat, 2.0 - 3.2 mils DFT, DFT per coat.
    b. Or approved equal.

M. Insulated Ducts/Pipes:
1. Surface Preparation: All surfaces to be clean and free of contaminants prior to application of the coating system.
2. Prime Coats: Series 6 Tneme-Cryl; one coat 2.0-3.0 mils DFT.

N. Concrete Gloss Epoxy:
1. Surface Preparation: All surfaces to be clean and free of contaminants prior to application of the coating system.
2. Prime Coat: Series 104 H.S. Epoxy; one coat 4.0-5.0 mils DFT.
3. Finish Coat: Series 104 H.S. Epoxy; one coat 4.0-5.0 mils DFT.

O. Concrete Semi-Gloss Latex:
1. Surface Preparation: All surfaces to be clean and free of contaminants prior to application of the coating system.
2. Prime Coat: Series 29 Tuf-Cryl; one coat 2.0-3.0 mils DFT.
3. Finish Coat: Series 29 Tuf-Cryl; one coat 2.0-3.0 mils DFT.

P. Ductile and Cast Iron (Exterior Exposure):
1. Surface Preparation: Solvent scrub with stiff bristle brush followed by brush-off abrasive blast cleaning to a minimum surface profile depth of 1.5 mils.
2. Prime Coat: Series 69-1255 (beige) H.B. Epoxoline II; one coat 3.0-5.0 mils DFT.
3. Finish Coat: Series 73 Endura-Shield; one coat 3.0-4.0 mils DFT.

Q. Ductile and Cast Iron (Interior Exposure):
1. Surface Preparation: Clean, dry, and free of contaminants.
2. Prime Coat: Series 135 Chembuild; one coat 4.0-6.0 mils DFT.
3. Finish Coat: Series 69 H.B. Epoxoline II; one coat 4.0-6.0 mils DFT.

R. Ductile and Cast Iron (Buried):
1. Surface Preparation: Solvent scrub with stiff bristle brush followed by brush-off abrasive blast cleaning to a minimum surface profile depth of 1.5 mils.
2. Prime Coat: Series 69-1255 (beige) H.B. Epoxoline II; one coat 3.0-5.0 mils DFT.
3. Finish Coat: Series 69 H.B. Epoxoline II; one coat 4.0-6.0 mils DFT.

S. Ductile and Cast Iron (Immersion):
   1. Surface Preparation: Solvent scrub with stiff bristle brush followed by brush-off abrasive blast cleaning to a minimum surface profile depth of 1.5 mils.
   2. Prime Coat: Series 66 H.B. Epoxoline; one coat 4.0-6.0 mils DFT.
   3. Finish Coat: Series 69 H.B. Epoxoline II; one coat 4.0-6.0 mils DFT.

2.5 PIPING MARKERS

A. General:
   1. For Pipes Over 3/4-inch Outside Diameter and Ductwork: Provide painted pipe markers.
   2. For Pipes Under 3/4-inch Outside Diameter: Provide stainless steel tags and tag chains, 1/2-inch diameter, with depressed 1/4-inch high black filled letters above 2-inch high black filled numbers.
   3. Each painted marker shall consist of at least one legend descriptive of the function of the pipe, and a directional arrow. The legend descriptive and direction arrow shall be stenciled on the pipe utilizing stencils as manufactured by Seton Name Plate Co., or approved equal.
   4. The size of lettering and marker shall conform to ANSI A13.1.
   5. Location of Markers:
      a. Adjacent to each valve and "T" connection.
      b. At each branch and riser takeoff.
      c. At each pipe passage through a wall, floor and ceiling.
      d. On all horizontal and vertical pipe runs at 25 foot intervals.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and his painting subcontractor (applicator) and the manufacturer shall examine the areas and conditions under which painting Work is to be performed and notify ENGINEER, in writing, of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected by the CONTRACTOR.

B. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to the formation of a durable paint film.

C. Quality Assurance: Surface preparation shall be based upon comparison with: "Pictorial Surface Preparation Standards for Painting Steel Surfaces", SSPC-Vis 1 ASTM Designation D220, NACE Standard TM-01-70, and as described below. Anchor profile for prepared surfaces shall be measured by using a nondestructive instrument such as a Keane-Tator Surface Profile Comparator or Testix Press-O-Film System. Temperature and dew point requirements noted herein shall apply to all surface preparation operations, except minimum temperature shall be 40° F. To facilitate inspection, the CONTRACTOR shall on the first day of abrasive

blasting operations, abrasively blast metal panels furnished by CONTRACTOR to the standard specified. These panels shall be equivalent to plates or structural stock used in the facility with minimum measurements of 8-1/2-inches by 11-inches or the nearest multiple for structural shapes. After agreeing a specific panel meets the requirements of the Specification, the panel shall be initiated by the CONTRACTOR and ENGINEER and coated with a clear non-yellowing finish. Panels shall be utilized for inspection purposes throughout the duration of abrasive blasting operations.

3.2 SURFACE PREPARATION

A. General:

1. Perform all preparation and cleaning procedures as specified herein and in strict accordance with the paint manufacturer's instructions for each particular substrate and atmospheric condition.
2. When required, prepare existing substrates to be painted under this Section as specified for new substrates. Where other methods of preparing existing substrates are proposed by the CONTRACTOR, they shall be submitted to the ENGINEER for approval. ENGINEER'S approval of alternate substrate preparation shall not relieve the CONTRACTOR of his required performance under this Section.
3. Remove all hardware, hardware accessories, machined surfaces, plates, lighting fixtures, and similar items in place and not to be finish painted, or provide surface applied protection prior to surface preparation and painting operations. Remove, if necessary, for the complete painting of the items and adjacent surfaces. Following completion of painting of each space or area, reinstall the removed items by workmen skilled in the trades involved.
4. Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease with clean cloths and cleaning solvents prior to mechanical cleaning. Program the cleaning and painting so that dust and other contaminants from the cleaning process will not fall in wet, newly painted surfaces.
5. All surfaces which were not shop painted or which were improperly shop painted, and all abraded or rusted shop painted surfaces, which are to be painted, as determined by ENGINEER, shall be prepared as specified below.
6. With the exception of motors, gears, and other equipment that might be damaged by sandblasting, and unless specified otherwise, shop applied protective coatings shall be completely removed at the job site by sandblasting.
7. All equipment and/or materials to be painted at the job site shall be placed on raised supports at least 2 feet above the ground. The prime coat shall be applied as quickly as possible after blasting. In no case shall bare metal surfaces be left overnight before applying the prime coat. Each coat of the paint shall be applied at proper consistency and shall be sprayed or brushed evenly and be free of brush marks, pin holes, sags, and runs with no evidence of poor workmanship. Care shall be exercised to prevent paint from being spattered on surfaces, which are not to be painted, and if paint is dropped or

spattered on surfaces not to be painted the paint shall be removed as directed by the ENGINEER. All equipment nameplates, valve stems, and areas not to be painted shall be masked prior to painting.

8. Multiple coats shall be applied in conformance with the paint manufacturer's recommendations for minimum drying time and maximum curing time between coats. The surface preparation and each coat of a multiple-coat system shall be of different colors (as selected by the ENGINEER) and inspected by the ENGINEER before subsequent coats are applied.
9. If thinning is required for proper application of a coating, it shall be done only in accordance with the recommendations of the paint manufacturer and only to the manufacturer's recommended limits.

B. Ferrous Surfaces:
   1. Ferrous metal surfaces to be painted including above and below ground piping, fittings, etc., supplied under Division 15, Mechanical, shall be prepared by field blast cleaning as specified below, unless described otherwise elsewhere in the Specifications.
   2. Prior to blast cleaning, the CONTRACTOR shall ensure that all rough welds are ground smooth and sharp steel edges ground to approximately 1/8-inch radius. Weld spatter shall be removed. Paint, mill scale, rust, flux, fume, and slag from weld deposits shall be removed by blast cleaning. Any grease or oil shall be removed by steam or solvent cleaning.
   3. Surfaces to be blast cleaned shall be dry blast cleaned to a commercial blast cleaned surface finish conforming to Section 310-2.5 "Blast Cleaning" of the SSPWC and SSPC-SP6. Surface profile for surfaces not subject to submergence shall be 1.5 to 1.9 mils. Surface profile for surfaces subject to submergence shall be 3.0 to 4.0 mils.
   4. All dust shall be removed by brushing, vacuum, or air blast. The prime coat shall be applied as soon as possible after blasting. In no case shall bare metal surfaces be left overnight before applying the prime coat.
   5. Sandblasting and painting shall not be performed concurrently in the same area. No sandblasting will be allowed in areas adjacent to equipment that might be damaged by sandblasting.
   6. Heavy deposits of grease or oil shall be removed from all surfaces to be coated using the paint manufacturer's specified cleaner prior to any other surface preparation. Any chemical contamination shall be neutralized and/or flushed off prior to any other surface preparation.
   7. In addition to the limitations imposed in Section 310-1 of the SSPWC, no surface preparation or coating shall be performed during periods of excessive wind which, in the opinion of the ENGINEER, would affect the quality of the Work, or produce nuisance conditions in adjacent areas. All coatings shall be applied in strict conformance with the manufacturer's printed recommendations regarding minimum and maximum allowable air and surface temperatures. No coatings shall be applied when the relative humidity is higher than 80% or when the temperature is less than or approved

equal to 5° F above dew point. No coatings shall be applied if any moisture is detectable on the surface to be coated.

C. Equipment That CANNOT Be Sandblasted:

1. Equipment that could be damaged by sandblasting, typically including motors, gear reducers, switchboards, and similar equipment, shall receive the shop coatings and finish coatings. The CONTRACTOR shall be solely responsible for ensuring that shop coating is done in conformance with the specifications and the approved paint submittal, and for repair or replacement of any shop coating that is determined to be inadequate by the ENGINEER. All components shall have a finish color to match the plant color scheme. Color samples shall be submitted for review and selection by the ENGINEER.
2. Shop-applied coatings shall be inspected and evaluated at the job site and shall be evenly applied and free of brush marks, sags, nicks, scratches, runs, holidays or other evidence of poor workmanship or damage. Shop coatings which are of good quality shall be solvent cleaned, and lightly sanded as directed by the ENGINEER and finish coated as specified. All bearings and openings shall be masked to prevent damage during sanding and painting. Color shall be as specified above. Prior to application, the CONTRACTOR shall perform spot testing to determine if the shop-applied paint is of the same manufacturer as the specified finish coats. If, in the opinion of the ENGINEER, the paints are not as specified, the CONTRACTOR shall apply a suitable paint to act as a barrier or "tie coat" between the shop-applied and field-applied finishes. Materials and application procedures for the "tie-coat" shall be subject to review and approval by the ENGINEER. "Tie coats" shall be applied at no increase in Contract Price. It shall be the CONTRACTOR'S sole responsibility to determine if shop applied primers and finishes are as specified and he shall be totally responsible for the entire coating system warranty.
3. Shop-applied coatings, which show evidence of poor materials or workmanship, or have been damaged, shall be repaired or replaced in the field as, directed by the ENGINEER. Nicks and scratches or other small imperfections in the finish shall be repaired by wire brushing to a bright metal, primed with a universal primer and finish coated as specified. Universal primer shall be Amercoat 185, 37-77H Kem Prime, Koppers Pug Primer, or approved equal, to a minimum dry film thickness of 2 mils. An epoxy primer may be used as a universal primer if a test patch is applied to check adhesion, and the ENGINEER approves. After repair, the equipment shall be solvent cleaned, lightly sanded, and painted as specified above for equipment with a good quality shop finish. If, in the opinion of the ENGINEER, the shop coating is of such poor quality that repair is not warranted, he may elect to either: (1) require the CONTRACTOR to return the equipment to the factory for refinishing, or (2) require the CONTRACTOR to completely remove the existing coating, prepare the surface for repainting and repaint the equipment using the applicable paint

system as specified herein. All Work shall be done in a manner that will prevent damage to the equipment. Costs incurred for repair or replacement of shop-applied coatings shall be the sole responsibility of the CONTRACTOR at his expense.

D. Galvanized Surfaces:
   1. Where coatings for galvanized surfaces are called for by the Specifications, the CONTRACTOR shall prepare the galvanized surfaces as follows.
   2. All surfaces shall be inspected jointly by the CONTRACTOR and the ENGINEER to determine the condition of existing surfaces. The ENGINEER shall then designate the surface condition and cleaning shall be performed as noted below. Any areas overlooked during the joint inspection shall not relieve the CONTRACTOR from completely preparing surfaces.
   3. First, all oily or greasy surface contaminants shall be removed by wiping the contaminated area with a clean rag wetted with de-greasing solution in accordance with Steel Structures Painting Council Specification SSPC-SP1 (Solvent Cleaning).
   4. Next, surface contaminants not easily removed by the previous step and complete surfaces shall be additionally cleaned in conformance with Steel Structures Painting Council Specification SSPC-SP7 (Brush-off Blast Cleaning).
   5. Next, all rusting, scaling, or damaged areas shall be blast cleaned in conformance with Steel Structures Painting Council Specification SSPC-SP10 (Near-White Blast Cleaning). Remaining galvanized surface shall be firmly bonded to the substrate with sandblast edges feathered. Extreme care shall be exercised to insure remaining galvanized surfaces are not damaged by cleaning operations.

E. Masonry/Concrete Block Surfaces:
   1. Prepare surfaces of concrete block to be painted by removing all efflorescence, chalk, dust, dirt, grease, oils, with soap and water.
   2. Determine the alkalinity and moisture content of the surfaces to be painted by performing appropriate tests. If the surfaces are found to be sufficiently alkaline to cause blistering and burning of the finish paint, correct this condition before application of paint. Provide ENGINEER with suitable testing materials in order to carry out alkalinity and moisture tests.
   3. Do not paint over surfaces where the moisture content exceeds 8%, unless otherwise permitted in the manufacturer's printed directions.
   4. Concrete block surfaces that cannot be adequately cleaned by soap and water shall be acid etched.
   5. Remove loose or incompatible existing finish coats as recommended by the paint manufacturer for full product responsibility. Brush blast to clean all residues and create uniform rough texture.

F. Non-Ferrous Metal Surfaces: Clean non-ferrous metal surfaces in accordance with the coating system manufacturer's instructions for the type of service, metal substrate, and application required.

G. PVC, CPVC Piping, and Fiberglass: Lightly sand and clean all surfaces to be painted.

H. Covering on Pipe: Clean free of oil and surface contaminants as recommended by the coating manufacturer for substrate and application required. Do not cut or damage the insulation in any way.

I. Gypsum Wallboard:
   1. Patch, sand and seal all rough spots before prime coat.
   2. Touch up all suction spots and hot spots with primer before application of finish coats.

J. Copper: Remove surface contamination by steam or high-pressure water.

K. Aluminum: Remove surface contamination by steam or high-pressure water. Remove oxidation with acid etch and solvent washing.

L. Tinting: Tint each undercoat a lighter shade to simplify identification of each coat, when multiple coats of the same material are applied. Tint undercoats to match the color of the finish coat, but provide sufficient differences in shade of undercoats to distinguish each separate coat.

M. Ductile Iron Pipe: All new Ductile Iron Pipe (DIP) intended for immersion service shall be prepared per coating manufacturer's specifications and as specified herein.
   1. Remove grease, rust scale, rust and touch up any chipped or abraded areas on items that have been shop coated. Items intended for immersion service that have not been shop coated shall be sandblasted to "Near White Blast Cleaning" condition per SSPC SP-10 prior to receiving coating.
   2. All new DIP intended for non-immersion service shall be sandblasted to "Commercial Blast Cleaning" condition per SSPC SP-6, prior to receiving coating.

3.3 MATERIALS PREPARATION

A. General:
   1. Mix and prepare painting materials in strict accordance with the manufacturer's directions.
   2. Do not mix coating materials produced by different manufacturers, unless otherwise permitted by the manufacturer's instructions.
   3. Store materials not in actual use in tightly covered containers. Maintain containers used in storage, mixing, and application of paint in a clean condition, free of foreign materials and residue.
   4. Stir all materials before application to produce a mixture of uniform density, and as required during the application of the materials. Do not stir any film

that may form on the surface into the material. Remove the film and, if necessary, strain the material before using.

5. Mixing:
    a. Mix only in containers placed in suitably sized non-ferrous or oxide resistant metal pans to protect concrete floor from splashes or spills that could stain exposed concrete or react with subsequent finish floor material.
    b. Mix and apply paint only in containers bearing accurate product name of material being mixed, or applied.

3.4 APPLICATION

A. General:
    1. Apply paint by brush, roller, air spray, or airless spray in accordance with the manufacturer's directions and recommendations of Paint Application Specifications No. 1 in SSPC Vol. 2, where applicable. Use brushes best suited for the type of material being applied. Use rollers of carpet, velvet back, or high pile sheep's wool as recommended by the paint manufacturer for material and texture required. Use air spray and airless spray equipment recommended by the paint manufacturer for specific coating system specified. Submit a list of application methods proposed, listing paint systems and location.
    2. The paint film thickness required is the same regardless of the application method. Do not apply succeeding coats until the previous coat has completely dried.
    3. Apply additional coats when undercoats, stains, or other conditions show through the final coat of paint, until the paint film is of uniform finish, color, and appearance. This is of particular importance regarding intense primary accent colors. Ensure that all surfaces, including edges, corners, crevices, welds, and exposed fasteners receive a film thickness equivalent to that of flat surfaces.
    4. Multiple coats shall be applied in conformance with the paint manufacturer's recommendations for minimum drying time and maximum curing time between coats. The surface preparation and each coat of a multiple-coat system shall be of different colors (as selected by the ENGINEER) and inspected by the ENGINEER before subsequent coats are applied. The CONTRACTOR shall provide forced ventilation in areas where inadequate ventilation exists. If thinning is required for proper application of a coating, it shall be done only in accordance with the recommendations of the paint manufacturer and with the written approval of the ENGINEER.
    5. Surfaces not exposed to view do not require color-coding but require the same coating system specified for exposed surfaces.
        a. "Exposed to view surfaces" is defined as those areas visible when permanent or built-in fixtures convector covers, covers, covers for finned tube radiation, grilles, etc., are in place in areas scheduled to be painted.

6. Paint interior surfaces of ducts, where visible through registers or grilles, with a flat, non-specular black paint as specified, before final installation of equipment.
7. Paint aluminum parts in contact with dissimilar materials as specified with appropriate primer and isolation gasket material.
8. Omit field primer on metal surfaces that have been shop primed touch-up paint shop prime coats only when approved by ENGINEER.
9. Paint the backs of access panels, and removable or hinged covers to match the exposed surfaces.
10. Paint all exposed pipes and pipe fittings according to the pipe-painting schedule at the end of this Specification.

B. Heating, Ventilating, Air Conditioning, and Electrical Work:
   1. Heating, ventilating, and air-conditioning items to be painted include but not limited to the following, whether factory pre-finished or not, with color selected by the ENGINEER:
      a. Piping, pipe hangers, and supports.
      b. Heat exchangers.
      c. Tanks.
      d. Ductwork and insulation.
      e. Motors, mechanical equipment, and supports.
      f. Accessory items.
   2. All mechanical and electrical items to be painted include, but are not limited to, the following whether factory pre-finished or not with color selected by the ENGINEER:
      a. Conduit and fittings.
      b. Valves and fittings, actuators, pipe supports, pipe hangers, canopies, canopy supports, hydraulic gates, flow meters, all level sensors/meters, eyewash etc.
      c. Switchgear, panels, VFDs, disconnects, junction boxes, blowers, transformers, and motor control centers, motors, pumps, and accessories.

C. Minimum Coating Thickness:
   1. Apply each material at not less than the manufacturer's recommended spreading rate and provide total dry film thickness as specified.
   2. Apply extra coat if required to obtain specified total dry film thickness.

D. Scheduling Painting:
   1. Apply the first-coat material to surfaces that have been cleaned, pretreated or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
   2. Allow sufficient time between successive coatings to permit proper drying. Do not recoat until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure and the application of another coat of paint does not cause lifting or loss of adhesion of the undercoat.

E. Prime Coats: Recoat primed and sealed walls and ceilings where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects caused by insufficient sealing.

F. Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance, and coverage.

G. Transparent (Clear) Finishes:
   1. On exposed to view portions, use multiple coats to produce glass-smooth surface film continuity of even matt luster. Provide a finish free of laps, cloudiness, color irregularity, runs, brush marks, orange peel, nail holes, or other surface imperfections.
   2. Provide satin finish for final coats, unless otherwise indicated.

H. Brush Application:
   1. Brush-out and work all brush coats onto the surfaces in an even film. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable. Neatly draw all glass and color break lines.
   2. Brush apply all primer or first coats, unless otherwise permitted to use mechanical applicators.

I. Mechanical Applicators:
   1. Use mechanical methods for paint application when permitted by governing ordinances, paint manufacturer, and approved by ENGINEER. If permitted, limit to only those surfaces impracticable for brush applications.
   2. Limit roller applications, if approved by ENGINEER, to interior wall finishes for second and third coats. Apply each roller coat to provide the equivalent hiding as brush-applied coats.
   3. Confine spray application to metal framework, siding, decking, wire mesh, and similar surfaces where hand brushwork would be inferior and to other surfaces specifically recommended by paint manufacturer.
   4. Wherever spray application is used, apply each coat to provide the equivalent hiding of brush-applied coats. Do not double back with spray equipment for the purpose of building up film thickness of two coats in one pass.

J. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint Work not in compliance with specified requirements as required by ENGINEER.

3.5 PROTECTION

A. Protect Work of other trades, whether to be painted or not, from the Work of this Section. Leave all such Work undamaged. Correct all damages by cleaning, repairing or replacing, and repainting, as acceptable to ENGINEER.

B. Provide "WET PAINT" signs as required to protect newly painted finishes. Remove all temporary protective wrappings provided for protection of this Contract and other contracts after completion of painting operations.

C. All equipment and/or materials to be painted at the job site shall be placed on raised supports at least 2 feet above the ground. The prime coat shall be applied as quickly as possible after blasting. In no case shall bare metal surfaces be left overnight before applying the prime coat. Each coat of the paint shall be applied at proper consistency and shall be sprayed or brushed evenly and be free of brush marks, pinholes, sags, and runs with no evidence of poor workmanship. Care shall be exercised to prevent paint from being spattered on surfaces that are not to be painted and, if paint is dropped or spattered on surfaces not to be painted, the paint shall be removed as directed by the ENGINEER. All equipment nameplates, valve stems, and areas not to be painted shall be masked prior to painting.

D. In addition to the limitations imposed in Section 310-1 of the SSPWC, no surface preparation or coating shall be performed during periods of excessive wind which, in the opinion of the ENGINEER, would affect the quality of the Work, or produce nuisance conditions in adjacent areas. All coatings shall be applied in strict conformance with the manufacturer's printed recommendations regarding minimum and maximum allowable air and surface temperatures. No coatings shall be applied when the relative humidity is higher than 80% or when the temperature is less than or equal to 5° F above dew point. No coatings shall be applied if any moisture is detectable on the surface to be coated.

E. The CONTRACTOR shall be responsible for containing all over spray. Any over spray on any item of equipment, piping, structures, paving, or others including vehicles shall be removed by the CONTRACTOR. If removal is not possible, the CONTRACTOR shall be responsible at CONTRACTOR'S cost for repainting the entire damaged item, to the satisfaction of the ENGINEER.

F. Any component of any system, the operation or maintenance of which has, in the opinion of the ENGINEER, been negatively impacted due to painting shall be returned to satisfactory condition through replacement or repair at no additional cost to the OWNER.

3.6 CLEAN-UP

A. During the progress of the Work, remove from the site all discarded paint materials, rubbish, cans, and rags at the end of each Work day.

B. Upon completion of painting work, clean all paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or otherwise damage, finished surfaces.

C. At the completion of Work of other trades, touch-up and restore all damaged or defaced painted surfaces as determined by ENGINEER.

3.7 WARRANTY

A. Warranty inspection shall be conducted by the paint manufacturer's representative during the application of the paint product. All defective work shall be repaired by the CONTRACTOR in accordance with this Specification and to the satisfaction of the ENGINEER and at the CONTRACTOR'S expense.

B. Any location where paint has peeled, bubbled, or cracked and any location where rusting is evident shall be considered to be a failure of the system. The CONTRACTOR shall make repair at all points where failures are observed by removing the deteriorated paint, cleaning the surface, and recoating or repainting with the same system. If the area of failure exceeds 25% of the total coated or painted surface, the entire coating, or paint system may be required to be removed and repainted in accordance with this Specification as determined by the ENGINEER.

C. All costs for CONTRACTOR'S inspection, manufacturer's inspection, and all costs for repair shall be borne by the CONTRACTOR.

3.8 INSPECTION

A. The CONTRACTOR shall furnish the following inspection equipment for use by the Independent Testing Firm during this Project prior to any surface preparation or painting activities.
   1. A Tinker and Rasor Model M-1, K-D "Bird Dog", or approved equal, low-voltage non-destructive holiday detector, complete with necessary accessories.
   2. A Microtest, Elcometer, or equal, magnetic dry film thickness gauge. The aforementioned equipment shall be in good working order, and shall be accurately calibrated. Testing results shall be furnished for each separate unit that is to be coated, to demonstrate compliance with the Contract Documents.

PIPING AND SIGN COLOR CODE SCHEDULE

PIPING AND LEGEND	LETTERING COLOR	BACKGROUND COLOR
WASTEWATER		
Sanitary Wastewater (Pressure & Gravity)	White	Dark Grey
OTHERS		
Electrical Conduits	None	Match background color

B. Positive identification of the contents of a piping system shall be lettered legibly, giving the name of the contents in full or abbreviated form at no greater than 25 foot intervals between markings. Arrows shall be used to indicate direction of flow at no greater than 10 foot intervals. Contents shall be identified by additional details required by the ENGINEER, such as temperature, pressure, etc., as necessary to identify the hazard.

C. Legend shall be brief and applied close to valves or flanges and adjacent to changes in direction, branches, and where pipes pass through walls or floors.

D. Where two or more pipes run parallel, markings shall be applied in the same relative location on each as to be in vertical or horizontal line and present a neat appearance.

E. In case a pipe is in such location that it can be seen only from one direction, such as pipes near a wall, two sets of the code designation shall be applied at each location, placed in two visible quadrants with respect to normal viewing positions.

Minimum Letter Sizes

O.D. of Pipe (inches)	Height of Letters (inches)
3/4 - 1-1/4	1/2
1-1/2 - 2	3/4
2-1/2 - 6	1-1/4
8 - 10	2-1/2
Over 10	3-1/2

END OF SECTION

SECTION 09910

SPECIAL FINISHES

PART 1 - GENERAL

1.1 SUMMARY

A. CONTRACTOR shall provide all labor, materials, services and incidentals required to furnish and install corrosion resistant coatings for the concrete surfaces in the Lift Station, and new Manhole. Coating system shall be used on floors, walls, and ceiling of the concrete structures, as specified herein, or indicated on the Drawings.

1.2 SECTION INCLUDES

A. Corrosion resistant coatings.

1.3 RELATED SECTIONS

A. Section 01300, Submittals.

B. Section 01640, Materials and Equipment.

1.4 REFERENCES

A. ASTM D4541 - Pull-off Strength of Coatings Using a Portable Adhesion Tester.

B. ASTM D4060 - Abrasion Testing.

C. ASTM D2584 - Volatile Matter Content.

D. ASTM D2240 - Durometer Hardness, Type D.

E. ASTM D543 - Resistance of Plastics to Chemical Reagents.

F. ASTM C109 - Compressive Strength Hydraulic Cement Mortars.

G. ASTM C348 - Flexural Strength Hydraulic Cement Mortars.

H. ASTM C396 - Compressive Strength of Cement Mortars.

I. ACI 506.2-77 - Specifications for Materials, Proportioning, and Application of Shotcrete.

J. ASTM C579 - Compressive Strength of Chemically Setting Silicate and Silica Chemical Resistant Mortars

K. ASTM C-580 - Flexural Strength, >4,600 psi, Tensile Strength, >1,980 psi.

L. ASTM C-478 - Bond to Dry or Damp Concrete.

M. ASTM C-413 - Absorption.

N. ASTM C-307 -Tensile Strength.

O. ASTM C-531 - Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing.

P. ASTM C-579 - Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing and Polymer Concretes.

Q. ASTM C-308 - Standard Test Methods for Working, Initial Setting, and Service Strength Setting Times of Chemical-Resistant Resin Mortars.

R. ASTM C-905 – Density.

S. ASTM - The published standards of the American Society for Testing and Materials, West Conshohocken, PA.

T. NACE - The published standards of National Association of Corrosion Engineers (NACE International), Houston, TX.

U. SSPC - The published standards of the Steel Structures Painting Council, Pittsburgh, PA.

1.5 SUBMITTALS

A. Submittals shall be made in accordance with Section 01300, Submittals.
   1. Submit the following for approval.
      a. Letters of Certification of Compliance on materials, equipment, etc.
      b. Identify product name and number, manufacturer and local distributer name, address and telephone number.
      c. Samples.
      d. Installation instructions, operating and/or service manuals and all other data pertinent to operating or servicing the complete apparatus. Include detailed procedures for light repairs such as dents and scratches.
      e. Identify manufacturer's recommended, published spreading rate and dry film thickness of each coating material proposed for use.
      f. Mixing instructions, shelf life, method of application, recommended number of coats and drying time.

g. General bulletins and catalog cuts describing the complete coating system, including all principles and fundamentals.
h. Materials of construction of all components.
i. Material gradation, design mix, job mix formula, and/or material analysis.
j. A copy of the CONTRACTOR'S proposed protection procedures in each area of work.

B. The CONRACTOR shall submit a written certification of the applicator's qualifications to the ENGINEER for approval.

C. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

1.6 STORAGE

A. All surface coating materials shall be delivered to the job site in original sealed containers and shall be used directly from these sealed containers.

B. All containers shall have the following labels naming title of material, manufacturer's name and stock number, contents by volume, color name and number and application instructions.

C. All surface coating materials shall be stored in an area according to manufacturer's recommendations.

D. All oily rags, waste, etc., shall be placed in a covered material container and removed by the CONTRACTOR at the end of each shift.

1.7 WARRANTY

A. Applicator shall provide a bonded warranty against defects in materials and workmanship for a period of five years from the date of Final Acceptance of the Project. CONTRACTOR shall, within a reasonable time after receipt of written

notice thereof, repair defects in materials or workmanship which may develop during said five year period, and any damage to other work caused by such defects or the repairing of same, at his own expense and without cost to the City of Willcox.

PART 2 - PRODUCTS

2.1 MATERIALS

A. A spray applied material specifically designed to protect concrete and steel surfaces of municipal wastewater treatment structures from chemical attack and physical abuse. Corrosion resistant coating shall provide an impermeable, high strength, corrosion resistant lining for new and existing concrete structures.

2.2 COATING MANUFACTURERS

A. Acceptable Manufacturers and Products:
   1. Sauereisen Sewerguard No. 210S.
   2. Raven Lining Systems, Inc. No. 405.
   3. Or approved equal.

B. The naming of a manufacturer in this Specification is not an indication that the manufacturer's standard equipment is acceptable in lieu of the specified component features. Naming is only an indication that the manufacturer may have the capability of engineering and supplying a system as specified.

PART 3 - EXECUTION

3.1 ACCEPTABLE APPLICATORS

A. Repair mortar contractors should be trained to properly apply the cementitious mortar according to manufacturer's recommendations.

B. Corrosion resistant coating must be applied by a certified contractor of the corrosion resistant coating manufacturer and according to manufacturer specifications.

3.2 EXAMINATION

A. All structures to be coated shall be readily accessible to CONTRACTOR.

B. Appropriate actions shall be taken to comply with local, State, and Federal regulatory and other applicable agencies with regard to environment, health, and safety.

C. Any active flows are the responsibility of the CONTRACTOR and shall be dammed, plugged, or diverted as required to ensure that the liquid flow is maintained below the surfaces to be coated. All extraneous flows into the structures at or above the area coated shall be plugged and/or diverted until the corrosion resistant coating has set hard to the touch. Flow diversion and/or plugging liquid flow is subject to prior approval by the Town of Wickenburg.

D. Pipe joint seals that are required shall be installed by the CONTRACTOR so no leaks may be present prior to commencing and during Work.

E. Installation of the corrosion resistant coating shall not commence until the concrete substrate has properly cured in accordance with these Specifications.

F. Temperature of the surface to be coated should be maintained between 65° F and 85° F during application. Prior to and during application, care should be taken to avoid exposure of direct sunlight or other intense heat source to the structure being coated. Where varying surface temperatures do exist, care should be taken to apply the coating when the temperature is falling versus rising (i.e., late afternoon into evening vs. morning into afternoon).

3.3 SURFACE PREPARATION

A. CONTRACTOR shall inspect all surfaces specified to receive a corrosion resistant coating prior to surface preparation. CONTRACTOR shall notify Town of any noticeable disparity in the surfaces which may interfere with the proper preparation or application of the repair mortar and corrosion resistant coating. In the event that the CONTRACTOR encounters surface deterioration that extends greater than 2-1/2-inches from the existing finish side of the manhole, the CONTRACTOR shall notify the Town. The Town shall inspect the area referenced above and make a determination whether or not to proceed with the corrosion resistant coatings.

B. All concrete or mortar that is not sound or has been damaged by chemical exposure shall be removed to a sound concrete surface.

C. All contaminants, including oils, grease, dust, incompatible existing coating, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants shall be removed.

D. Surface preparation method(s) shall be based upon the conditions of the substrate, service environment, and the requirements of the corrosion resistant coating to be applied.

E. All surfaces shall be repaired as required by the corrosion resistant coating system in the intended service condition.

F. Surfaces to receive corrosion resistant coating shall be cleaned and abraded to produce a sound surface with adequate profile and porosity to provide a strong bond between the corrosion resistant coating and the substrate. This shall be achieved with a high pressure water cleaning using equipment capable of 5,000 psi at 4 gpm. High pressure cleaning shall be followed by abrasive blasting, shot blasting, or sand blasting. Detergent water cleaning and hot water blasting may be necessary to remove oils, grease, or other hydrocarbon residues from the concrete. The method(s) used shall be performed in a manner that provides a uniform sound clean neutralized surface that is not excessively damaged.

G. A mild chlorine solution may be used to neutralize the surface to diminish microbiological bacteria growth prior to final rinse and coating.

H. Infiltration shall be stopped by using a material which is compatible with the specified repair mortar and is suitable for top coating with the specified corrosion resistant coating.

I. The CONTRACTOR shall be responsible to test prepared surfaces after cleaning but prior to application of the corrosion resistant coating to determine if a specific pH or moisture content of the concrete is required according to manufacturer's recommendations.

J. Any area that might exhibit movement or cracking due to expansion and contraction, shall be grouted with a pre-approved flexile or elastomeric grout or gel. Castings can be abrasive blasted and coated to prevent corrosion if desired.

K. All surfaces should be inspected by the ENGINEER during and after preparation and before the repair mortar is applied.

L. In no event shall any debris or material removed from the concrete surface be allowed into the existing system. CONTRACTOR shall demonstrate procedures for the protection of the existing system from falling debris and prescribe methods for removing said material.

3.4 APPLICATION OF CORROSION RESISTANT COATING

A. Application procedures shall conform to the recommendations of the corrosion resistant manufacturer, including material handling, mixing, environmental controls during application, safety, and spray equipment.

B. The spray equipment shall be specifically designed to accurately ratio and apply the specified corrosion resistant coating materials and shall be regularly maintained and in proper working order.

C. The corrosion resistant coating material must be spray applied by a certified applicator of the corrosion resistant coating manufacturer.

D. Specified surfaces shall be coated by spray application of a corrosion resistant coating as further described herein. Spray application will be allowed to minimum and average wet film thicknesses of 60 mils.

E. Airless spray application equipment approved by the coating manufacturer shall be used to apply each coat of the corrosion resistant coating to avoid any potential contamination from compressed air oil which may encourage inter-coat delamination. Air assisted spray application equipment may be acceptable, especially for thinner coats (<10 mils), only if the air source is filtered to completely remove all oil and water.

F. If necessary, subsequent top coating or additional coats of the corrosion resistant coating should occur as soon as the basecoat becomes tack free, unless additional prior coat surface preparation is performed. The corrosion resistant coating manufacturer must be consulted for any additional coat surface preparation guidelines, if necessary.

G. Fiberglass woven-roving fabric may be rolled into the resin or chopped glass spray applied with the resin for added tensile and flexural strength where desired. Sloped surfaces of the floor may be made non-skid by broadcasting aluminum oxide or silica sand into the surface prior to gelation.

H. Depending on flow levels and how long flow can be stopped, inverts may be lined with an approved 100% solids, fast setting epoxy coating, grout, or cementitious material.

3.5 TESTING AND INSPECTION

A. During application, a wet film thickness gage, such as those meeting ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages, shall be used to ensure a monolithic coating and uniform thickness during application.

B. After the corrosion resistant coating has set hard to the touch it shall be inspected with high-voltage holiday detection equipment. An induced holiday shall be made on to the coated concrete surface and shall serve to determine the minimum/maximum voltage to be used to test the coating for holidays at that particular area. The spark tester shall be initially set at 100 volts per 1 mil (25 microns) of film thickness applied but may be adjusted as necessary to detect the induced holiday. All detected holidays shall be marked and repaired by abrading the coating surface with grit disk paper or other hand tooling method. After abrading and cleaning, additional corrosion resistant coating material can be hand applied to the repair area. All touch-up/repair procedures shall follow the corrosion resistant coating manufacturer's recommendations.

C. Measurement of bond strength of the corrosion resistant coating to the substrate can be measured in accordance with ASTM D4541. Any areas detected to have inadequate bond strength shall be evaluated by the ENGINEER. Further bond tests may be performed in that area to determine the extent of potentially deficient bonded area and repairs shall be made by Applicator in strict accordance with manufacturer's recommendations.

D. If the wet well or manholes fails the initial test, repairs and adjustments necessary due to extenuating circumstances (i.e., pipe joint, liner, plug sealing) should be made. Retesting shall proceed until a satisfactory test is obtained.

E. A final visual inspection shall be made by the inspector and manufacturer's representative. Any deficiencies in the finished coating shall be marked and repaired according to the procedures set forth herein by the applicator.

F. The system may be put back into non-severe operational service as soon as the final inspection has taken place. However, for severe corrosion duty, such as high concentrations of acids, bases, or solvents, three to seven days and/or force cure by heat induction to the coated surfaces may be necessary prior to returning to service. Consult coating manufacturer for further details.

3.6 FINAL INSPECTION AND ACCEPTANCE OF WORK

A. When all Work comprised in the Contract has been completed, including cleanup and restoration, the CONTRACTOR shall notify the ENGINEER in writing, and the ENGINEER will then make final inspection. When defects, errors, and omissions disclosed by the final inspection have been corrected, acceptance will be given in writing; but, until such inspection acceptance, the CONTRACTOR will be responsible for the Work covered by this Contract.

B. At the option of the ENGINEER, acceptance may be given prior to the correction of such defects, errors, and omissions which do not preclude the operation and use of the facility; however, in this event, final payment will be withheld until all corrections have been made.

3.7 CLEANUP

A. The CONTRACTOR at all times shall keep the premises free from accumulation of waste materials or rubbish caused by his operations. At the completion of Work, he shall remove all equipment, tools, and surplus materials, and shall completely clean the premises, removing and disposing of all stains, spots, marks, dirt, smears, etc.

END OF SECTION

SECTION 11100

ELECTRIC MOTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: This Section includes alternating current induction motors, 250 horsepower or less, to be provided with the driven equipment. Unless specified otherwise, electric motors shall be provided by the manufacturer of the driven equipment under the provisions of the individual equipment specification. This Section refers to motors by enclosure type as defined in NEMA MG 1, except as noted.

B. For motors larger than 250 horsepower, see the individual driven equipment specifications for motor requirements.

C. Horsepower Rating:
   1. Motor horsepower ratings noted in individual Equipment Specifications are estimates only and it is the responsibility of the CONTRACTOR to furnish motors, electric circuits, and other equipment of ample horsepower capacity to operate the equipment furnished without exceeding the nameplate full-load current at rated nameplate voltage. Full-load amps information shall be furnished with Submittals.

1.2 QUALITY ASSURANCE

A. General: Motors shall be built in accordance with UL 674, UL 1004, NEMA Standard MG 1, and to the requirements specified.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
   1. AFBMA 9-90, or latest edition, Load Rating and Fatigue Life for Ball Bearings.
   2. AFBMA 11-90, or latest edition, Load Ratings and Fatigue Life for Roller Bearings.
   3. EEE 112-1984, or latest edition, Polyphase Induction Motors and Generators.
   4. NEMA ICS 2-88, or latest edition, Industrial Control Devices, Controllers and Assemblies.
   5. NEMA ICS 6-88, or latest edition, Enclosures for Industrial Controls and Systems.
   6. NEMA MG 1-87, or latest edition, Motors and Generators.

7. UL 674-89, or latest edition, Motors and Generators, Electric, for Use in Hazardous Locations, Class I, Groups C and D, Class II, Groups E, F, and G.
8. UL 1004-89, or latest edition, Motors, Electric.

1.3 AMBIENT CONDITIONS

A. Unless specified otherwise, motors shall be suitable for continuous operation at an elevation of approximately 1,500 feet above sea level. Motors to be installed outdoors shall be suitable for continuous operation in a 50° C ambient temperature.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Nameplates shall be stainless steel with embossed or pre-printed lettering and fastened to the motor frame with Type 316 stainless steel pins. Nameplates shall have stamped on them the motor manufacturer's name, design voltage, number of hertz and phase, horsepower rating, amperage and temperature rise at rated load, full load speed, NEMA code letter, service factor, minimum guaranteed efficiency, model number, AFBMA bearing number, serial number, and maintenance manual number, in accordance with NEMA MG 1-10.40.1.

B. A separate nameplate shall provide lubrication instructions and a separate nameplate connection diagram for dual voltage motors.

2.2 CONSTRUCTION

A. Unless specified otherwise, all motors provided under this Section shall have the following features of construction and operation:
   1. All motors shall be of the motor manufacturer's premium energy-efficient design, different from manufacturer's standard product through the use of premium materials, design and improved manufacturing process that reduces motor losses approximately 40% from standard efficient designs.
   2. Motor efficiency shall be determined in accordance with NEMA Standard MG 1-12.54.1 and guaranteed minimum full load efficiency labeled on motor nameplate, in accordance with NEMA Standard MG 1-12.54.2 or MG 1-10.40.1.
   3. All motors shall successfully operate under power supply variations in accordance with NEMA MG1-14.30.
   4. All motors shall be NEMA Design B, with torque and starting currents in accordance with NEMA MG 1-12.35 and 12.37, except in special

      applications requiring higher starting torques where NEMA Design C is permitted.

5. All motors shall have a 1.15 service factor at a specific temperature per the individual equipment specifications. Polyphase integral horsepower motors shall be sized so that under maximum load conditions imposed by the driven equipment, for the conditions specified, the motor nameplate rated horsepower and Class B temperature rise at the nameplate horsepower will not be exceeded. Motors with a service factor of 1.15 shall be selected for operation within their full load rating without applying the service factor.
6. Each motor shall be of the speed and horsepower specified or required to properly operate the driven equipment, torque characteristics as required by the drive load and suitable for direct coupling or V-belt drive, as shown on the Drawings and specified herein. Motors shall be designed for full voltage starting, unless otherwise specified.
7. Frames shall be of corrosion-resistant cast iron with integrally cast feet or bases. End bells, conduit box and cover and bases shall be cast iron, with precision machined bearing fits, ASTM Type A48, Class 25 or better. UL approved automatic stainless steel breather drains shall be provided in the lowest part of front and back brackets to allow drainage of condensation on TEFC and explosion proof motors.
8. Each stator core assembly shall consist of stacked lamination made from specially selected electrical sheet silicon steel.
9. Insulation materials for polyphase integral horsepower motors shall be non-hygroscopic and meet or exceed Class F definition, utilizing materials, and insulation systems evaluated in accordance with IEEE 117 classification tests. Motor temperature rating shall not exceed Class B temperature limits as measured by resistance method when the motor is operated at full load at 1.0 service factor, continuously, in a maximum ambient temperature of 50° C. Windings shall be copper.
10. Rotor cages shall be die cast aluminum or fabricated copper. Shafts shall be made from carbon steel.
11. Rotors on frames 213T and above shall be keyed shrunk or welded to shaft and rotating assembly, dynamically balanced to NEMA limits in accordance with MG 1-12.06. Balance weights, if required, shall be secured to the rotor resistance ring or fan blades by rivets. Machine screws and nuts are prohibited. The entire rotating assembly between bearing inner caps shall be coated with a corrosion-resistant epoxy.
12. Bearings shall be ball, open, single-row, deep groove, Conrad type, and shall have a Class 3 internal fit conforming to AFBMA Standard No. 20. For belted duty applications, drive end bearing may be cylindrical roller type. Bearings shall be selected to provide L-10 rating life of 17,500 hours minimum for belted applications, 100,000 hours minimum for flexible direct coupled applications. Calculations shall be based on external loads using NEMA belted applications limits in accordance with MG 1-14.41 and typical sheave weights and internal loads defined by the manufacturer, including magnetic pull and rotating assembly weight.
13. Motor lubrication system shall consist of a sealed bearing or a grease inlet on motor bracket with capped grease fitting on inlet, grease relief plug 180

degrees from inlet, grease reservoir in bracket, and grease reservoir in cast inner cap. Motor shall be greased by manufacturer with a premium moisture resistant polyuria thickened grease, containing rust inhibitors and suitable for operation over temperatures from -25° C to 120° C. Vertical motors lubrication system shall be manufacturer's standard oil or grease.

14. All bolt and cap screws shall be of high strength, SAE Grade 5, zinc-plated and chromatic steel. Screwdriver slot fasteners are unacceptable.
15. All motor parts including frame, brackets, fan cover, and terminal box shall receive a minimum of two coats of high-grade, USDA accepted epoxy paint. Motor assembly shall successfully withstand salt spray tests for corrosion in accordance with ASTM B117 for 96 hours.
16. On all motors used in conjunction with variable frequency drives (VFDs) and elsewhere where required by the Contract Documents, shall be furnished with factory-installed thermostats in each phase of the motor for over-temperature protection. Leads from the sensors shall be installed through flexible sleeves from the stator windings to a separate junction box. Sleeves shall be free of insulating varnish or coating material applied to the stator windings. Thermostats are to be wired in series, contacts normally closed, rated for 120 VAC, and shall reset automatically upon falling temperature.
17. All motors shall have a normally closed high temperature switch included in the motor winding.

2.3 MOTORS LESS THAN 1/2 HORSEPOWER

A. General:
   1. Unless otherwise specified, motors less than 1/2 horsepower shall be squirrel cage, single-phase, capacitor start, induction run type. Construction features listed in Paragraph 2.2, above, shall be as normally supplied by the equipment manufacturer. Single-phase motors shall have Class B insulation. Small fan motors may be split-phase or shaded pole-type. Windings shall be copper.

B. Rating:
   1. Unless specified otherwise, motors shall be rated for operation at 115 volts, single-phase, 60 Hz, and shall be continuous-time rated in conformance with NEMA Standard MG 1, Paragraph 10.35. Dual voltage (115/230) rated motors are acceptable if all leads are brought out to the conduit box. Motors shall be non-overloading at all points of the equipment operation.

C. Enclosures:
   1. Unless otherwise specified, motors shall have totally enclosed fan-cooled or totally enclosed non-ventilated enclosures.

2.4 MOTORS 1/2 HORSEPOWER THROUGH 250 HORSEPOWER

A. General:

1. Unless otherwise specified, motors 1/2 horsepower through 250 horsepower shall be 3-phase, squirrel cage, full voltage start induction type. Unless otherwise specified, motors shall have a NEMA MG 1-1.16, design letter B or C torque characteristic as required by the driven equipment's starting torque requirements.

B. Rating:
   1. Unless otherwise specified, motors shall be rated for operation at 460 volts, 3-phase, 60 Hz, and shall be continuous time rated in accordance with NEMA Standard MG 1, Paragraph 10.35. Dual voltage (230/460) rated motors are acceptable if all leads are brought out to the conduit box.
   2. Motors for variable frequency systems shall not be required to deliver more than 80% of the motor's service factor rating by any load imposed by the driven machine, at any specified operating condition, or any condition imposed by the driven machine's performance curve at maximum operating speed.

C. Enclosure:
   1. Unless otherwise specified, provide totally enclosed motors on outdoor equipment, equipment installed below grade, chemical feed and chemical handling equipment, and equipment operating in wet or dust-laden locations. Drip-proof motors, or totally enclosed at the supplier's option, shall be furnished on equipment in indoor, above-grade, clean, and dry locations.

D. Motors for Variable Frequency Drives:
   1. Motors intended for use with VFDs shall be compatible with the characteristics of the intended VFDs. The motors shall be rated for inverter duty. Motors shall be capable of withstanding a pulse voltage of greater than 1,750 volts with a rate of rise up to 750 V/microsecond, and shall be in compliance with the power quality levels published in NEMA MG 1 Part 31.

E. Minimum Nameplate Efficiency:
   1. Motors shall meet the minimum full load efficiency values for PE motors listed in table 12-10 of NEMA MG-1-1993.

F. Vertical Motors:
   1. Unless otherwise specified, vertical motors shall be full voltage with a Type P base specifically designed for vertical installation. Universal position motors are not acceptable. Vertical motors shall have solid shafts unless specified otherwise. Thrust bearing rating shall be compatible with the loads imposed by the driven equipment.

G. Conduit Boxes:
   1. The CONTRACTOR is cautioned that external conduit boxes on motors shall be sized to accommodate oversized feeder conductors and shall not be less than one size larger than NEMA standards. The conduit boxes shall be

diagonally split and rotatable in 90 degree steps. A gasket shall be furnished between the conduit box and frame. Motor leads shall be stranded copper wire, Class F or better insulated, non-wicking, with permanent identifications spaced 1-1/2-inches maximum. Clamp-type grounding terminals shall be provided in the conduit boxes.

H. Lifting Eyes:
   1. Motors weighing more than 50 lbs. shall be fitted with at least one lifting eye.

I. Current Imbalance:
   1. Current imbalance shall not exceed the values tabulated below when the motor is operating at any load within its service factor rating and is supplied by a balanced voltage system.
      a. Under 5 Horsepower: 10%.
      b. 5 Horsepower and Above: 10%.
   2. Imbalance criteria shall be based upon the lowest value measured.

2.5 PRODUCT DATA

A. The following information shall be provided for each motor in accordance with the individual Equipment Specification and Section 01300, Submittals.
   1. Motor outline, dimensions and weight.
   2. Manufacturer's general descriptive information relative to motor features.
      a. Locked rotor current on motors 10 horsepower and above.
      b. Motor current, efficiency and power factor at full load, 3/4 load, and no load.
      c. Motor test reports.
      d. Space heater data, if applicable.
      e. Type of bearings and lubrication.
      f. Motor thermostat, RTD, or thermistor data, if applicable.
   3. Where a winding over-temperature device is required, provide a response curve for the temperature device.
   4. Applicable operation and maintenance information specified in Section 01300, Submittals. Provide overhaul instructions for each motor 5 horsepower and over.

2.6 SOURCE QUALITY CONTROL

A. Motor Tests:
   1. Test motors in accordance with NEMA and IEEE procedures. Include the following:
      a. Routine Test:
         1) Running no-load amperes.
         2) Locked rotor amperes.

3) Winding resistance, DC.
4) High-potential test at twice-rated voltage plus 1,000 V, with a minimum of 2,200 V for one minute, winding to ground.
5) Vibration check.

b. Complete Test:
1) Rated load temperature rise.
2) Slip in percent.
3) Locked rotor amperes (3-phase, full voltage).
4) Locked rotor torque.
5) Breakdown torque.
6) High potential test at twice-rated voltage plus 1,000 V, with a minimum of 2,200 V for one minute, winding to ground.
7) Efficiencies tabulated at 100%, 75%, and 50% of full load.
8) Power factor tabulated at 100%, 75%, and 50% of full load.

2. Routine test all motors 5 Horsepower and larger.
3. Provide complete test for motors 100 Horsepower and larger. Test one motor of each size and type. Complete test results for prototype motors identical to those furnished will be acceptable.

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 11200

ABOVE GROUND PUMP STATION
WITH DUPLEX SELF-PRIMING PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work under this section includes, but is not limited to furnishing and installing a 6'x6' above ground fiberglass lift station consisting of two (one working and one standby) self-priming pumps, check valves, plug valves, air release valves wit fittings, thermostatically controlled ventilator fans and insulation kit as indicated on the project drawings, herein specified, as necessary for proper and complete performance.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of 5 years of experience in production of above ground sewage lift stations with self-priming pumps and shall show evidence of satisfactory service in at least 5 installations.

B. Reference Standards:
   1. ANSI B16.1: Cast iron pipe flanges and flanged fittings.
   2. ANSI/AWWA C115/A21.51: Cast/ductile iron pipe with threaded flanges.
   3. ANSI 253.1: Safety Color Code for Marking Physical Hazards.
   4. ANSI B40.1: Gages, Pressure and Vacuum.
   5. AWWA C508: Single Swing Check Valves.
   6. ASTM A48: Gray Iron Castings.
   7. ASTM A126: Valves, Flanges, and Pipe Fittings.
   8. ASTM A307: Carbon Steel Bolts and Studs.
   9. ASTM A36: Structural Steel.
   10. IEEE Std 100: Standard Dictionary of Electrical Terms.
   11. IEEE Std 112: Test Procedure for Polyphase Induction Motors.
   12. IEEE Std 242: Protection of Industrial and Control Power Systems.
   13. NEC: National Electrical Code.
   14. NEMA Std MG1: Motors and Generators.
   15. Ten-State Standards Recommended Standards for Sewage Works.
   16. Hydraulic Institute Std for Centrifugal, Rotary and Reciprocating Pumps.
   17. ISO 9001 International Organization for Standardization.
   18. ISO 14001 International Organization for Standardization.

C. Pump Performance Certifications:
   1. Solids Handling Capability:
      a. All internal passages, impeller vanes, and recirculation ports shall pass a 3" spherical solid. Smaller internal passages that create a maintenance

nuisance or interfere with priming and pump performance shall not be permitted. Upon request from the engineer, manufacturer's certified drawings showing size and location of the recirculation port(s) shall be submitted for approval.

2. Reprime Performance:
   a. Consideration shall be given to the sanitary sewage service anticipated, in which debris is expected to lodge between the suction check valve and its seat, resulting in the loss of the pump suction leg, and siphoning of liquid from the pump casing to the approximate center line of the impeller. Such occurrence shall be considered normal, and the pump must be capable of automatic, unattended operation with an air release line installed.
   b. During unattended operation, the pump shall retain adequate liquid in the casing to insure automatic repriming while operating at its rated speed in a completely open system. The need for a suction check valve or external priming device shall not be required.
   c. Pump must reprime 21.90 vertical feet at the specified speed and impeller diameter. Reprime lift is defined as the static height of the pump suction above the liquid, while operating with only one-half of the liquid remaining in the pump casing. The pump must reprime and deliver full capacity within five minutes after the pump is energized in the reprime condition. Reprime performance must be confirmed with the following test set-up:
      1) A check valve to be installed down stream from the pump discharge flange. The check valve size shall be equal (or greater than) to the pump discharge diameter.
      2) A length of air release pipe shall be installed between pump and the discharge check valve. This line shall be open to atmosphere at all times duplicating the air displacement rate anticipated at a typical pump station fitted with an air release valve.
      3) The pump suction check valve shall be removed. No restrictions in the pump or suction piping will prevent the siphon drop of the suction leg. Suction pipe configuration for reprime test shall incorporate a 2 feet minimum horizontal run, a 90 degree elbow and vertical run at the specified lift. Pipe size shall be equal to the pump suction diameter.
      4) Impeller clearances shall be set as recommended in the pump service manual.
      5) Repeatability of performance shall be demonstrated by testing five consecutive reprime cycles. Full pump capacity (flow) shall be achieved within five minutes during each cycle.
      6) Liquid to be used for reprime test shall be water.
3. Upon request from the engineer, certified reprime performance test results, prepared by the manufacturer, and certified by a registered professional engineer, shall be prepared and forwarded to the customer.

D. Certified Pump Performance Test:

1. Tests shall be conducted in accordance with Hydraulic Institute Standards 14.6.3.4 Acceptance Grade 2B at the specified head, capacity, rated speed and horsepower. The performance tests will validate the correct performance of the equipment at the design head, capacity and speed.
2. For pumps utilizing up to (13 HP) motors; but larger than (1.3 HP), tests shall be conducted in accordance with Hydraulic Institute Standards 14.6.3.4.1, as the specified head, capacity, rated speed and horsepower.

E. Factory System Test:
1. All internal components including the pumps, motors, valves, piping and controls will be tested as a complete working system at the manufacturer's facility. Tests shall be conducted in accordance with Hydraulic Institute Standards at the specified head, capacity, rated speed and horsepower. Factory operational test shall simulate actual performance anticipated for the complete station.
2. Upon request from the ENGINEER, the operational test may be witnessed by the ENGINEER, and/or representatives of his choice, at the manufacturer's facility.

F. Manufacturer's Start-up Services:
1. The manufacturer's technical representative shall inspect the completed installation, correct or supervise the correction of any defect or malfunction, and instruct operating personnel in the proper operation and maintenance of the equipment as described in Part 3 of this section.

1.3 SYSTEM DESCRIPTION

A. Design requirements consist of pump station design, including materials of construction, pump features, valves and piping, and motor controls shall be in accordance with requirements listed under PART 2 - PRODUCTS of this section.
1. Contractor shall furnish and install one above ground, automatic pump station. The station shall be complete with all equipment specified herein, factory assembled in a fiberglass reinforced polyester resin enclosure.
2. In addition to the station enclosure, the pump station shall include two horizontal, self priming, centrifugal sewage pumps, V-belt drives, motors, internal piping, valves, motor control panel, automatic liquid level control system, and internal wiring.

B. Performance Criteria:
1. Pumps must be designed to handle raw, unscreened, domestic sanitary sewage. Pumps shall have 2" suction connection, and 3" discharge connection. Each pump shall be selected to perform under following operating conditions:

a.	Capacity (GPM)	61.11
b.	Total Dynamic Head(FT)	31.5
c.	Maximum Repriming Lift(FT)	21.90

d. Maximum Static Suction Lift(FT) ___21.90____
e. Total Static Head(FT) ___25.90____

1.4 SUBMITTALS

A. Submittals shall be made in accordance with Section 01300, Submittals.
   1. Shop Drawings:
      a. Letters of Certification of Compliance on materials, equipment, etc.
      b. Final Certified Drawings showing outline dimensions, foundation layout or mounting information, and other pertinent dimensions.
      c. Field erection instructions, assembly drawings and/or diagrams, detailed reference drawing lists, lists of erection details, and list of spare parts supplied with equipment.
      d. Shop Detail Drawings showing individual sub- assemblies and fabricated pieces with material specifications and other applicable data.
      e. Installation instructions, operating and/or service manuals, and all other data pertinent to operating or servicing the complete apparatus. Preventative maintenance instructions and recommended frequency.
      f. Schematic and wiring diagrams of power, control, and piping systems. A detailed description of operation shall be included for each diagram to describe all modes of operation of the system indicated. Where the integrated system requires interlocking and control of other components in normal operation, these components shall be included in the description of operation.
      g. General bulletins and catalog cuts describing complete apparatus, including operating principles and fundamentals.
      h. Service data sheets showing design performance, utility requirements, etc., as applicable to the specific duty for which the equipment is furnished.
      i. Certified head and capacity curves for pumps. Impeller size furnished and maximum size available shall be noted on these data sheets.
      j. Curves and/or data for overall range of operation from minimum to maximum capacity or load, showing capacity or load, utilities motive medium required, total or incremental differential head, and other pertinent information applicable to the equipment or its component assemblies.
      k. Materials of construction of all components.
      l. Renewal parts list with diagrammatic or cross-section drawings showing part identification. Material analysis or trades designation for each significant part is to be noted on parts lists or on a separate sheet.
      m. Stuffing box sizes; packing sizes; specifications and arrangement; and mechanical seal details, specifications, etc., if furnished in equipment.

B. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are

needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Operations and Maintenance Manuals: Submit complete operations and maintenance manuals in conformance with operations and maintenance manuals section of specification 01300, Submittals.

1.5 MANUFACTURER'S WARRANTY

A. The pump station manufacturer shall warrant all equipment to be of quality construction, free of defects in material and workmanship. A written warranty shall include specific details described below.
   1. In addition to defects in material and workmanship, fiberglass reinforced polyester station enclosures are warranted for sixty (60) months to be resistant to rust, corrosion, corrosive soils, effects of airborne contamination or physical failures occurring in normal service for the period of the pump station warranty.
   2. All other equipment, apparatus, and parts furnished shall be warranted for sixty (60) months, excepting only those items that are normally consumed in service, such as light bulbs, oils, grease, packing, gaskets, O-rings, etc. The pump station manufacturer shall be solely responsible for warranty of the station and all components.

B. Components failing to perform as specified by the ENGINEER, or as represented by the manufacturer, or as proven defective in service during the warranty period, shall be replaced, repaired, or satisfactorily modified by the manufacturer.

PART 2 - PRODUCT

2.1 UNITARY RESPONSIBILITY

A. In order to unify responsibility for proper operation of the complete pumping station, it is the intent of these Specifications that all system components be furnished by a single supplier (unitary source). The pumping station must be of standard catalog design, totally warranted by the manufacturer. Under no circumstances will a system consisting of parts compiled and assembled by a manufacturer's representative or distributor be accepted.

2.2 MANUFACTURER

A. The Gorman-Rupp Company or equal which are deemed most suitable for the service anticipated.

2.3 STATION ENCLOSURE

A. The station enclosure shall contain and protect all pumps, interior piping, valves and associated controls. Enclosure shall incorporate the following design and service features:
   1. Access panels must be supplied on all sides. Location and size shall permit access for routine maintenance functions such as pump and motor inspection, drive belt adjustment, and pump clean-out. Non-hinged panels shall be secured with stainless steel tamper-proof hardware.
   2. A continuous hinge and latch shall be installed on at least two access panels. The hinged panels shall allow easy access to the electrical controls for frequent adjustments and inspections. A two-point mechanical latch assembly shall secure the panel at top and bottom. Latch handle locks shall be match keyed, requiring only one key to open all access panels.
   3. A vent in one access panel shall allow free air flow for enclosure ventilation.
   4. The complete station enclosure, less base, must be completely removable after disengaging reusable hardware. After disassembly, no portion of the enclosure (except electrical service entrance) shall project above the base surface to interfere with maintenance or endanger personnel.
   5. Disassembly and removal of the enclosure shall require no more than two people working without assistance of lifting equipment.

B. Station enclosure shall be manufactured of molded reinforced orthophthalic polyester resins with a minimum of 30% fiberglass, and a maximum of 70% resin. Resin fillers or extenders shall not be used.
   1. Chopped glass fibers of 1 1/4 inch average length shall be sprayed and rolled. Major design consideration shall be given to structural stability, corrosion resistance, and watertight integrity. The polyester laminates shall provide a balance of mechanical, chemical, and electrical properties to insure long life. They must be impervious to micro-organisms, mildew, mold, fungus, corrosive liquids, and gases which are expected to be present in the environment surrounding the wet well.
   2. All interior surfaces of the housing shall be coated with a polyester resin-rich finish providing maintenance-free service, abrasion resistance, and protection from sewage, greases, oils, gasoline, and other common chemicals.
   3. Outside surfaces of the enclosure shall be coated with gel-coat pigmented resin to insure long maintenance-free life and UV protection. Color used shall de-emphasize the presence of dirt, grease, etc.

C. Station base shall be constructed of pre-cast, reinforced concrete encapsulated in a fiberglass mold. The design shall resist deformation of the structure during shipping, lifting, or handling. Base shall incorporate drainage provisions, and an

opening sized to permit installation of piping and service connections to the wet well. After installation, the opening shall serve as a grout dam to be utilized by the contractor. The base shall incorporate anchor bolt recesses for securing the complete station to a concrete pad (supplied by the contractor) in accordance with the project plans.

D. A blower mounted in the station roof shall be sized to exchange station air volume at least once every two minutes. Blower motor shall energize automatically at approximately 70 degrees F, and turn off at 55 degrees F. The blower motor control circuit shall incorporate a thermal-magnetic circuit breaker providing overcurrent and overload protection. Exhaust and inlet locations shall prevent the entrance of rain, snow, or debris.

2.4 PUMP DESIGN

A. Pumps shall be horizontal, self-priming centrifugal type, designed specifically for handling raw, unscreened, domestic sanitary sewage. Pump solids handling capability and performance criteria shall be in accordance with requirements listed under PART 1 - GENERAL of this section.

B. The pump manufacturer must be ISO 9001:2000 revision certified, with scope of registration including design control and service after sales activities.

C. Materials and Construction Features:
   1. Pump casing: Casing shall be cast iron Class 30 with integral volute scroll. Casing shall incorporate following features:
      a. Mounting feet sized to prevent tipping or binding when pump is completely disassembled for maintenance.
      b. Fill port coverplate, 3 1/2" diameter, shall be opened after loosening a hand nut/clamp bar assembly. In consideration for safety, hand nut threads must provide slow release of pressure, and the clamp bar shall be retained by detente lugs. A Teflon gasket shall prevent adhesion of the fill port cover to the casing.
      c. Casing drain plug shall be at least 1 1/4" NPT to insure complete and rapid draining.
      d. Liquid volume and recirculation port design shall be consistent with performance criteria listed under PART 1 - GENERAL of this section.
   2. Cover plate: Coverplate shall be cast iron Class 30. Design must incorporate following maintenance features:
      a. Retained by hand nuts for complete access to pump interior. Coverplate removal must provide ample clearance for removal of stoppages, and allow service to the impeller, seal, wearplate or check valve without removing suction or discharge piping.
      b. A replaceable wearplate secured to the coverplate by weld studs and nuts shall be AISI 1015 HRS.
      c. In consideration for safety, a pressure relief valve shall be supplied in the coverplate. Relief valve shall open at 75-200 PSI.

d. Two O-rings of Buna-N material shall seal coverplate to pump casing.
e. Pusher bolt capability to assist in removal of coverplate. Pusher bolt threaded holes shall be sized to accept same retaining capscrews as used in rotating assembly.
f. Easy-grip handle shall be mounted to face of coverplate.

3. Rotating Assembly: A rotating assembly, which includes impeller, shaft, mechanical shaft seal, lip seals, bearings, sealplate and bearing housing, must be removable as a single unit without disturbing the pump casing or piping. Design shall incorporate following features:
   a. Sealplate and bearing housing shall be cast iron Class 30. Separate oil filled cavities, vented to atmosphere, shall be provided for shaft seal and bearings. Cavities must be cooled by the liquid pumped. Three lip seals will prevent leakage of oil.
      1) The bearing cavity shall have an oil level sight gauge and fill plug check valve. The clear sight gauge shall provide easy monitoring of the bearing cavity oil level and condition of oil without removal of the fill plug check valve. The check valve shall vent the cavity but prevent introduction of moist air to the bearings.
      2) The seal cavity shall have an oil level sight gauge and fill/vent plug. The clear sight gauge shall provide easy monitoring of the seal cavity oil level and condition of oil without removal of the fill/vent plug.
      3) Double lip seal shall provide an atmospheric path providing positive protection of bearings, with capability for external drainage monitoring.
   b. Impeller shall be ductile iron, two-vane, semi-open, non-clog, with integral pump out vanes on the back shroud. Impeller shall thread onto the pump shaft and be secured with a lockscrew and conical washer.
   c. Shaft shall be AISI 4140 alloy steel unless otherwise specified by the engineer, in which case AISI 17-4 pH stainless steel shall be supplied.
   d. Bearings shall be anti-friction ball type of proper size and design to withstand all radial and thrust loads expected during normal operation. Bearings shall be oil lubricated from a dedicated reservoir. Pump designs which use the same oil to lubricate the bearings and shaft seal shall not be acceptable.
   e. Shaft seal shall be oil lubricated mechanical type. The stationary and rotating seal faces shall be tungsten titanium carbide alloy. Each mating surface shall be lapped to within three light bands flatness (35 millionths of an inch), as measured by an optical flat under monochromatic light. The stationary seal seat shall be double floating by virtue of a dual O-ring design; an external O-ring secures the stationary seat to the sealplate, and an internal O-ring holds the faces in alignment during periods of mechanical or hydraulic shock (loads which cause shaft deflection, vibration, and axial/radial movement). Elastomers shall be viton. Cage and spring to be stainless steel. Seal shall be oil lubricated from a dedicated reservoir. The same oil shall not lubricate both shaft

seal and shaft bearings. Seal shall be warranted in accordance with requirements listed under PART 1 - GENERAL of this section.

f. Pusher bolt capability to assist in removal of rotating assembly. Pusher bolt threaded holes shall be sized to accept same capscrews as used for retaining rotating assembly.

4. Adjustment of the impeller face clearance (distance between impeller and wearplate) shall be accomplished by external means.
   a. Clearances shall be maintained by a four point external shimless coverplate adjustment system, utilizing a four collar and four adjusting screw design allowing for incremental adjustment of clearances by hand as required. Each of the four points shall be lockable to prevent inadvertent clearance increases or decreases due to equipment vibration or accidental operator contact. The four point system also allows for equal clearance gaps at all points between the impeller and wear plate. Requirement of realignment of belts, couplings, etc., shall not be acceptable. Coverplate shall be capable of being removed without disturbing clearance settings. Clearance adjustment systems that utilize less than four points will not be considered.
   b. There shall be provisions for additional clearance adjustment in the event that adjustment tolerances have been depleted from the coverplate side of the pump. The removal of stainless steel shims from the rotating assembly side of the pump shall allow for further adjustment as described above
   c. Clearance adjustment which requires movement of the shaft only, thereby adversely affecting seal working length or impeller back clearance, shall not be acceptable.
5. Suction check valve shall be molded Neoprene with integral steel and nylon reinforcement. A blow-out center shall protect pump casing from hydraulic shock or excessive pressure. Removal or installation of the check valve must be accomplished through the coverplate opening, without disturbing the suction piping. Sole function of check valve shall be to save energy by eliminating need to reprime after each pumping cycle. Pumps requiring a suction check valve to assist reprime will not be acceptable.
6. Spool flanges shall be one-piece cast iron, class 30 fitted to suction and/or discharge ports. Each spool shall have one 1-1/4" NPT and one 1/4" NPT tapped hole with pipe plugs for mounting gauges or other equipment.

2.5 VALVES AND PIPING

A. Check Valve: Each pump shall be equipped with a full flow type check valve capable of passing a 3" spherical solid. Valve shall be constructed with flanged ends and fitted with an external lever and torsional spring. Valve seat shall be constructed of stainless steel, secured to the body to ensure concentricity, sealed by an O-ring, and shall be replaceable. The valve body shall be cast iron incorporating a clean-out port large enough to allow removal and/or replacement of the valve clapper without removing valve or piping from the line. Valve clapper shall have a molded neoprene seating surface incorporating low pressure

sealing rings. Valve hinge pin and internal hinge arm shall be stainless steel supported on each end in brass bushings. Shaft nut shall have double O-rings which shall be shall be easily replaceable without requiring access to interior of valve body. All internal hardware shall be stainless steel. Valve shall be rated at 175 PSI water working pressure, 350 PSI hydrostatic test pressure. Valves other than full flow type or valves mounted in such a manner that prevents the passage of a 3" spherical solid shall not be acceptable.

B. Plug Valve: A 3-way plug valve must allow either or both pumps to be isolated from the force main. The plug valve shall be non-lubricated, tapered type. Valve body shall be cast iron with flanged end connections drilled to 125 pound standard. The drip-tight shutoff plug shall be mounted in stainless steel bearings, and shall have a resilient facing bonded to the sealing surface. Valve shall be operated with a single lever actuator providing lift, turn, and reseat action. The lever shall have a locking device to hold the plug in the desired position.

C. Automatic air release valves:
   1. An automatic air release valve shall be furnished for each pump designed to permit the escape of air to the atmosphere during initial priming or unattended repriming cycles. Upon completion of the priming cycle or repriming cycle, the valve shall close to prevent recirculation. Valves shall provide visual indication of valve closure, and shall operate solely on discharge pressure. Valves which require connection to the suction line shall not be acceptable.
   2. All valve parts exposed to sewage shall be constructed of cast iron, stainless steel, or similar corrosion resistant materials. Diaphragms, if used, shall be of fabric-reinforced neoprene or similar inert material.
   3. A cleanout port, three inches in diameter, shall be provided for ease of inspection, cleanout, and service.
   4. Valves shall be field adjustable for varying discharge heads.
   5. Connection of the air release valves to the station piping shall include stainless steel fittings.

D. Gauge Kit:
   1. A gauge kit shall be supplied for each pump. Suction pressure must be monitored by a glycerin-filled compound gauge, and discharge pressure by a glycerin-filled pressure gauge. Gauges to be at least 4 inches in diameter, graduated in feet water column. Rated accuracy shall be 1% of full scale reading. Compound gauge shall be graduated -34 to +34 feet water column minimum. Pressure gauge to be graduated 0 to 140 feet water column minimum.
   2. Gauges to be factory mounted on a resilient panel with frame assembly secured to pumps or piping. Gauge installations shall be complete with all hoses and stainless steel fittings, including a shutoff valve for each gauge line at the point of connection to suction and discharge pipes.

E. Piping:
   1. Flanged header pipe shall be centrifugally cast, ductile iron, complying with ANSI/AWWA A21.51/C115 and class 53 thickness.
   2. Flanges shall be cast iron class 125 and Comply with ANSI B16.1.
   3. Pipe and flanges shall be threaded and suitable thread sealant applied before assembling flange to pipe.
   4. Bolt holes shall be in angular alignment within 1/2 degree between flanges. Flanges shall be faced with a gasket finish having concentric grooves a minimum of 0.01 inch deep by approximately 0.03 inch wide, with a minimum of three grooves on any given surface spaced a maximum of 1/4 inch apart.

F. Supports and Thrust Blocks: Contractor must insure all pipes connected to the pump station are supported to prevent piping loads from being transmitted to pumps or station piping. Pump station discharge force main piping shall be anchored with thrust blocks where shown on the contract drawings.
   1. The bypass connection shall be accessible behind the hinged access panel on the wet well side of the station enclosure and shall terminate with a male OPW type quick connect fitting.

2.6 DRIVE UNIT

A. Motors (Note: Maximum motor frame size is 326T open drip-proof.)
   1. Pump motors shall be 3 HP, horizontal ODP, 1,800 RPM, NEMA design B with cast iron frame with copper windings, induction type, with class F insulation and 1.15 Service Factor for normal starting torque and low starting current characteristics, suitable for continuous service. The motors shall not overload at the design condition or at any head in the operating range as specified. Motors shall be suitable for operation using the utility power available specified in part 1 of this section.
   2. Motors shall be tested in accordance with provisions of ANSI/IEEE Std. 112, Method B.

B. Drive Transmission:
   1. Power to pumps transmitted V-belt drive assemblies. The sheave/belt combination shall provide the speed ratio needed to achieve the specified pump operating conditions.
   2. Each drive assembly shall utilize at least two V-belts providing minimum a combined safety factor of 1.5. Single belt drives or systems with a safety factor of less than 1.5 are not acceptable. Computation of safety factors shall be based on performance data published by the drive manufacturer.
   3. Precise alignment tolerances of the drive assemblies shall be achieved by means of a belt/sheave laser alignment system resulting in the reduction of vibration, accelerated wear, and premature failure.
   4. The pump manufacturer shall submit power transmission calculations which document the following:
      a. Ratio of pump/motor speed.

b. Pitch diameter of driver and driven sheaves.
c. Number of belts required per drive.
d. Theoretical horsepower transmitted per belt, based on vendor's data.
e. Center distance between pump and motor shafts.
f. Arc-length correction factor applied to theoretical horsepower transmitted.
g. Service factor applied to established design horsepower.
h. Safety factor ratio of power transmitted/brake horsepower required.

5. Pump drives to be enclosed on all sides by a guard constructed of fabricated steel or combination of materials including expanded, perforated, or solid sheet metal. No opening to a rotating member shall exceed 1/2 inch.
   a. Guards must be completely removal without interference from any unit component, and shall be securely fastened and braced to the unit base.
   b. Metal to be free from burrs and sharp edges. Structural joints shall be continuously welded. Rivet spacing on panels shall not exceed five inches. Tack welds shall not exceed four inch spacing.
   c. The guard shall be finished with one coat of gray W.R. non-lift primer and one coat of orange acrylic alkyd W.R. enamel in accordance with section 3, Color Definitions of ANSI 253.1; Safety Color Code for Marking Physical Hazards.

2.7 FINISH

A. Pumps, piping and exposed steel framework shall be cleaned prior to coating using an approved solvent wipe or phosphatizing cleaner. The part must thoroughly dry before paint application. Open joints shall be caulked with an approved polyurethane sealant. Exposed surfaces to be coated with two coats of a semi gloss white 2-component epoxy/polyamide to a dry film thickness of a minimum of 10 mils (5 mils minimum per coat). Coating shall be a high solids, 2 component epoxy/polyamide semi-gloss white coating for optimum illumination enhancement. The coating shall be corrosion, moisture, oil, and solvent resistant when completely dry. The factory finish shall allow for over-coating and touch-up for 6 months after coating.

2.8 ELECTRICAL CONTROL COMPONENTS

A. The pump station control panel will be tested as an integral unit by the pump station manufacturer. The control panel shall also be tested with the pump station as a complete working system at the pump station manufacturer's facility.

B. Panel Enclosure:
   1. Electrical control equipment shall be mounted within a common NEMA 1 stainless steel, dead front type control enclosures. Doors shall be hinged and sealed with a neoprene gasket and equipped with captive closing hardware. Control components shall be mounted on removable steel back panels secured to enclosure with collar studs.

2. All control devices and instruments shall be secured to the sub-plate with machine screws and lockwashers. Mounting holes shall be drilled and tapped; self-tapping screws shall not be used to mount and component. All control devices shall be clearly labeled to indicate function.

C. UL Label Requirement:
   1. Pump station controls shall conform to third party safety certification. The panel shall bear a serialized UL label listed for "Enclosed Industrial Control Panels". The enclosure, and all components mounted on the sub-panel or control cover shall conform to UL descriptions and procedures.

D. UL Label Requirement:
   1. Pump station components and controls shall conform to third party safety certification. The station shall bear a UL label listed for “Packaged Pumping System”. The panel shall bear a serialized UL label listed for "Enclosed Industrial Control Panels". The pump station components, panel enclosure, and all components mounted on the sub-panel or control cover shall conform to UL descriptions and procedures.

E. Branch Components:
   1. All motor branch and power circuit components shall be of highest industrial quality. The short circuit current rating of all power circuit devices shall be a tested combination or evaluated per the National Electrical Code Article 409. the lowest rated power circuit component shall be the overall control panel short circuit rating and shall not be less than the fault current available. The minimum control panel rating shall not be less than 10 kA, rms symmetrical. Control assemblies operating at 120 volts nominal or less may be provided with transformers which limit the fault current and may be rated less than the minimum required short circuit rating.
   2. Circuit Breakers and Operating Mechanisms:
      a. A properly sized heavy duty circuit breaker shall be furnished for each pump motor. The circuit breakers must be sealed by the manufacturer after calibration to prevent tampering.
      b. An operating mechanism installed on each motor circuit breaker shall penetrate the control panel door. A padlockable operator handle shall be secured on the exterior surface. Interlocks must prevent opening the door until circuit breakers are in "OFF" position. An additional mechanism(s) shall be provided on the circuit breaker permitting the breaker to be operated and/or locked with the control panel door in the open position.
   3. Motor Starters:
      a. An open frame, across-the-line, NEMA rated magnetic starter with under-voltage release, and overload protection on all three phases, shall be furnished for each pump motor. Starters of NEMA size 1 and above shall allow addition of at least two auxiliary contacts. Starters rated "O", "OO", or fractional size are not acceptable. Power contacts to be double-break type made of cadmium oxide silver. Coils to be epoxy

molded for protection from moisture and corrosive atmospheres. Contacts and coils shall be easily replaceable without removing the starter from its mounted position. Each starter shall have a metal mounting plate for durability.

4. Overload Relays:
   a. Overload relays shall be solid-state block type, having visual trip indication with trip-free operation. Electrically resetting the overload will cause one (1) normally open and one (1) normally closed isolated alarm/control contact to reset, thus re-establishing a control circuit. Trip setting shall be governed by solid-state circuitry and adjustable current setting. Trip classes shall be 10, 15 and 20. Additional features to include phase loss protection, selectable jam/stall protection and selectable ground fault protection.
   b. A reset pushbutton, mounted through the control panel door, shall permit resetting the overload relays without opening the door.
5. Phase Monitor:
   a. The control panel shall be equipped to monitor the incoming power and shut down the pump motors when required to protect the motor(s) from damage caused by phase reversal, phase loss, voltage unbalance, high voltage, and low voltage. An adjustable time delay shall be provided to minimize nuisance trips. The motor(s) shall automatically restart, following an adjustable time delay, when power conditions return to normal.
6. Pump Start Delay:
   a. The control circuit for pump #2 shall be equipped with a time delay to prevent simultaneous motor starts.

F. Control Circuit:
   1. A normal duty thermal-magnetic circuit breaker shall protect all control circuits by interrupting control power.
   2. Pump mode selector switches shall permit manual start or stop of each pump individually, or permit automatic operation under control of the liquid level control system. Manual operation shall override all shutdown systems, except the motor overload relays. Selector switches and start/stop push buttons to be oil-tight design with contacts rated NEMA A300 minimum.
   3. Pump alternation shall be integral to the liquid level controller. Provisions for automatic alternation or manual selection shall also be integral to the liquid level controller.
   4. Six digit elapsed time meter (non-reset type) shall be connected to each motor starter to indicate total running time of each pump in "hours" and "tenths of hours". An integral pilot light shall be wired in parallel to indicate that the motor is energized and should be running.
   5. A high pump temperature protection circuit shall override the level control and shut down the pump motor(s) when required to protect the pump from excessive temperature. A thermostat shall be mounted on each pump casing and connected to a high pump temperature shutdown circuit. If casing temperature rises to a level sufficient to cause damage, the thermostat causes

the pump shutdown circuit to interrupt power to the motor. A visible indicator located on the control panel door shall indicate motor stopped due to high pump temperature. The motor shall remain locked out until the pump has cooled and circuit has been manually reset. Automatic reset of this circuit is not acceptable.

6. A duplex ground fault receptacle providing 115 VAC, 60 Hz, single phase current, will be mounted on the side of the control enclosure. Receptacle circuit shall be protected by a 15 ampere thermal-magnetic circuit breaker.
7. The lift station shall be equipped with a 3 KVA stepdown transformer to supply 115 volt, AC, single phase for the control and auxiliary equipment. The primary and secondary side of the transformer to be protected by a thermal magnetic circuit breaker, sized to meet the power requirements of the transformer. An operating mechanism shall penetrate the control panel door. and a padlockable operator handle shall be secured on the exterior surface. Interlocks must prevent opening the door until circuit breakers are in "OFF" position. An additional mechanism(s) shall be provided on the circuit breaker permitting the breaker to be operated and/or locked with the control panel door in the open position.
8. Wiring:
    a. The pump station, as furnished by the manufacturer, shall be completely wired, except for power feed lines to the branch circuit breakers and final connections to remote alarm devices.
    b. All wiring, workmanship, and schematic wiring diagrams shall comply with applicable standards and specifications of the National Electric Code (NEC).
    c. All user serviceable wiring shall be type MTW or THW, 600 volts, color coded as follows:
        1) Line and Load Circuits, AC or DC power: Black
        2) AC Control Circuit Less Than Line Voltage: Red
        3) DC Control Circuit: Blue
        4) Interlock Control Circuit, from External Source: Yellow
        5) Equipment Grounding Conductor: Green
        6) Current Carrying Ground: White
        7) Hot With Circuit Breaker Open: Orange
    d. Control circuit wiring inside the panel, with exception of internal wiring of individual components, shall be 16 gauge minimum, type MTW or THW, 600 volts. Power wiring to be 14 gauge minimum. Motor branch wiring shall be 10 gauge minimum.
    e. Motor branch and other power conductors shall not be loaded above the temperature rating of the connected termination. Wires must be clearly numbered at each end in conformance with applicable standards. All wire connectors in the control panel shall be ring tongue type with nylon insulated shanks. All wires on the sub-plate shall be bundled and tied. All wires extending from components mounted on door shall terminate at a terminal block mounted on the back panel. All wiring outside the panel shall be routed through conduit.

f. Control wires connected to door mounted components must be tied and bundled in accordance with good commercial practice. Bundles shall be made flexible at the hinged side of the enclosure. Adequate length and flex shall allow the door to swing full open without undue stress or abrasion. Bundles shall be held on each side of hinge by mechanical fastening devices.

9. Conduit:
   a. Factory installed conduit shall conform to following requirements:
      1) All conduit and fittings to be UL listed.
      2) Liquid tight flexible metal conduit to be constructed of smooth, flexible galvanized steel core with smooth abrasion resistant, liquid tight polyvinyl chloride cover.
      3) Conduit to be supported in accordance with articles 346, 347, and 350 of the National Electric Code.
      4) Conduit shall be sized according to the National Electric Code.
10. Grounding:
   a. Station manufacturer shall ground all electrical equipment inside the pump station to the control panel back plate. All paint must be removed from the grounding mounting surface before making final connection.
   b. The contractor shall provide an earth driven ground connection to the pump station at the main grounding lug in accordance with the National Electric Code (NEC).
11. Equipment Marking:
   a. Permanent corrosion resistant name plate(s) shall be attached to the control and include following information:
      1) Equipment serial number
      2) Control panel short circuit rating
      3) Supply voltage, phase and frequency
      4) Current rating of the minimum main conductor
      5) Electrical wiring diagram number
      6) Motor horsepower and full load current
      7) Motor overload heater element
      8) Motor circuit breaker trip current rating
      9) Name and location of equipment manufacturer
   b. Control components shall be permanently marked using the same identification keys shown on the electrical diagram. Labels shall be mounted adjacent to device being identified.
   c. Switches, indicators, and instruments mounted through the control panel door shall be labeled to indicate function, position, etc. Labels shall be mounted adjacent to, or above the device.

2.9 LIQUID LEVEL CONTROL

A. The manufacturer of the liquid level control system must be ISO 9001:2000 revision certified, with scope of registration including design control and service after sales activities.

B. The level control system shall start and stop the pump motors in response to changes in wet well level, as set forth herein.

C. The level control system shall be capable of operating as either an air bubbler type level control system, submersible transducer type system, or ultrasonic transmitter type system.

D. The level control system shall utilize alternation to select first one pump, then the second pump, then the third pump (if required), to run as lead pump for a pumping cycle. Alternation shall occur at the end of a pumping cycle, or in the event of excessive run time.

E. The level control system shall utilize an electronic pressure switch which shall continuously monitor the wet well level, permitting the operator to read wet well level at any time. Upon operator selection of automatic operation, the electronic pressure switch shall start the motor for one pump when the liquid level in the wet well rises to the "lead pump start level". When the liquid is lowered to the "lead pump stop level", the electronic pressure switch shall stop this pump. These actions shall constitute one pumping cycle. Should the wet well level continue to rise, the electronic pressure switch shall start the second and/or third pump (if required) when the liquid reaches the "lag pump start level", or “standby pump start level” so that all pumps are operating. These levels shall be adjustable as described below.
   1. The electronic pressure switch shall include integral components to perform all pressure sensing, signal conditioning, EMI and RFI suppression, DC power supply and 120 volt outputs. Comparators shall be solid state, and shall be integrated with other components to perform as described below.
   2. The electronic pressure switch shall be capable of operating on a supply voltage of 12-24Vdc in an ambient temperature range of -10 degrees C (14 degrees F) through 55 degrees C (131 degrees F). Ingress Protection of IP56 for indoor use with closed cell neoprene blend gasket material. Evaluated by Underwriters Laboratories for Pollution Degree 2 device for U.L. and cU.L. Control range shall be 0 to 33.3 feet of water with an overall repeat accuracy of (plus/minus) 0.1 feet of water. Memory shall be non-volatile. A Battery backed real time clock shall be standard.
   3. Eleven optically isolated, user defined digital inputs for pump and alarm status. Rated at 10mA at 24Vdc. Eight digital output relays (mechanical contacts), configurable for pump start/stop or alarms. Three relays rated at 12 Amp @ 28Vdc and 120Vac, five relays rated at 3 Amp @ 30Vdc and 120Vac. The electronic pressure switch shall consist of the following integral components: pressure sensor, display, electronic comparators, digital inputs and digital output relays.
      a. The internal pressure sensor shall be a strain gauge transducer and shall receive an input pressure from the air bubbler system. The transducer shall convert the input to a proportional electrical signal for distribution to the display and electronic comparators. The transducer output shall be filtered to prevent control response to level pulsations or surges. The

transducer range shall be 0-14.5 PSI, temperature compensated from -40 degrees C (-40 degrees F) through 85 degrees C (185 degrees F), with a repeat accuracy of (plus/minus) 2.5% full scale about a fixed temperature. Transducer overpressure rating shall be 3 times full scale.

b. The electronic pressure switch shall incorporate a digital back lighted LCD panel display which, upon operator selection, shall indicate liquid level in the wet well, and pump status indication for up to 3 pumps. The display shall include a 128 x 64 bit resolution LCD to read out directly in feet of water, accurate to within one-tenth foot (0.1 foot), with a full scale indication of not less than 12 feet. The display shall be easily convertible to indicate English or metric units.

c. Level adjustments shall be electronic comparator set-points to control the levels at which the lead, lag and standby pumps start and stop. Each of the level settings shall be easily adjustable with the use of membrane type switches, and accessible to the operator without opening any cover panel on the electronic pressure switch. Controls shall be provided to permit the operator to read the selected levels on the display. Such adjustments shall not require hard wiring, the use of electronic test equipment, artificial level simulation or introduction of pressure to the electronic pressure switch.

d. Each digital input can be programmed as pump run, pump HOA, pump high temp, pump moisture/thermal, starter failure (FVNR), and phase failure. Inputs are used for status and alarm indication.

e. Each output relay in the electronic pressure switch shall be hard contact mechanical style. Each relay input shall be optically isolated from its output and shall incorporate zero crossover switching to provide high immunity to electrical noise. Each output relay shall have an inductive load rating equivalent to one NEMA size 3 contactor. A pilot relay shall be incorporated for loads greater than a size 3 contactor.

4. The electronic pressure switch shall be equipped with alarm banners with time and date history for displaying alarm input notification. Alarm history will retain a 16 of the most recent alarm events.
5. The electronic pressure switch shall be equipped with pump start/stop and alarm input delay(s) that have an adjustable delay set points.
6. An Antiseptic function with a built in timer shall be incorporated in the electronic pressure switch to prevent the well from becoming septic.
7. The electronic pressure switch shall be capable of jumping to next available pump if current pump is out of service due to pump failure or manual selection. Circuit design in which application of power to the lag pump motor starter is contingent upon completion of the lead pump circuit shall not be acceptable.
8. The electronic pressure switch shall be equipped with a simulator system capable of performing system cycle testing functions.
9. The electronic pressure switch shall be capable of calculating and displaying pump elapse run time. The elapse run time is resettable and adjustable.

10. The electronic pressure switch shall have internal capability of providing automatic simplex, duplex, and triplex alternation, manual selection of pump sequence operation, and alternation in the event of 1-24 hours of excessive run time.
11. The electronic pressure switch shall be equipped with a security access code to prevent accidental set-up changes and provide liquid level set-point lock-out. The supervisor access code is adjustable.
12. The electronic pressure switch shall be equipped with one (1) 0-33 ft. W.C. input, one (1) scalable analog input of either 0-5Vdc, or 4-20mA, and one (1) scalable analog output of either 0-5Vdc, 0-10Vdc or 4-20mA. Output is powered by 10-24Vdc supply. Load resistance for 4-20mA output shall be 100-1000 ohms.
13. The electronic pressure switch shall include a DC power supply to convert 120Vac control power to 12 or 24Vdc power. The power supply shall be 500 mA (6W) minimum and be UL listed Class II power limited power supply.
14. The electronic pressure switch shall be equipped with an electronic comparator and mechanical output relay to alert maintenance personnel to a high liquid level in the wet well. An alarm banner, visible on the front of the controller, shall indicate that a high wet well level exists. The alarm signal shall be maintained until the wet well level has been lowered and the circuit has been manually reset. High water alarm shall be furnished with a dry contact wired to terminal blocks.
15. The electronic pressure switch shall be equipped with an electronic comparator and mechanical output relay to alert maintenance personnel to a low liquid level in the wet well. An alarm banner, visible on the front of the controller, shall indicate that a low wet well level exists. The alarm signal shall be maintained until the cause for the low wet well level has been corrected and the circuit has been manually reset. A low liquid level condition shall disable all pump motors. When the wet well rises above the low level point, all pump motors shall be automatically enabled. Low water alarm shall be furnished with a dry contact wired to terminal blocks.

F. Submersible Transducer System:
1. The level control system shall utilize a submersible transducer. It shall be a strain gauge transducer with a pressure sensor housed in a 316 SST or Titanium case designed to extend into the wet well. The pressure transducer shall provide a proportional signal for distribution to the display and electronic comparators of the electronic pressure switch, and remainder of the level control system. Sensor range shall be 0-12 ft. W.C. minimum with an over-pressure rating 3 times full scale. The transducer shall have output capability of 1.5-7.5VDC or 4-20mA. The transducer's polyurethane jacketed shielded cable shall be of suitable length for proper installation into the wet well without splicing.
2. An intrinsically safe repeater shall be supplied in the control enclosure. Repeater must be recognized and listed as intrinsically safe by a nationally recognized testing laboratory. Station manufacturer shall make all

connections from repeater to feeder lines and motor controls. Installing contractor shall make connections from repeater to transducer.

G. An alarm silence switch shall provide maintenance personnel a means to de-energize the external alarm device while corrective actions are under way. After silencing the alarm, manual reset of the alarm signal shall provide automatic reset of the alarm silence relay.

2.10 LIQUID LEVEL CONTROL (Intrinsically Safe Float Switch Type)

A. The level control system shall start and stop pump motors in response to changes in wet well level. It shall be a mercury free float switch type, incorporating intrinsically safe relays. Floats to be secured to a vertical pipe in the wet well. Rising and falling liquid level in the wet well causes switches within the floats to open and close, providing start and stop signals to the remainder of the level control system.

B. The level control system shall start and stop the pumps in accordance to the wet well level. Upon operator selection of automatic operation, a float switch shall start one pump motor when water rises to the "lead pump start level". When the water is lowered to the "lead pump stop level", the system shall stop this pump. These actions shall constitute one pumping cycle. Should the water level continue to rise, an additional float switch will start the second pump after reaching the "lag pump start level" so that both pumps operate together. Both pumps shall stop at the same "all pumps off level". Circuit design in which application of power to the lag pump motor starter is contingent upon completion of the lead pump circuit shall not be acceptable.

C. The level control system shall work in conjunction with an alternator relay to select first one pump, then the second pump, to run as "Lead" pump. Alternation will occur at the end of each pumping cycle.

D. Float switches shall be supplied for installation by the contractor. Each float shall contain a mercury free switch type sealed in a polypropylene housing, with 30 feet of power cord, and polypropylene mounting hardware. A PVC or stainless steel mounting pipe shall be furnished by the contractor to secure the switches in the wet well.

E. A junction box shall be supplied for installation in the wet well by the contractor. Junction box shall be NEMA 4X, non-corrosive type incorporating terminal blocks match-marked to terminals in the control panel.

F. Intrinsically safe relays shall be supplied in a separate level control enclosure. Relays must be recognized and listed as intrinsically safe by a notionally recognized testing laboratory. Station manufacturer shall make all connections from relays to feeder lines and motor controls. Installing contractor shall make connections from relays to float switch junction box.

G. A separate float switch, and intrinsically safe relay shall be used to alert maintenance personnel to a high water level in the wet well (Low level float switch is optional). Should the wet well level rise to the "high water alarm" level, the float switch and intrinsically safe relay shall energize the alarm signal. The alarm signal shall complete a 115-volt AC circuit for an external alarm device. An indicator, visible from front of control panel, shall indicate high level condition exists. The alarm signal shall be maintained until wet well level is lowered and alarm circuit manually reset.

H. An alarm silence switch shall provide maintenance personnel a means to de-energize the external alarm device while corrective actions are under way. After silencing the alarm, manual reset of the alarm signal shall provide automatic reset of the alarm silence relay.

I. Alarm Light (External):
   1. Station manufacturer will supply one 115 VAC alarm light fixture with vapor-tight shatter resistant red globe, conduit box, and mounting base. The design must prevent rain water from collecting in the gasketed area of the fixture, between the base and globe. The alarm light will be shipped loose for installation by the contractor.

J. Alarm Horn (External):
   1. Station manufacturer will supply one 115 VAC weatherproof alarm horn with projector, conduit box, and mounting base. The design must prevent rain water from collecting in any part of the horn. The alarm horn will be shipped loose for installation by the contractor.

2.11 AUTOMATIC TELEPHONE DIALER

A. The dialer shall be a solid state component capable of dialing up to 16 phone numbers, each up to 24 digits in length. Phone numbers and standard pulse dialing of Touch Tone DTMF dialing are user programmable via the system's keyboard or touch tone phone. The dialer operating temperature shall range at least from 32° F (0°C) to 122° F (50° C).

B. Solid State Voice Message Recording and Playback:
   1. The unit shall have two different categories of speech message capability, all implemented with permanent nonvolatile solid state circuitry with no mechanical tape mechanisms. The unit shall allow for message recording from a remote telephone as well as from the front panel.
   2. User Field Recorded Messages: The user may record and re-record his own voice messages for each input channel and for the station ID.
   3. There shall be no limit on the length of any particular message, within the overall available message recording time; which shall be 40 seconds for 4 channel units, 80 seconds for 8 channel units, and 160 seconds for 16 or more channels.

4. The unit shall allow selective recording of both Normal and Alarm advisory messages for each input channel.
5. The unit shall provide for automatic setting of the optimum speech memory usage rate for the total set of messages recorded in order to achieve optimum recording sound quality.
6. Circuit board switches or jumper straps shall not be acceptable means of manipulating message length or recording rates.
7. Permanent Resident Non-Recorded Messages: Permanent built-in messages shall be included to support user programming operations, to provide supplemental warning messages such as advising that the alarms have been disabled, and to allow the unit to be fully functional even when the installer has not recorded any messages of his own.

C. Local & Remote Programming Capabilities:
1. The user may optionally elect to alter the following parameters from their standard normal default values via keyboard entry or remotely from any touch tone phone.
2. Alarm Call Grouping: Upon alarm activation, the system shall selectively call the correct phone numbers according to the current alarm(s).
3. Alarm Response Delay: .1 to 999.9 seconds.
4. Delay Between Alarm Call Outs: .1 to 99.9 minutes.
5. Alarm Reset Time: .1 to 99 hours or "NO RESET."
6. Incoming Ring Response (Answer) Delay: 1 to 20 rings.
7. Number of Message Repetitions: 1 to 20 repetitions.
8. Input Alarm Criteria: Each channel shall be independently configured for "Alarm On Open Circuit", "Alarm On Closed Circuit", and "No Alarm."
9. Autocall Test: When enabled, the unit shall place a single round of test calls, both at the time this function is enabled and also at regular subsequent intervals until this function is disabled at the keyboard.
10. Run Time Meter: Selected inputs shall accumulate and report the number of hours that its input contacts have been closed.
11. Remote System Microphone Activation.
12. Remote and Local Arming and Disarming of System.
13. Pulse Totalizer Function.

D. User entered programming and voice messages shall be kept intact even during power failures or when all power is removed for up to ten years.

E. Acknowledgement of an alarm phone call is to be accomplished by pressing a touch tone "9" as the alarm call is being received, and/or by returning a phone call to the unit after having received an alarm call.

F. The unit shall continuously monitor the presence of AC power and the status of four contact closure inputs. The unit shall optionally be field upgradeable to incorporate a total of 8, 16, 24, or 32 dry contact inputs. AC power failure, or violation of the alarm criteria at any input, shall cause the unit to go into alarm status and begin dial outs. The unit shall, upon a single program entry,

automatically accept all input states as the normal non-alarm state; eliminating possible confusion about Normally Open versus Normally Closed inputs. Further, as a diagnostic aid, the unit shall have the capability of directly announcing the state of any given input as currently "Open Circuit" or "Closed Circuit", without disturbing any message programming. Each input channel shall also be independently programmable, without the need to manipulate circuit board switches or jumpers, as Normally Open or Normally Closed, or for No Alarm (Status Only), or for Pulse Totalizing, or for Run Time Metering.

G. Any dry contact input can be programmed to accumulate and report the number of hours their respective input circuits have been closed. Any such channels will never cause an alarm, but on inquiry will recite the channel's message according to the status of the input and then report the closed circuit time to the tenth of an hour. The input will accumulate and report in tenths of hours up to a total accumulated running time of 99,999.9 hours. The initial value of the Run Time Meter shall be programmable in order to agree with existing electro-mechanical run time meters. Up to a total of 8 Run Time Meters may be programmed.

H. Any dry contact input can be programmed to accumulate the number of pulses (momentary contact closures) occurring at the input.

I. Upon initiating an alarm phone call, the system is to "speak" only those channels that are currently in "alarm status."

J. The unit shall provide a complete verbal report of all programmable functions and their programmed values on command form from any remote touch tone phone.

K. The unit shall be capable of dialing any phone number on command and function as a speakerphone.

L. Inquiry phone calls can be made directly to the unit at any time from any telephone, locally or long distance, for a complete status report of all variables being monitored; including power status.

M. Normal power shall be 105-135 VAC, 15 watts nominal. The product is to contain its own gel cell rechargeable battery which is automatically kept charged when AC power is present. The system shall operate on battery power for a minimum of 20 continuous hours in the event of AC power failure. A shorter backup time shall not be acceptable. The built-in charger shall be precision voltage controlled, not a "trickle charger", in order to minimize recharge time and maximize battery life available.

N. The dialer is to use a standard rotary pulse or touch tone "dial-up" phone line (direct leased line not to be required) and is to be F.C.C. approved. Connection to the telephone is through a 4-pin modular jack (RJ-11.)

O. All power, phone line, dry contact, and analog signal inputs shall be protected at the circuit board to IEEE Standard 587, Category B (6,000 volts open

circuit/3,000 amps closed circuit.) Gas tubes followed by solid state protectors shall be integral to the circuit board for each such line. Protectors mounted external to the main circuit board shall not be an acceptable substitute. The installer shall provide a good electrical ground connection point near the unit to maximize the effectiveness of the surge protection.

P. The system shall include expansion connectors to accommodate field upgrades for additional dry contact inputs, remote supervisory control outputs, analog inputs and communication with remote printers and computers.

Q. All keyboard and front panel switches shall be sealed to prevent contamination. Front panel LED's shall indicate: Normal Operation, Program Mode, Phone Call in Progress, Status for each channel, AC Power Present, AC Power Failure, and Discharging or Recharging Battery. On any inquiry telephone call or on site status check, the voice shall provide specific warning if no dial out phone numbers are entered, or if the unit is in the "alarm disable" mode, or if AC power is off or has been off since last reset. A built-in microphone shall allow anyone at a remote phone to listen to local sounds and have a two-way conversation with personnel at the dialer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Contractor shall off-load equipment at installation site using equipment of sufficient size and design to prevent injury or damage. Station manufacturer shall provide written instruction for proper handling. Immediately after off-loading, contractor shall inspect complete pump station and appurtenances for shipping damage or missing parts. Any damage or discrepancy shall be noted in written claim with shipper prior to accepting delivery. Validate all station serial numbers and parts lists with shipping documentation. Notify the manufacturer’s representative of any unacceptable conditions noted with shipper.

3.2 INSTALLATION

A. Install, level, align, and lubricate pump station as indicated on project drawings. Installation must be in accordance with written instructions supplied by the manufacturer at time of delivery.

B. Suction pipe connections are vacuum tight. Fasteners at all pipe connections must be tight. Install pipe with supports and thrust blocks to prevent strain and vibration on pump station piping. Install and secure all service lines (level control, air release valve or pump drain lines) as required in wet well.

C. Check motor and control data plates for compatibility to site voltage. Install and test the station ground prior to connecting line voltage to station control panel.

D. Prior to applying electrical power to any motors or control equipment, check all wiring for tight connection. Verify that protective devices (fuses and circuit breakers) conform to project design documents. Manually operate circuit breakers and switches to ensure operation without binding. Open all circuit breakers and disconnects before connecting utility power. Verify line voltage, phase sequence and ground before actual start-up.

E. After all anchor bolts, piping and control connections are installed, completely fill the grout dam in the pump station base with non-shrink grout.

3.3 FIELD QUALITY CONTROL

A. Operational Test
   1. Prior to acceptance by owner, an operational test of all pumps, drives, and control systems shall be conducted to determine if the installed equipment meets the purpose and intent of the specifications. Tests shall demonstrate that all equipment is electrically, mechanically, structurally, and otherwise acceptable; it is safe and in optimum working condition; and conforms to the specified operating characteristics.
   2. After construction debris and foreign material has been removed form the wet well, contractor shall supply clear water volume adequate to operate station through several pumping cycles. Observe and record operation of pumps, suction and discharge gage readings, ampere draw, pump controls, and liquid level controls. Check calibration of all instrumentation equipment, test manual control devices, and automatic control systems. Be alert to any undue noise, vibration or other operational problems.

B. Manufacturer's Start-up Services
   1. Coordinate station start-up with manufacturer's technical representative. The representative or factory service technician will inspect the completed installation. He will calibrate and adjust instrumentation, correct or supervise correction of defects or malfunctions, and instruct operating personnel in proper operation and maintenance procedures.

3.4 CLEANING

A. Prior to acceptance, inspect interior and exterior of pump station for dirt, splashed material or damaged paint. Clean or repair accordingly. Remove from the job site all tools, surplus materials, scrap and debris.

3.5 PROTECTION

A. The pump station should be placed into service immediately. If operation is delayed, drain water from pumps and piping. Open motor circuit breakers and protect station controls and interior equipment from cold and moisture. Station is to be stored and maintained per manufacturer's written instructions.

END OF SECTION

SECTION 15050

PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. This Section specifies systems of process piping and general requirements for piping systems. Detailed Specifications for the components listed on the Piping System Specification Sheets are found in the applicable Sections of Division 15, Mechanical. This Section shall be used in conjunction with those Sections.
   2. Provide all labor, materials, equipment, and incidentals as shown on the Drawings, specified, and required to furnish, install, and test all piping, fittings, and specials. The Work includes, but is not limited to, the following:
      a. All types and sizes of piping, except those specified under other Sections.
      b. Piping beneath, embedded, or within structures.
      c. Supports, restraints, and thrust blocks.
      d. Pipe encasements.
      e. Testing.
      f. Cleaning and disinfecting.
      g. Installation of all jointing and gasket materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, and all other Work required to complete the piping installation.
      h. Incorporation of valves, meters, and special items shown on the Drawings or specified into the piping systems as required and as specified in the appropriate Division 15, Mechanical, Sections.
      i. Unless otherwise specifically shown on the Drawings, specified, or included under other Sections, all buried piping work required begins at the outside face of structures or structure foundations and extending away from structure.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work that is related to this Section.

C. Definitions:
   1. Pressure terms used in this Section and elsewhere in Division 15, Mechanical, are defined as follows:
      a. Maximum: The greatest continuous pressure at which the piping system operates.

b. Working: The approximate normal continuous pressure at which the piping system operates.
c. Test: The hydrostatic pressure used to determine system acceptance.

D. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
1. Section 09900, Painting.
2. Section 15051, Buried Piping Installation.
3. Division 15, Mechanical, Applicable Sections on Piping, Valves, and Appurtenances.

1.2 QUALITY ASSURANCE

A. Conform to all applicable requirements of Parts 600 and 700 of the Uniform Standard specifications for Public Work Construction by the Maricopa Association of Governments (MAG). If there is a conflict between MAG Standard Specifications and these Specifications, the provisions of these Specifications shall govern.

B. Requirements of Regulatory Agencies:
1. Comply with requirements of UL, FM, and other jurisdictional authorities where applicable.
2. Refer to the General and Supplementary Conditions regarding permit requirements for this Work.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
1. AASHTO M36/M36M, Metallic (Zinc or Aluminum) Coated Corrugated Steel Culverts and Underdrains.
2. ANSI A13.1, Scheme for the Identification of Piping Systems.
3. ANSI B1.20.1, Pipe Threads, General Purpose (Inch).
4. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800.
5. ANSI B16.3, Malleable Iron Threaded Fittings Class 150 and 300.
6. ANSI B16.5, Pipe Flanges and Flanged Fittings.
7. ANSI B16.9, Factory-Made Wrought Steel Buttwelding Fittings.
8. ANSI B16.11, Forged Steel Fittings, Socket Welding and Threaded.
9. ANSI B16.12, Cast Iron Threaded Drainage Fittings.
10. ANSI B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
11. ANSI B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.
12. ANSI B31.1, Power Piping.
13. ANSI B31.3, Chemical Plant and Petroleum Refinery Piping.

14. ASME SECTION IX, Boiler and Pressure Vessel Code; Welding and Brazing Qualifications.
15. ASNI B 36.10, Welded and Seamless Wrought Steel Pipe.
16. ASTM A47, Specification for Ferritic Malleable Iron Castings.
17. ASTM A53, Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
18. ASTM A74, Specification for Cast Iron Soil Pipe and Fittings.
19. ASTM A105/A105M, Specification for Carbon Steel Forgings for Piping Components.
20. ASTM A106, Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
21. ASTM A120.
22. ASTM A126, Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
23. ASTM A193.
24. ASTM A197, Specification for Cupola Malleable Iron.
25. ASTM A234/A234M, Specification for Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
26. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
27. ASTM A312/A312M, Specification for Seamless and Welded Austenitic Stainless Steel Pipe.
28. ASTM A403/A403M, Specification for Wrought Austenitic Stainless Steel Piping Fittings.
29. ASTM A536, Specification for Ductile Iron Castings.
30. ASTM A570/A570M, Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
31. ASTM B88, Specification for Seamless Copper Water Tube.
32. ASTM C76, Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
33. ASTM C200, Steel Water Pipe 6-Inches and Larger.
34. ASTM C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied.
35. ASTM C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4-Inches and Larger - Shop Applied.
36. ASTM C206, Field Welding of Steel Water Pipe.
37. ASTM C207, Steel Pipe Flanges for Waterworks Service - Sizes 4-Inches Through 144-Inches.
38. ASTM C208, Dimensions for Fabricated Steel Water Pipe Fittings.
39. ASTM C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fittings for Steel Water Pipelines.
40. ASTM C296, Specification for Asbestos-Cement Pressure Pipe.
41. ASTM C443-REV A, Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
42. ASTM C564, Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.

43. ASTM D1248, Specification for Polyethylene Plastics Molding and Extrusion Materials.
44. ASTM D1784, Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds.
45. ASTM D2241, Specification for Poly Vinyl Chloride (PVC) Plastic Pipe (SDR-PR).
46. ASTM D2513, Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
47. ASTM D2665, Specification for Poly Vinyl Chloride (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
48. ASTM D2996, Specification for Filament-Wound Reinforced Thermosetting Resin Pipe.
49. ASTM D3034, Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
50. ASTM D3261, Specification for Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
51. ASTM D4174, Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems.
52. ASTM D4101, Specification for Propylene Plastic Injection and Extrusion Materials.
53. ASTM F441, Specification for Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe, Schedules 40 and 80.
54. AWWA C105, Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids.
55. AWWA C110, Ductile Iron and Gray Iron Fittings, 3-Inches Through 48-Inches, for Water and Other Liquids.
56. AWWA C111, Rubber Gasket Joints for Ductile Iron and Gray Iron Pressure Pipe and Fittings.
57. AWWA C115, Flanged Ductile Iron and Gray Iron Pipe with Threaded Flanges.
58. AWWA C151, Ductile Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
59. AWWA C200, Steel Water Pipe 6 Inches and Larger.
60. AWWA C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inches and Larger - Shop Applied.
61. AWWA C206, Field Welding of Steel Water Pipe.
62. AWWA C207, Steel Pipe Flanges for Waterworks Services - Sizes 4 Inches Through 144 Inches.
63. AWWA C208, Dimensions for Fabricated Steel Water Pipe Fittings.
64. AWWA C209, Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines.
65. AWWA C210, Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe.
66. AWWA C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.

67. AWWA C301, Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.
68. AWWA C303, Reinforced Concrete Pressure Pipe-Steel Cylinder Type, Pretensioned, for Water and Other Liquids.
69. AWWA C600, Installation of Ductile Iron Water Mains and Their Appurtenances.
70. AWWA C651, Disinfecting Water Mains.
71. AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe, 4-Inches Through 12-Inches, for Water.
72. AWWA M11, Steel Pipe-A Guide for Design and Installation.
73. CISPI 301, specification Data for Hubless Cast Iron Sanitary System with No-Hub Pipe and Fittings.
74. FEDSPEC L-C-530B(1), Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy.
75. MIL-H-13528B, Hydrochloric Acid, Inhibited, Rust Removing.
76. MIL-STD-810C, Environmental Test Methods.
77. SAE J1227, Assessing Cleanliness of Hydraulic Fluid Power Components and Systems.
78. UPC, Uniform Plumbing Code as amended by the City of Phoenix, Building Construction Code.

D. Fitting and Coupling Compatibility:
   1. To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturers.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Detailed drawings and data on pipe, fittings, gaskets, and appurtenances. Submit these with Shop Drawings required under Section 15050, Piping Systems, and Section 15051, Buried Piping Installation.

B. Certificates: Submit Certificates of Compliance with referenced standards.

C. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of

the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. General:
   1. Deliver materials to the site to ensure uninterrupted progress of the Work.
   2. Handle all pipe, fittings, specials, and accessories carefully with approved handling devices. Do not drop or roll material off trucks. Do not otherwise drop, roll, or skid piping.
   3. Store pipes and fittings on heavy wood blocking or platforms so they are not in contact with the ground.
   4. Unload pipe, fittings, and specials opposite to or as close to the place where they are to be installed as is practical to avoid unnecessary handling. Keep pipe interiors completely free from dirt and foreign matter.
   5. Inspect delivered pipe for cracked, gouged, chipped, dented, or other damaged material and immediately remove defective pipe from site.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings, and coatings shall be selected from those listed on the Piping System Specification Sheets. Piping materials shall conform to detailed Specifications for each type of pipe and piping appurtenances specified in the applicable Sections of Division 15, Mechanical.

B. All piping materials or products, including but not limited to pipe, gaskets, fittings, linings, coatings, etc., which can contact drinking water or a water treatment chemical furnished and installed under this Section, shall require NSF/ANSI 61, Drinking Water System Components Health Effects approval or comply with Arizona Administrative Code R18-4-119, Standards for Additives, Materials, and Equipment.

2.2 PIPING IDENTIFICATION

A. Marking Piping:
   1. Clearly mark each piece of pipe or fitting with a designation conforming to that shown on the approved Shop Drawings.
   2. Cast or paint material, type and pressure designation on each piece of pipe or fitting 4-inches in diameter and larger.
   3. Pipe and fittings smaller than 4-inches in diameter shall be clearly marked by manufacturer as to material, type, and rating.

4. Markers bearing the legends on the background colors specified in Section 09900, Painting, and shall be provided in the following letter heights:

Outside Pipe Diameter[a] (inches)	Letter Height (inches)
Less than 1-1/2	1/2
1-1/2 through 3	1-1/8
Greater than 3	2-1/4

[a] Outside pipe diameter shall include insulation and jacketing.

In addition, pipe markers shall include uni- and bi-directional arrows in the same sizes as the legend. Legends and arrows shall be white on blue or red backgrounds and black on other specified backgrounds.

B. Plastic Tracer Tape: Tracer tape shall be 6-inches wide, colored the same as the background colors as specified in Section 09900, Painting, and made of inert plastic material suitable for direct burial. Tape shall be capable of stretching to twice its original length and shall be as manufactured by Allen Systems, W. H. Brady Co., Seton Name Plate Corporation, Marking Services Inc., or equal. One message shall be printed on the tape. The message shall read "CAUTION CAUTION CAUTION _____ PIPE BURIED BELOW" with bold letters approximately 2-inches high. The blank shall be filled with the particular system fluid such as chlorine, oxygen, or sulfur dioxide.

C. Magnetic Tracer Tape: Polyethylene magnetic tracer tape shall be as manufactured by Allen Systems, W.H. Brady Co., Seton Name Plate Corporation, Marking Services, Inc., or equal. Tape shall be acid and alkali-resistant, 3-inches wide, 0.005-inch thick, and have 1,500 psi strength and 140% elongation value. The tape shall be colored the same as the background colors as specified in Section 09900, Painting, and shall be inscribed with the word "CAUTION - PIPE BURIED BELOW" and the name of the piping system.

2.3 VALVES

A. Valves of the same size and service shall be provided by a single valve manufacturer. Packing shall be non-asbestos material. Actual length of valves shall be within ±1/16-inch of the manufacturer's specified length. Flanges shall meet the requirement of ANSI B16.5. Push-on and mechanical joints shall meet the requirements of AWWA C111 and conform to the requirements of Section 15051, Buried Piping Installation.

2.4 FLANGE BOLTS AND GASKETS

A. Unless otherwise specified, all flanged connections shall be installed using ASTM A307 Grade A bolts, ASTM A563 nuts, and 1/8-inch red rubber gaskets. All flanged connections on stainless steel piping shall be made with 304 stainless steel bolts and nuts and 1/8-inch red rubber gaskets.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Location:
   1. Piping shall be provided as specified, except for adjustments to avoid architectural and structural features, and shall be coordinated with electrical construction.

B. Piping Sizes:
   1. Where the size of piping is not shown on the Drawings or specified, CONTRACTOR shall provide piping of the sizes required by UPC. Unless specified otherwise, small piping (less than 1-inch in diameter) required for services not described by UPC shall be 1/2-inch.

C. Pipe Support, Anchorage, and Seismic Bracing:
   1. Piping shall be supported by anchor brackets, guides, saddles, or hangers. Acceptable types of supports, guides, saddles, hangers, and structure attachments for general pipe support, expansion/contraction and for seismic bracing, as well as anchorage details, are shown on the Drawings. Minimum spacing shall be as specified for supports and for seismic bracing. Where a specific type of support or anchorage is shown on the Drawings, then only that type shall be used there. Piping shall be vertically supported by anchor brackets, guides, saddles or hangers and shall be seismically braced where indicated to resist lateral load. Supports shall be provided on each run at each change of direction. Pipe supports, components and hardware shall be Type 304L stainless steel. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.

D. Mechanical Seals (Pipe Wall and Floor Penetrations):
   1. Ductile Iron Pipe (DIP) and steel pipe may be installed through a new cast-in-place wall or floor with cast-in wall pipes of the same material and thickness as the pipe, complete with thrust collars/waterstop plates. PVC, DIP, Stainless steel, Stainless steel tubing, Copper, and Galvanized steel installed in new walls or floors shall be installed through a "link-seal" type wall sleeve with a mechanical seal. Where new pipes must penetrate existing walls or floors, and no opening exists, a new opening must be core drilled, inspected, finished as required, and a mechanical seal installed. Where

existing penetrations exist and they are too small to accommodate the new pipe and a mechanical seal, or the existing surface is unacceptable to achieve a watertight seal, a new opening must be core drilled, inspected, finished as required, and a mechanical seal installed. If the surface and size of existing penetrations meet the mechanical seal manufacturer's requirements for a watertight seal, the pipe and mechanical seal may be installed.

2. Each core drilled penetration in existing walls shall be inspected for concrete integrity. CONTRACTOR shall be responsible for evaluating the core surface condition remediating surfaces as required by the mechanical seal manufacturer to produce a watertight seal. If the core surface condition shows any small cracks and/or crevices, the entire surface shall be coated with an epoxy grout. The resultant surface shall meet the mechanical seal manufacturer's requirements for proper surface conditions to assure a watertight seal. Once this remediation has been completed to the manufacturer's requirements, CONTRACTOR shall install the seal.
3. The CONTRACTOR shall be responsible for achieving watertight seals at all penetrations. If any penetration leaks, the CONTRACTOR shall correct the installation at no additional cost to the OWNER so that the penetrations are watertight.

E. Thrust Restraint:
   1. General: All plugs, caps, tees, and bends in buried pressure piping systems shall be anchored by means of reaction bracking or restrained joints as specified.
   2. Restrained Pipe Joints: All pipe shall be restrained. Pipe joints shall be restrained by means suitable to the type of pipe being installed.
      a. Ductile iron push-on joints and mechanical joints shall be restrained utilizing a proprietary restrained joint system such as American Loc-Ring or Flex-Ring, Clow Super-Lock Joint, EBBA Iron Sales, Inc., Megalug, U.S. Pipe TR Flex Joint, or other system approved by ENGINEER.
      b. Steel pipe shall have welded joints, flanged joints, or flexible or mechanical coupling connectors. Tie rods connected to ears welded to the steel pipe shall be provided for restraint at all flexible coupling connectors.
      c. Thermoplastic and copper piping shall generally be installed with soldered, solvent weld, threaded, flanged, or similar type joints. Where push-on type or other non-restrained joints are provided, CONTRACTOR shall provide tie rods or other suitable joint restraint system for these joints, subject to the approval of ENGINEER.
      d. Harnessed lengths for pipe shall be determined by the pipe manufacturer in accordance with the formula in Section 15051, Buried Piping Installation, for determination of harnessed lengths.
      e. Restrain ductile iron pipe connected to flexible couplings or flanged coupling adapters by harnessing across the coupling or adapter using tie rods or extended bolts connecting between flanges.

3. Concrete Thrust Blocks and Anchor Blocks:
    a. Thrust blocks and anchors shall be constructed of Class "B" concrete.
    b. Blocks shall be placed against undisturbed soil and sized as shown on the Drawings or as directed by the ENGINEER. Concrete shall be placed so that pipe joints and fitting joints will be accessible for repair.

F. Manufacturer's Installation Specialist:
    1. Provide the services of a competent installation specialist of the pipe manufacturer when pipe laying begins, if CONTRACTOR is not experienced in laying and jointing a particular type of pipe.
    2. Retain installation specialist at the site for a minimum of two days or until competency of the pipe laying crew has been satisfactorily demonstrated.

G. Bedding and Backfill:
    1. Bedding and backfill for buried piping shall conform to the requirements of Section 15051, Buried Piping Installation.

3.2 PIPING IDENTIFICATION

A. Pipe Coding:
    1. After application of the specified coating and insulation systems, exposed piping, interior and exterior, and piping in ceiling spaces, pipe trenches, pipe chases and valve boxes shall be identified with painted bonding and lettering as specified in Paragraph 2.2, above. Legend markers and directional arrows shall be located at each side of walls, floors, and ceilings, at one side of each piece of equipment, at piping intersections, and at approximately 25 foot centers.

B. Plastic Tracer Tape:
    1. A single line of tape as specified in Paragraph 2.2.B., above, shall be provided 2.5 feet above the centerline of buried pipe. For pipelines buried 8 feet or greater below finished grade, CONTRACTOR shall provide a second line of tape 12-inches below finished grade, above and parallel to each buried pipe. Tape shall be spread flat with message side up before backfilling.

C. Magnetic Tracer Tape:
    1. Polyethylene magnetic tracer tape shall be buried 12-inches to 18-inches below finished grade and shall be above and parallel to buried nonferrous, plastic and reinforced thermosetting resin pipe lines. For pipelines buried 8 feet or greater below finished grade, CONTRACTOR shall provide a second line of tape 2.5 feet above and parallel to each buried pipe.

3.3 VALVE IDENTIFICATION

A. Stainless steel tags bearing the specified valve number stamped in 1/4-inch high letters shall be installed on valve flanges in a position visible from floor level.

Flangeless valves 8-inches in diameter and larger shall have tags attached to the valve body by self-tapping corrosion resistant metal screws. Flangeless valves 6-inches in diameter and smaller shall have tags attached to the valve stem by stainless steel wire. Wire shall be 0.063-inch minimum.

3.4 WORK AFFECTING EXISTING PIPING

A. Location of Existing Piping:
   1. Locations of existing piping shown on the Drawings should be considered approximate.
   2. Determine the true locations of existing piping to which connections are to be made and locations of other facilities which could be disturbed during earthwork operations, or which may be affected by CONTRACTOR'S Work already installed.
   3. Conform to applicable requirements of Division 1, General Requirements, pertaining to cutting and patching and connections to existing facilities.

B. Taking Existing Pipelines Out of Service:
   1. Do not take pipelines out of service, unless specifically listed below or approved by ENGINEER.
   2. Notify ENGINEER at least 48 hours prior to taking pipeline out of service.

C. Work on Existing Pipelines:
   1. Cut or tap pipes, as shown on the Drawings or required, with machines specifically designed for this Work.
   2. Install temporary plugs to prevent entry of mud, dirt, water, and debris.
   3. Provide all necessary adapters, fittings, pipe, and appurtenances required to complete the Work.
   4. Existing pipelines which are cut and abandoned shall be adequately capped or filled with grout.

3.5 TESTING

A. General:
   1. The CONTRACTOR shall be responsible for testing all pipe segments per Table D Pipe Schedule. The steel liner segments shall not be pressure tested. Testing requirements shall be as specified in this Section.
   2. Upon completion of piping, but prior to application of insulation on exposed piping, CONTRACTOR shall test the piping systems. Pressures, media, and test durations shall be as specified below. Equipment which may be damaged by the specified test conditions shall be isolated. Testing shall be performed using calibrated test gages and calibrated volumetric measuring equipment to determine leakage rates. Each test gage shall be selected so that the specified test pressure falls within the upper half of the gauge's range. Unless otherwise specified, CONTRACTOR shall notify the ENGINEER 24 hours prior to each test.

3. Unless otherwise specified, testing, as specified herein, shall include existing piping systems which connect with new piping systems. Existing pipe shall be tested to the nearest existing valve. Any piping which fails the test shall be repaired. Repair of existing piping will be considered and paid for as extra work.

B. Testing:
   1. The CONTRACTOR shall be responsible for testing pipe lines as described above. All testing shall be performed in the presence of the ENGINEER and conform to the following Paragraphs.
   2. Hydrostatic testing shall be performed on all pressure lines in accordance with ADEQ Administrative Code AWWA C-600 and MAG Section 610.14. All pressure pipe shall be tested at 150 or 200 psi, depending on size, per MAG Section 610.15-A.
   3. Pressure Testing for Gravity Pipe:
      a. Sewer lines shall be air or hydrostatically tested per MAG Section 615. Test duration shall be 60 minutes.
      b. Storm drains shall be hydrostatically tested per the requirements of MAG Section 618. Test duration shall be 60 minutes.
      c. Concrete cylinder gravity pipes shall be hydrostatically tested per the requirements of MAG Section 615, with a minimum test head of 25 feet above the top of the pipe at the upper end. Test duration shall be 60 minutes.
      d. All ductile iron gravity and steel pipe shall be hydrostatically tested to a pressure of 50 psi at the upper end. No measurable water loss shall occur during the 120 minute duration of the test.

C. Liquid Systems:
   1. Leakage shall be zero at the specified test pressure throughout the specified duration for the following systems: Exposed piping, buried piping, and buried or exposed piping carrying liquid chemicals.

D. Drains:
   1. Drain systems, other than pumped drain systems, shall be tested in accordance with UPC.

3.6 CLEANING AND FLUSHING

A. General:
   1. Piping systems shall be cleaned following completion of testing and prior to connection to operating, control, regulating, or instrumentation equipment. CONTRACTOR may, at his option, clean and test sections of the buried or exposed piping systems. Use of this procedure, however, will not waive the requirement for a full pressure test of the completed system. Unless specified otherwise, piping 24-inches in diameter and smaller shall first be cleaned by pulling a tightly fitted cleaning ball or swab through the system. Piping

larger than 24-inches in diameter may be cleaned manually or with a cleaning ball or swab.

B. Liquid Systems:
   1. After completion of cleaning, liquid systems, unless otherwise specified, shall be flushed with clean water. With temporary screens in place, the liquid shall be circulated through the piping system using connected equipment for a minimum period of 15 minutes and until no debris is collected on the screens.

C. Potable Water Systems:
   1. Potable water piping systems shall be flushed and disinfected in accordance with AWWA C651.

3.7 PIPING SPECIFICATION SHEET

A. General:
   1. Piping schedule is shown in Table D. Table D indicates the working pressure, fluid category, pipe material, interior lining, exterior coating, joint type, and additional information. The following abbreviations in Table A, B, and C are used in the Table D.

Table A - Material Abbreviations

Polyvinyl Chloride	PVC	Copper	COP
Ductile Iron	DIP	Steel	STL
Vitrified Clay	VCP	Reinforced Concrete	RCP
Acrylonitrile Butadiene Styrene	ABS	Galvanized Steel	GST
Chlorinated Polyvinyl Chloride	CPVC	Fiberglass Reinforced Plastic Resin	FRP
Stainless Steel	SST	Prestressed Concrete Cylinder	PCCP
High-Density Polyethylene	HDPE	Rubber Gasketed Reinforced Concrete	RGRCP
Galvanized Steel	GST	Corrugated Metal Pipe	GST

Table B - Lining/Coating Abbreviations

Cement Mortar	CM	Polyethylene Wrap	PE
Bituminous Coating	BC	Glass Lined	GL
Galvanized	GALV	Paint per Section 09900	P
Petroleum Tape	PT	Polyurethane	PY

Table C - Joint Abbreviations

Bell and Spigot	BS	Welded	W
Flanged	FLG	Mechanical Joint	MJ
Push On	PO	Grooved End Fitting	GEF
Solvent Welded	SW	Butt Wrapped	BW
Threaded	THD	Butt Fusion	BP
Soldered	SL		BF

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Table D - Pipe Schedule

EXPOSED PIPE

SERVICE DESCRIPTION	PIPING SYMBOL-SERVICE	WORKING PRESSURE	SPECIFICATION	FLUID CATEGORY	PIPE MATERIAL	CLASS/ TYPE	INTERIOR LINING	EXTERIOR COATING	JOINT TYPE	TEST PRESSURE	SHEET NUMBER
-		-	-	-	-	-	-	-	-	-	-

BURIED PIPE

SERVICE DESCRIPTION	PIPING SYMBOL-SERVICE	WORKING PRESSURE	SPECIFICATION	FLUID CATEGORY	PIPE MATERIAL	CLASS/ TYPE	INTERIOR LINING	EXTERIOR COATING	JOINT TYPE	TEST PRESSURE	SHEET NUMBER
4” DUCTILE IRON PIPE	FM	100 PSI	15061	FORCEMAIN	DIP	350	CM/CIPP	BC/PE	MJ	200 PSI	--
4” High-Density Ploye thylene	HDPE	100 PSI	15070	FORCEMAIN	HDPE	DR 21	--	--	BF	200 PSI	--
8” SANITARY SEWER GRAVITY LINE	PVC	--	15065	SANITARY SEWER	PVC SDR 35	--	--	--	SW	--	--

+ + END OF SECTION + +

SECTION 15051

BURIED PIPING INSTALLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to install and test all buried piping, fittings, and specials. The Work includes, but is not limited to, the following:
      a. All types and sizes of buried piping, except those specified under other Sections.
      b. Piping beneath structures.
      c. Supports restraints.
      d. Pipe encasements.
      e. Work on or affecting existing piping.
      f. Testing.
      g. Cleaning and disinfecting.
      h. Installation of all jointing and gasketing materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, and all other Work required to complete the buried piping installation.
      i. Incorporation of valves, meters, and special items shown or specified into the piping systems as required and as specified in the appropriate Division 15, Mechanical, Sections.
      j. Unless otherwise specifically shown, specified, or included under other Sections, all buried piping work required begins at the outside face of structures or structure foundations and extending away from structure.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work that is related to this Section.
   2. Section 15051, Buried Pipe Installation, specifies the installation of all buried piping materials specified in Sections of Division 15, Mechanical. Coordinate with these Sections.

C. Related Work Specified Elsewhere:
   1. Section 02200, Earthwork.
   2. Section 15061, Ductile Iron Pipe.
   3. Section 15065, Thermoplastic Pipe and Accessories.

1.2 QUALITY ASSURANCE

A. CONTRACTOR shall conform to all applicable requirements of Parts 600 and 700 of the Uniform Standard Specifications for Public Work Construction by the Maricopa Association of Governments (MAG). If there is a conflict between MAG Standard Specifications and these Specifications, the provisions of these Specifications shall govern.

B. Requirements of Regulatory Agencies:
   1. Comply with requirements of NFPA Standard No. 24 for "Outside Protection" where applicable to water pipe systems used for fire protection.
   2. Comply with requirements of UL, FM, and other jurisdictional authorities, where applicable.
   3. Refer to the General and Supplementary Conditions regarding permit requirements for this Work.
   4. Applicable building codes.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ASTM D 2321, Practice for Underground Installation of Flexible Thermoplastic Pipe.
   2. ASTM D 2774, Practice for Underground Installation of Thermoplastic Pressure Piping.
   3. AWWA C105, Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids.
   4. AWWA C111, Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
   5. AWWA C104, Cement Mortar Protective Lining and Coating for Ductile Iron Pipe.
   6. AWWA C600, Installation of Ductile Iron Water Mains and Their Appurtenances.
   7. AWWA C606, Grooved and Shouldered Joints.
   8. AWWA C651, Disinfecting Water Mains.
   9. AWWA M23, PVC - Design and Installation.
   10. ASCE MOP No. 37, Design and Construction of Sanitary and Storm Sewers.

1.3 SUBMITTALS

A. Shall be in accordance with Section 01300, Submittals.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work.

B. Handle all pipe, fittings, specials, and accessories carefully with approved handling devices. Do not drop or roll material off trucks. Do not otherwise drop, roll, or skid piping.

C. Store pipes and fittings on heavy wood blocking or platforms so they are not in contact with the ground.

D. Unload pipe, fittings, and specials opposite to or as close to the place where they are to be installed as is practical to avoid unnecessary handling. Keep pipe interiors completely free from dirt and foreign matter.

E. Inspect delivered pipe for cracked, gouged, chipped, dented, or other damaged material and immediately remove defective pipe from site.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Required pipe materials are as shown on the detail drawings. Refer to applicable Sections for material specifications.

B. General:
   1. Marking Piping:
      a. Clearly mark each piece of pipe or fitting with a designation conforming to those as shown on the detail drawings.
      b. Cast or paint material, type, and pressure designation on each piece of pipe or fitting 4-inches in diameter and larger.
      c. Pipe and fittings smaller than 4-inches in diameter shall be clearly marked by manufacturer as to material, type, and rating.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Installation of all pipe, fittings, valves, specials, and appurtenances shall be subject to the review and/or approval of the ENGINEER.
   2. Install piping as shown, specified, and as recommended by the manufacturer and in conformance with referenced standards, and approved Shop Drawings.
   3. Request instructions from ENGINEER before proceeding if there is a conflict between the manufacturer's recommendations and the Contract Documents.
   4. All piping shall be inspected by the ENGINEER prior to installation. ENGINEER'S inspection will not relieve CONTRACTOR or manufacturer from responsibility for damaged products.

5. All piping shall be carefully examined for cracks, damage, or other defects before installation. Any piping that is defective, including but not limited to, cracked, damaged, in poor condition, or with damaged linings or improper markings shall be rejected unless the product can be repaired in a manner acceptable to the manufacturer and ENGINEER. Any piping found to be broken or defective after it has been installed shall be removed, replaced or repaired at the CONTRACTOR'S expense.
6. Minimum earth cover over the piping shall be as shown on the Drawings, specified or directed by the ENGINEER, but in no case shall the earth cover be less than 4 feet for all piping, except drains.
7. Required earthwork shall be as specified in applicable Sections of Division 2, Site Work.
8. Present all conflicts between piping systems and equipment, structures or facilities to ENGINEER for determination of corrective measures before proceeding.
9. Take field measurements, where required, prior to installation to ensure proper fitting of Work. The CONTRACTOR shall uncover the existing pipelines sufficiently in advance of the proposed Work in order that the type and location of the existing pipes and joints and other information required to fabricate the proposed piping can be determined. It shall be the responsibility of the CONTRACTOR to obtain whatever information is required to complete the connections of the proposed pipelines to the existing pipelines. Refer to Paragraph 3.3 of this Section, as applicable.
10. Interior of all piping and mating surfaces shall be inspected and all dirt, gravel, sand, debris, or other foreign material shall be completely removed from the interior and mating surfaces before installation. Measures shall be taken to maintain the interior of all piping clean until acceptance of the completed Work. Care shall be taken to prevent foreign matter from entering joint space. Bell and spigot mating surfaces shall be wiped clean immediately before piping is laid. For ductile iron pipe, the bell and spigot mating surfaces shall be thoroughly cleaned with a wire brush.
11. Install piping accurately to line and grade shown, specified, or directed, unless otherwise approved by the ENGINEER. Accurate means of determining and checking the alignment and grade shall be used, which shall be subject to the approval of the ENGINEER. Any modifications to the Contract Documents to suit the pipe manufacturer's standard shall be approved by the ENGINEER. Remove and relay piping that is incorrectly installed at CONTRACTOR'S expense.
12. Do not lay piping in water, unless otherwise specified in these Specifications or approved by the ENGINEER. Ensure that the water level in the trench is at least 6-inches below the bottom of piping. Maintain a dry trench until jointing and backfilling are complete, unless otherwise specified in these Specifications or approved by the ENGINEER.
13. Where unforeseen conditions will not permit the installation of piping as shown or specified, no piping shall be installed without approval of the

ENGINEER. Do not modify structures or facilities without approval of the ENGINEER.

14. Start laying piping at lowest point and proceed toward the higher elevations, unless otherwise approved by the ENGINEER. Slope piping uniformly between elevations shown on the Drawings or as otherwise directed by the ENGINEER.
15. Place bell and spigot piping so that the bells face the direction of laying, unless otherwise approved by the ENGINEER.
16. Piping shall be installed so that the barrel of the piping, and not the joints, receives the bearing pressure from the trench bottom or other bedding condition.
17. No piping shall be brought into position until the preceding length, valve, fitting, or special has been bedded and secured in place.
18. Whenever pipe laying is not actively in progress, the open ends of the piping shall be closed by a temporary plug or cap to prevent soil, water, and other foreign matter from entering the piping.
19. Field cutting of metallic piping, where required for inserting valves, fitting, specials, and closures, shall be made with a machine specially designed for cutting piping and in accordance with the manufacturer's instructions. Cuts shall be carefully done, without damage to piping, so as to leave a smooth end at right angles to the axis of the piping. Cut end shall be tapered and sharp edges filed off smooth. Flame cutting shall not be permitted. Piping damaged by the CONTRACTOR by improper or careless methods of cutting shall be replaced or repaired at his expense.
20. Blocking under piping shall not be permitted, unless specifically approved by ENGINEER for special conditions.
21. Protective linings and coatings shall be touched up prior to installation, where required.
22. Except where bends, wyes, or similar fittings are used, changes in alignment and grade of the piping shall be made by deflecting joints or with beveled pipe. Permissible joint deflection shall not exceed 75% of the amount allowed by the manufacturer.
23. All joints shall be made in the presence of the ENGINEER, or his duly authorized representative, except as otherwise approved.
24. Special care shall be taken to ensure that each section of piping abuts against the next in such a manner that there will be not shoulder or unevenness of any kind along the piping invert.
25. Piping shall be rotated as required to place outlets in proper position.
26. Blind flanges and cleanouts shall be provided at locations shown on the Drawings, specified, or required. Cleanouts on buried piping shall include all pipe, fittings, and appurtenances required to bring cleanout to finished grade and terminate in a flange and blind flange or suitably capped piping as shown. Cleanout piping shall be same as that specified for the main run.
27. All gravity lines shall pitch uniformly at the grade shown or as specified or approved.

28. Short pipe stubs, maximum 4 feet in length, shall be used at all manholes and other wall faces, except as otherwise specified.
29. Field painting shall be accomplished after joints are made.
30. All piping shall be plugged watertight with a suitable cap or plug securely fastened to the end of the piping at all contact interfaces.
31. CONTRACTOR shall notify ENGINEER in advance of backfilling operations.
32. On steep slopes, take measures acceptable to ENGINEER to prevent movement of the pipe during installation.
33. Thrust Restraint: During the installation of the pipe, thrust blocks, tied joints, or proprietary restrained joint systems shall be provided wherever required for thrust restraint. Thrust restraint shall conform to the applicable requirements of Paragraph 3.2. of this Section.
34. Exercise care to avoid flotation when installing pipe in cast-in-place concrete.

B. Separation of Sewers and Potable Water Pipe Lines:
   1. Conform to the requirements of all applicable requirements of the Uniform Standard Specifications for Public Work Construction by the Maricopa Association of Governments (MAG).

C. Plugs:
   1. Temporarily plug installed pipe at the end of each day's Work or other interruption to the installation of any pipe line. Plugging shall prevent the entry of animals, liquids, or persons into the pipe or the entrance or insertion of deleterious materials.
   2. Install standard plugs into all bells at dead ends, tees, or crosses. Cap all spigot ends.
   3. Fully secure and block all plugs and caps installed for pressure testing to withstand the specified test pressure.
   4. Where plugging is required for phasing of the Work or for subsequent connection of piping, install watertight, permanent type plugs.

D. Bedding Pipe: Bed pipe as specified below and in accordance with the details shown.
   1. Trench excavation and backfill and bedding materials shall conform to the requirements of Section 02200, Earthwork, as applicable.
   2. Excavate trenches below the pipe bottom by an amount specified. Remove all loose and unsuitable material from the trench bottom.
   3. Carefully and thoroughly compact all pipe bedding with hand held pneumatic compactors.
   4. Do not lay pipe until the ENGINEER approves the bedding condition. If a conflict exists, obtain clarification from ENGINEER before proceeding.
   5. No pipe shall be brought into position until the preceding length has been bedded and secured in its final position.

E. Laying Pipe:
   1. Conform to manufacturer's instructions and requirements of the standards listed below, where applicable:
      a. Ductile Iron Pipe: AWWA C600, AWWA C105.
      b. Thermoplastic Pipe: ASTM D 2774.
      c. ASCE Manual of Practice No. 37.

F. Polyethylene Encasement:
   1. Provide polyethylene encasement for ductile iron piping to prevent contact between the pipe and surrounding bedding material and backfill.
   2. Polyethylene may be supplied in tubes or in sheet material.
   3. Polyethylene encasement materials and installation shall be in accordance with the requirements of MAG Section 610.5.

G. Jointing Pipe:
   1. Ductile Iron Mechanical Joint Pipe:
      a. Wipe clean the socket, plain end and adjacent areas immediately before making joint. Make certain that cut ends are tapered and sharp edges are filed off smooth.
      b. Lubricate the plain ends and gasket with soapy water or an approved pipe lubricant, in accordance with AWWA C111, just prior to slipping the gasket onto the plain end of the joint assembly.
      c. Place the gland on the plain end with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end.
      d. Insert the pipe into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during assembly.
      e. Push gland toward socket and center it around pipe with the gland lip against the gasket.
      f. Insert bolts and hand tighten nuts.
      g. Make deflection after joint assembly, if required, but prior to tightening bolts. Alternately tighten bolts 180 degrees apart to seat the gasket evenly. The bolt torque shall be as follows:

Pipe Size (inches)	Bolt Size (inches)	Range of Torque (ft-lbs)
3	5/8	45-60
4-24	3/4	75-90
30-36	1	100-120
42-48	1-1/4	120-150

      h. All bolts and nuts shall be heavily coated with two 10 mil minimum coats of coal-tar epoxy coating as manufactured by Koppers, Tnemec, or approved equal.
      i. Restrained mechanical joints shall be in accordance with Section 15061, Ductile Iron Pipe.

2. Ductile Iron Push-On Joint Pipe:
    a. Prior to assembling the joints, the last 8-inches of the exterior surface of the spigot and the interior surface of the bell shall be thoroughly cleaned with a wire brush, except where joints are lined or coated with a special protective lining or coating.
    b. Rubber gaskets shall be wiped clean and flexed until resilient. Refer to manufacturer's instructions for procedures to ensure gasket resiliency when assembling joints in cold weather.
    c. Insert gasket into joint recess and smooth out the entire circumference of the gasket to remove bulges and to prevent interference with the proper entry of the spigot of the entering pipe.
    d. Immediately prior to joint assembly, apply a thin film of approved lubricant to the surface of the gasket that will come in contact with the entering spigot end of pipe. CONTRACTOR may, at his option, apply a thin film of lubricant to the outside of the spigot of the entering pipe.
    e. For assembly, center spigot in the pipe bell and push pipe forward until it just makes contact with the rubber gasket. After gasket is compressed and before pipe is pushed or pulled all the way home, carefully check the gasket for proper position around the full circumference of the joint. Final assembly shall be made by forcing the spigot end of the entering pipe past the rubber gasket until it makes contact with the base of the bell. When more than a reasonable amount of force is required to assemble the joint, the spigot end of the pipe shall be removed to verify the proper positioning of the rubber gasket. Gaskets that have been scoured or otherwise damaged shall not be used.
    f. Maintain an adequate supply of gaskets and joint lubricant at the site at all times when pipe jointing operations are in progress.
3. Proprietary Joints:
    a. Pipe which utilizes proprietary joints such as Fastite, by American Cast Iron Pipe Company; Tyton by U.S. Pipe Incorporated; restrained joints described under Paragraph 3.2. of this Section; or other such joints shall be installed in strict accordance with the manufacturer's instructions.
4. Thermoplastic Pipe Joints:
    a. Solvent Cement Joints:
        1) Bevel pipe ends and remove all burrs before making joints. Clean both pipe and fittings thoroughly. Do not attempt to make solvent cement joints if temperature is below 40° F or above 90° F when exposed to direct sunlight or in wet conditions.
        2) Use solvent cement supplied or recommended by the pipe manufacturer.
        3) Apply joint primer and solvent cement and assemble joints in strict accordance with the recommendations and instructions of the manufacturer of the joint materials and the pipe manufacturer.
        4) Observe safety precautions with the use of joint primers and solvent cements. Allow air to circulate freely through pipelines to permit

solvent vapors to escape. Slowly admit water when flushing or filling pipelines to prevent compression of gases within pipes.

b. Push-On Joints:
   1) Bevel all field-cut pipe, remove all burrs, and provide a reference mark the correct distance from the pipe end.
   2) Clean the pipe end and the bell thoroughly before making the joint. Insert the O-ring gasket, making certain it is properly oriented. Lubricate the spigot well with an approved lubricant; do not lubricate the bell or O-ring. Insert the spigot end of the pipe carefully into the bell until the reference mark on the spigot is flush with the bell.

5. Copper Tubing Joints:
   a. Assemble copper tubing with soldered joints. Solder shall be 95-5 tin-antimony solder conforming to ASTM B 32.
   b. Ream or file pipe to remove burrs.
   c. Clean and polish contact surfaces of joints.
   d. Apply flux to both male and female ends.
   e. Insert end of tube into full depth of fitting socket.
   f. Heat joint evenly.
   g. Form continuous solder bead around entire circumference of joint.
   h. Runs shall contain unions at connection to equipment and at reasonable distances along the lengths of runs to permit convenient disassembly of piping and removal of equipment.
6. Mechanical Coupling Joints:
   a. Prior to the installation and assembly of mechanical couplings, the joint ends shall be cleaned thoroughly with a wire brush to remove foreign matter. Following this cleaning, lubricant shall be applied to the rubber gasket or inside of the coupling housing and to the joint ends. After lubrication, the gasket shall be installed around the joint end of the previously installed piece and the joint end of the subsequent piece shall be mated to the installed piece. The gasket shall be positioned and the coupling housing placed around the gasket and over the grooved or shouldered joint ends. The bolts shall be inserted and the nuts screwed up tightly by hand. The bolts shall then be tightened uniformly in order to produce an equal pressure on all parts of the housing. When the housing clamps meet metal to metal, the joint is complete and further tightening is not required.

H. Backfilling:
   1. Conform to the applicable requirements of Section 02200, Earthwork.
   2. Place backfill as construction progresses. Backfill by hand and use power tampers until pipe is covered by at least 1 foot of fill.

I. Connections to Valves and Hydrants:
   1. Install valves and hydrants as shown.

2. Provide suitable adapters when valves or hydrants and piping have different joint types.
3. Provide thrust restraint at all hydrants and at valves at pipeline terminations.

3.2 THRUST RESTRAINT

A. Provide thrust restraint on all pressure piping systems and where otherwise shown and specified. Pipe joints shall be restrained as specified in Paragraph 3.2.C of this Section.

B. Thrust restraint shall be accomplished by means of restrained pipe joints. Thrust restraints shall be designed for the axial thrust exerted by the test pressure given in Section 15050, Piping Systems, Paragraph 3.5.

C. Restrained Pipe Joints:
   1. Pipe joints shall be restrained by means suitable to the type of pipe being installed.
      a. Ductile iron push-on joints and mechanical joints shall be restrained utilizing a proprietary restrained joint system such as American Lok-Ring, Lok-Fast, Lok-Set, U.S. Pipe Field Lok Gasket, U.S. Pipe TR Flex System, lugs and tie rods, or other system approved by ENGINEER.
      b. Thermoplastic and copper piping shall generally be installed with soldered, solvent weld, threaded, flanged, or similar type joints. Where push-on type or other non-restrained joints are provided, the CONTRACTOR shall provide tie rods or other suitable joint restraint system for these joints, subject to the approval of ENGINEER.
      c. Pipe thrust restraint shall be in accordance with the Schedule of Restrained Pipe Lengths and as noted on the Project Drawings.
   2. Schedule of Restrained Pipe Lengths: Restrained pipe lengths shall conform to the requirements of AWWA M41 for ductile iron pipe and to AWWA M11 for steel pipe. Restrained pipe lengths shall be as shown on the construction plans.

D. Concrete Thrust Blocks:
   1. Thrust blocks shall be constructed of Class “B” concrete, conforming to the requirements of MAG.
   2. Blocks shall be placed against undisturbed soil as shown on Drawings or as directed by the ENGINEER. Concrete shall be placed so that pipe joints and fitting joints will be accessible for repair.
   3. Size of concrete thrust blocks shall be as shown on the Drawings or as directed and approved by ENGINEER.
   4. Concrete thrust blocks shall not be used for pipe restraint, except where specifically shown on the Drawings or as approved by the ENGINEER.

3.3 WORK AFFECTING EXISTING PIPING

A. Location of Existing Piping:
   1. Locations of existing piping shown should be considered approximate.
   2. CONTRACTOR shall determine the true locations of existing piping to which Work is to be performed and locations of other facilities which could be disturbed during earthwork operations, or which may be affected by CONTRACTOR'S Work already installed.

B. Taking Existing Pipelines Out of Service:
   1. Do not take pipelines out of services, unless specifically provided for under this Project, or approved by ENGINEER.
   2. Notify ENGINEER at least 48 hours prior to taking pipeline out of service.

C. Work on Existing Pipelines:
   1. Cut or tap pipes as shown or required with machines specifically designed for this Work.
   2. Install temporary plugs to prevent entry of mud, dirt, water, and debris.
   3. Provide all necessary adapters, fittings, pipe, and appurtenances required to complete the Work.
   4. Existing pipelines that are cut and abandoned shall be adequately capped or filled with grout.

3.4 TESTING OF PIPING

A. General:
   1. Test all piping except as otherwise authorized by ENGINEER.
   2. Notify ENGINEER 48 hours in advance of testing.
   3. Provide all testing apparatus, including pumps, hoses, gages, and fittings.
   4. Unless otherwise noted, pipelines shall hold specified test pressure for two hours.
   5. Repair and retest pipelines that fail to hold specified test pressure or which exceed the allowable leakage rate.
   6. Unless otherwise specified, test pressures required are at the lowest elevation of the pipeline section being tested.
   7. Conduct all tests in the presence of ENGINEER.
   8. Advise local authorities having jurisdiction if their presence is required during testing.
   9. All testing shall conform to the MAG Standard Specifications and Town of Wickenburg Guidelines. In case of contradiction with these Specifications the CONTRACTOR shall notify the ENGINEER before proceeding with the testing.

B. Schedule of Pipeline Tests:
   1. Test piping at the test pressures listed in Section 15050, Piping Systems, Paragraph 3.5, and respective pipe material specification.
   2. All piping shall be water tested after installation, except as otherwise specified or directed by ENGINEER.

3. For piping not included in the Schedule, the ENGINEER will notify CONTRACTOR in writing of the test pressure to be used.

C. Pressure Test Procedure:
   1. Complete backfill and compaction at least to the pipe centerline before testing, unless otherwise required or approved by ENGINEER.
   2. Allow concrete for thrust blocks to reach design strength before testing.
   3. Fill section to be tested slowly with water and expel all air. Install corporation cocks if necessary to remove all air.
   4. Test only one section of pipe at a time.
   5. Apply specified test pressure for two hours and observe pressure gage. Check carefully for leaks while test pressure is being maintained.

D. Leakage Testing:
   1. Conduct leakage test for all liquid piping after satisfactory completion of pressure test.
   2. Maintain test pressure constantly for the minimum test period and accurately measure the amount of water which must be added to maintain the test pressure.
   3. Allowable Leakage Rates (in gallons per hour per 1,000 feet per inch diameter):
      a. DIP Push-On or Mechanical Joints: 0.075.
      b. Copper, Steel, and Thermoplastic: None.
   4. Leakage Test Procedure:
      a. Examine exposed pipe, joints, fittings, and valves. Repair visible leakage or replace the defective pipe, fitting, or valve.
      b. Refill the line under test to reach the required test pressure.
      c. Provide a test container filled with a known quantity of water at the start of the test. Attach the test pump suction to the test container.
      d. Pump water from the test container into the line with the test pump to hold the specified test pressure for the test period. Water remaining in the container shall be measured and the amount used during the test shall be recorded on the test report.
      e. Perform all repair, replacement, and retesting required because of failure to meet testing requirements.
      f. Leakage shall be less than rate specified above.

E. Required Tests for Sanitary Sewer Connections:
   1. CONTRACTOR shall use water test procedures only.
      a. Tests shall be performed after backfilling is completed, but shall be performed before final cleanup and acceptance of Work.
      b. Tests shall be performed prior to final acceptance.
         1) Test all piping and manholes for leakage by means of the tests described below.
         2) Test to be performed between adjacent manholes or as approved by the ENGINEER.

c. Prior to making tests, the CONTRACTOR shall submit details of his testing procedures, with a description of methods and equipment he proposes to use, to the ENGINEER for approval. The CONTRACTOR shall furnish all necessary labor, equipment, water, watertight bulkheads, rodding machine, generator, pumps, and all else necessary to carry out the required tests.

2. Water Test:
   a. When water test is performed PVC pipe, the test section shall be filled with water and allowed to stand for 24 hours. The water shall then be replenished and the test performed.
   b. Insert test plugs and securely brace.
   c. Fill the pipe and manhole with water to provide a positive differential head on the top of the pipe at the highest point of the pipeline under test of at least the test pressure specified in the Buried Piping Schedule.
   d. The amount of water added to maintain this head shall be the leakage.
   e. Test for a period of at least four hours.
   f. Total leakage of any section tested shall not exceed the following rates:
      1) Gravity Sewer: 0.5 gallons per hour per 100 feet of pipe per inch diameter of pipe.
   g. If the leakage in the section tested exceeds the specified amount, the CONTRACTOR shall make the necessary repairs or replacements required to reduce the leakage to within the specified limits and the test shall be repeated until the leakage requirements is met.
   h. On steep grades it may be necessary to place plugs in the pipe between manholes to avoid excessive pressures in the pipe.
3. Visual Inspection:
   a. Prior to final acceptance, a visual inspection by ENGINEER of all appurtenant structures, e.g., manholes, chambers, etc., shall be required. Any visual leaks, regardless of their magnitude, shall be repaired by the CONTRACTOR.
4. Watertight Sewers:
   a. It is imperative that all sewers and appurtenant structures be constructed as watertight as practicable. The CONTRACTOR shall adhere rigidly to all requirements of the Contract Documents and follow all directions of the ENGINEER to secure a watertight sewer. If, during the Work or after its completion, any leaks are discovered, they shall be repaired in a satisfactory manner at the expense of the CONTRACTOR even though the pipe and appurtenant structures may have already successfully passed the leakage tests.

3.5 DISPOSAL OF WATER

A. CONTRACTOR shall provide suitable means for disposal of test and flushing water so that no damage results to facilities or waterways.

B. Means of disposal of test and flushing water shall be subject to the approval of ENGINEER, local governing authorities, and regulatory agencies.

C. CONTRACTOR shall be responsible for any damage caused by his water disposal operations.

3.6 CLEANING

A. Cleaning:
   1. Thoroughly clean all piping and flush prior to placing in service in a manner approved by ENGINEER.
   2. Piping 24-inches in diameter and larger shall be inspected from inside and all debris, dirt, and foreign matter removed.
   3. If piping that requires disinfection has not been kept clean during storage or installation, CONTRACTOR shall swab each section individually before installation with a 5% hypochlorite solution to ensure clean piping.

END OF SECTION

SECTION 15061

DUCTILE IRON PIPE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install ductile iron pipe and fittings.
   2. The extent of ductile iron pipe is shown on the Drawings.

B. Related Sections:
   1. Section 02200, Earthwork, Excavation, and Backfill.
   2. Section 15051, Buried Piping Installation.

1.2 QUALITY ASSURANCE

A. Manufacturers' Qualifications:
   1. Manufacturer shall have a minimum of five years of experience producing ductile iron pipe and fittings, and shall show evidence of at least five installations in satisfactory operation.
   2. Ductile iron pipe and fittings shall be the product of one manufacturer.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. AWWA C104, Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water.
   2. AWWA C105, Polyethylene Encasement for Ductile Iron Pipe Systems.
   3. AWWA C110, Ductile-Iron and Gray-Iron Fittings, 3-inches through 48-inches, for Water and Other Liquids.
   4. AWWA C111, Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
   5. AWWA C115, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges, 3-inches through 64-inches, for Water Supply Service.
   6. AWWA C116, Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings, for Water or Other Liquids.
   7. AWWA C150, Thickness Design of Ductile-Iron Pipe.
   8. AWWA C151, Ductile Iron Pipe, Centrifugally Cast, 3-inches through 64-inches, for Water or Other Liquids.
   9. AWWA C153, Ductile-Iron Compact Fittings, 3-inches through 64-inches, for Water Service.

10. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
11. ANSI B18.2.1, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
12. ANSI B18.2.2, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
13. ASTM A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.
14. ASTM A354, Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.
15. AWWA C600, Installation of Ductile Iron Water Mains and Their Appurtenances.

1.3 SUBMITTALS

A. Submittals shall be in accordance with Section 01300, Submittals

B. Shop Drawings: Submit for approval the following:
   1. Detailed Drawings and data on pipe, fittings, gaskets, and appurtenances. Submit these with Shop Drawings required under Section 15051, Buried Piping Installation.

C. Certificates. Submit Certificates of Compliance with referenced standards.

D. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up Specification sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

E. CONTRACTOR shall submit soft copies and hard copies per Specification 01300, Submittals. Soft copies shall be in DVD format and shall include all information provided in hard copy. Text shall be in electronic pdf format. Drawings and figures shall be in AutoCAD compatible with AutoCAD Map 3D 2008, or tiff format at 150 dpi.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 15051, Buried Piping Installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: If not specified, provide flanged joints for exposed piping and push-on or mechanical joints for buried piping. Couplings shall be provided on pipe with plain or grooved ends, where shown or where approved by ENGINEER.

B. Ductile Iron Pipe and Fittings:
   1. Flanged Pipe: Fabricate in accordance with requirements of AWWA C115.
      a. Thickness: As shown on Piping Schedules. If not shown, use Special Thickness Class 53.
      b. Mechanical groove and shouldered type fittings are not acceptable.
   2. Non-Flanged Pipe: Conform to AWWA C151 for material, pressure, dimensions, tolerances, tests, markings, and other requirements.
      a. Pressure: As shown on Piping Schedules. If not shown, use Pressure Class 350 (Buried Piping).
      b. Special Thickness Class 53 (Exposed Piping).
   3. Joints:
      a. Flanged Joints: Conform to AWWA C110 or AWWA C153 and AWWA C115 capable of meeting, working, and test pressure specified in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
         1) Gaskets: High temperature resistant sealing compounds (Loctite PST 592) or equivalent with Dimethacrylate ester base and Teflon can be used.
            a) Gaskets: Unless otherwise specified, gasket stock shall be a synthetic rubber, 1/8-inch thick, full face, compound in which the elastomer is nitrile or neoprene. The compound shall contain not less than 50% by volume nitrile or neoprene and shall be free from factice, reclaimed rubber, and other deleterious substances.
         2) Bolts and Nuts: Conform to ANSI B18.2.1 and ANSI B18.2.2, respectively. Exposed bolts and nuts shall be ASTM A307, Grade B. Buried or submerged bolts and nuts shall be Type 316 stainless steel.
      b. Mechanical Joints: Conform to AWWA C110 or AWWA C153 and AWWA C151.
         1) Glands: Ductile iron.
         2) Gaskets: Plain tip. Gaskets shall comply with AWWA C111.
         3) Bolts and Nuts: High strength, low alloy steel.

c. Push-On Joints: Conform to AWWA C111.
    1) Gaskets: Molded rubber. Gaskets shall comply with AWWA C111.
    2) Stripes: Each plain end shall be painted with a circular stripe to provide a guide for visual check that the joint is properly assembled.
d. Restrained Push-On Joints: Restrained push-on joints shall be capable of being deflected after full assembly. Joint assembly shall be in strict conformance with AWWA C600 and manufacturer's recommendations. No field cuts of restrained pipe are permitted without prior approval of the ENGINEER.
e. Restrained Joints:
    1) Restrained joints for mechanical joint piping shall be one of the following:
        a) Push-On Restrained Joint, as manufactured by Clow Cast Iron Pipe and Foundry Division of the Clow Corporation.
        b) Megalug, as manufactured by EBBA Iron Sales, Inc.
        c) Or approved equal.
    2) Restrained joints for push-on joint piping shall be one of the following:
        a) Clow Super-lock Joint Pipe Style F-128, as manufactured by Clow Cast Iron Pipe and Foundry Division of Clow Corporation.
        b) Lok-Ring Joint, as manufactured by American Cast Iron Pipe Company.
        c) Or approved equal.

4. Flanged Fittings: Conform to AWWA C110 or AWWA C153 and AWWA C115.
    a. Pressure Rating: 150 psig.
    b. Material: Ductile iron.
    c. Gaskets: As specified above for joints.
    d. Bolts and Nuts: As specified above for joints.
5. Mechanical Joint Fittings: Conform to AWWA C110 or AWWA C153.
    a. Pressure Rating: 150 psig.
    b. Material: Ductile iron.
    c. Glands: Use ductile iron glands only. Cast iron glands are not allowed.
    d. Gaskets: As specified above for joints.
    e. Bolts and Nuts: As specified above for joints.
6. Coatings:
    a. Exposed pipe shall be prime coated in accordance with Section 09900, Painting. Field painting shall be performed in accordance with Paragraph 2.3 of this Section.
    b. Buried pipe and fittings shall be coated on the outside with a bituminous coating, approximately 1 mil thick. Buried pipe shall be provided with polyethylene encasement in accordance with Section 15051, Buried Piping Installation.

1) All buried ductile iron pipe, valves, and fittings shall be wrapped in a polyethylene sleeve or sheet for protection against corrosive soils. The polyethylene sleeve for protective wrap shall conform to the requirements of ANSI/AWWA C105/A21.5-05 and be as manufactured by the American Cast Iron Pipe Company or equal. Installation of polyethylene wrap shall be per MAG 610.

7. Linings:
   a. Pipe and fittings shall be lined with the same materials.
   b. Cement-mortar lining with a bituminous seal shall be provided in accordance with AWWA C104.
   c. Epoxy Lining Material: Where shown on the pipe schedules, epoxy lining shall be provided. The material shall be an amine cured novalac epoxy containing at least 20% by volume of ceramic quartz pigment. Epoxy lining material manufacturer shall demonstrate a successful history of lining pipe and fittings for sewer service and submit a test report verifying the following properties, and a certification of the test results.
      1) A permeability rating of 0.00 when tested according to Method A of ASTM E-96-66, Procedure A, with a test duration of 30 days.
      2) The following test shall be run on coupons from factory lined ductile iron pipe:
         a) ASTM B1117 Salt Spray (scribed panel): Results to equal 0.0 undercutting after two years.
         b) ASTM G95 Cathodic Disbondment 1.5 volts @ 77° F: Results to equal no more than 0.5 mm undercutting after 30 days.
         c) Immersion Testing rated using ASTM D-714-87.
            i) 20% Sulfuric Acid: No effect after two years.
            ii) 25% Sodium Hydroxide: No effect after two years.
            iii) 160° F Distilled Water: No effect after two years.
            iv) 120° F Tap Water (scribed panel): 0.0 undercutting after two years with no effect.
      3) An abrasion resistance of no more than 4 mils loss after one million cycles - European Standard EN 598: 1994 Section 7.8 Abrasion Resistance.
      4) Interior of the pipe shall receive 40 mils dry film thickness.
      5) Applicator: The lining shall be applied by a competent firm with a successful history of applying linings to the interior of ductile iron pipe and fittings.
      6) Surface Preparation: Pipe surfaces shall be cleaned and sandblasted prior to lining application in accordance with manufacturer's recommended procedures.
      7) Inspection and Certification:
         a) All ductile iron pipe and fitting linings shall be checked for thickness using a magnetic film thickness gauge. The thickness testing shall be done using the method outlined in SSPC-PA-2 Film Thickness Rating.

b) The interior lining of all pipe barrels and fittings shall be tested for pinholes with a non-destructive 2,500 volt test. Any defects found shall be repaired prior to shipment.
c) The pipe or fitting manufacturer shall supply a certificate attesting to the fact that the applicator met the requirements of this Specification.

8) Produce and Manufacturer: Provide one of the following:
a) Protecto 401.
b) Or approved equal.

8. Glass Lining:
1) General:
a) All glass-lined ductile iron pipe shall adhere to the General Specifications of the ductile iron pipe.
b) The glass lining shall be a specially formulated internal porcelain coating for handling sludge at a wastewater treatment facility, and shall be resistant to adherence of grease and crystalline metal salt deposits within these systems. All metal preparation, application and processing will follow the manufacturer's recommended procedures.
c) The lining shall consist of special glasses and inorganic materials applied to internal surfaces in a minimum of two coatings, separately fired, each to a maturing temperature greater than 1,300° F. The resulting bond shall be sufficient to withstand a metal yield of 0.001-inch/inch without damage to the glass.
d) The entire lining system shall have a minimum thickness of 0.010-inch and a maximum thickness of 0.020-inch. It shall have a hardness exceeding on the MOHS Scale and a density of 2.5 to 3.0 grams per cubic centimeter. The lining shall be capable of withstanding an instantaneous thermal shock of 350° F without crazing, blistering, or spalling; and shall be resistant to corrosion by most solutions between PH-3 and PH-10 at 125° F. Shall show a weight loss of not more than 3 milligrams per square inch when tested according to ASTM Designation C283-54. There shall be no visible loss of surface gloss after immersion of a normal production run sample in an 8% sulfuric acid solution at 148° F for a period of 10 minutes.
e) The glass lining shall provide continuous coverage when tested by a low voltage (67.5 volt) wet sponge holiday detection unit such as a Tinker and Rasor Model M-1 low voltage detection device. Isolated detectable pinholes are permitted, providing they are limited to less than 0.01% of the total glass-lined surface (no more than 1-2 pinholes per fitting or an average of 5 or less per 20 feet of pipe). Documented test results shall be furnished with all shipments.

f) Testing procedures and acceptance criteria shall be provided for approval as a part of the glass-lined pipe and fitting submittal information.
g) Glass-lining shall be performed by Vitco Corp., Type SG-14, or approved equal.

2) Installation:
a) Glass-lined pipe requires no special handling procedures from that of any other type of lined piping. The materials should not be lifted internally. Hooks, forks, straps, or cables are recommended.
b) External impact or vibration during handling will not affect the glass lining provided that the base metal material is not dented or bent beyond the yield point of the metal itself.
c) Field cutting should be limited to one piece per run of pipe from closure purposes only. Cuts should be made using a band saw with a Lenox neo-type blade, 1/4-inch wide by 0.125-inch thick by 18 teeth per inch, or finer, set at a speed of 100 feet per minute or faster. If the material is not forced against the blade, but set so that the cut is progressive in a natural way, chipping or spalling of the glass lining is held to a minimum. Pipe can also be cut with an abrasive high speed cutting wheel.
d) Acceptable Defects:
i) Scratches: A 1/16-inch wide maximum-providing there is no bare metal showing. No more than two scratches per pipe or fittings.
ii) Chips (caused by physical damage or field cutting): No larger than a ten cent piece, preferably smaller; not more than one per pipe or fitting.

3) Maintenance:
a) All field repair is based on judgment by the ENGINEER. An occasional repair will not impair the function of glass-lined pipe, but an excessive amount of repair could eventually encourage build-up within the system.
b) For repair of any minor chipping or spalling which occurs during cutting, Glidden Glid-Guard Epoxy Resin shall be used.
c) Welding on glass-lined material is not permitted.
d) Glass-lined pipe requires no special storage.

C. Specials:
1. Transition Pieces:
a. Furnish suitable transition pieces (adapters) for connections to existing piping.
b. Unless shown on Drawings, expose existing piping to determine material, dimensions and other data required for transition pieces.
2. Taps:

a. Provide taps, where shown or required for small diameter pipe connections.
b. Provide corporation stops where shown or required.
c. Where pipe wall thickness or tap diameter will not permit the engagement of two full threads, provide a tapping saddle as manufactured by The Ford Meter Box Company., Model No. FC 202.

3. Tangential Outlets:
   a. Provide tangential outlet fittings as shown on the Drawings.

D. Pipe and fittings shall be the product of a single manufacturer.

2.2 MARKING FOR IDENTIFICATION

A. All pipeline materials shall be stamped, marked, or identified with the following:
   1. Name or trade mark of the manufacturer.
   2. Pipe class.
   3. Size and length dimensions.
   4. Date and place of manufacture.

2.3 SURFACE PREPARATION AND SHOP PAINTING

A. Exposed Pipe and Fittings:
   1. Clean and prime coat ferrous metal surfaces of piping in the shop.

B. Buried Pipe and Fittings:
   1. Refer to Paragraph 2.1.B.6.b., above.

PART 3 - EXECUTION

3.1 INSTALLATION

A. For buried piping installation and testing, Section 15051, Buried Piping Installation.

3.2 INSPECTION

A. CONTRACTOR shall inspect all piping to assure that piping is free from defects in material and workmanship. The compatibility of all pipe, fittings, and coatings shall be verified by CONTRACTOR.

END OF SECTION

SECTION 15065

THERMOPLASTIC PIPE AND ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown on the Drawings, specified, and required to furnish, install, and place in satisfactory service, polyvinyl chloride (PVC) fittings, and specialties.
   2. The extent of piping is shown on the Drawings and in the schedules included in Section 15051, Buried Piping Installation.

B. Related Sections:
   1. Section 15051, Buried Piping Installation.
   2. Section 09900, Painting.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years of experience in the production of thermoplastic pipe and fittings, and shall show evidence of satisfactory service in at least five installations.
   2. Thermoplastic pipe and fittings shall be the product of one manufacturer.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ASTM D1598, Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure.
   2. ASTM D1599, Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings.
   3. ASTM D1784, Standard Specification for Rigid Poly (Vinyl Chloride) PVC Compounds and Chlorinated Poly (Vinyl Chloride) CPVC Compounds.
   4. ASTM D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
   5. ASTM D2122, Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.
   6. ASTM D2152, Standard Test Method for Adequacy of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion.
   7. ASTM D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

8. ASTM D2241, Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
9. ASTM D2467, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
10. ASTM D2564, Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
11. ASTM D2737, Standard Specification for Polyethylene (PE) Plastic Tubing.
12. ASTM D2774, Standard Specification for Underground Installation of Thermoplastic Pressure Piping.
13. ASTM D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
14. ASTM D2846, Standard Specification for Chlorinated Poly (Vinyl Chloride) Plastic Hot- and Cold-Water Distribution Systems.
15. ASTM D2855, Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
16. ASTM D3034, Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
17. ASTM D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
18. ASTM D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals.
19. ASTM D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
20. ASTM F412, Standard Terminology Relating to Plastic Piping Systems.
21. ASTM F437, Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
22. ASTM F439, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
23. ASTM F441, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
24. ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
25. ASTM F493, Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
26. ASTM F679, Standard Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
27. ASTM F2618 Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Fittings for Chemical Waste Drainage Systems.
28. AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4-inches through 12-inches, for Water Distribution.
29. AWWA C901, Polyethylene (PE) Pressure Pipe and Tubing, 1/2-inch through 3-inches for Water Service.
30. Standard No. 14, National Sanitation Foundation.
31. American National Standards Institute.

C. Shop Tests:

1. Piping manufacturer shall maintain a continuous quality control program. All PVC plastic molding materials used to manufacture pipe and fittings under this Section shall be tested for conformance to the requirements of ASTM D1784 and ASTM D1785.

1.3 SUBMITTALS

A. Refer to Section 15050, Piping Systems, for submittal requirements.

1.4 PRODUCT DELIVERY, HANDLING, AND STORAGE

A. Refer to Section 15051, Buried Piping Installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. PVC Gravity Sewer Pipe:
   1. Pipe and fittings and specials shall conform to requirements of ASTM D1784, Class 12454B, and ASTM D3034 for SDR 26 and SDR 35. Elastomeric gaskets for joints shall conform to requirements of ASTM F477 and ASTM D3212. Sewer pipe shall meet the requirements of MAG Section 745. Sewer installation shall meet the requirements of MAG Section 615.

B. Couplings:
   1. Type: Quick-connect, male adapter with treaded ends for permanent pipe installation, hose shank coupler for hose connection.
   2. Materials:
      a. Body: Polypropylene.
      b. Cam Arms: Stainless steel.
      c. Gaskets: Viton or EPDM.
      d. Ends: As specified above.
   3. Each adapter provided shall be equipped with adapter cap constructed of same materials.
   4. Product and Manufacturer: Provide one of the following:
      a. Plastic Piping System, Inc.
      b. Or equal.

C. Expansion Joints (Bellows Type):
   1. Provide expansion joints as part of the pipe support system, as required.
   2. Provide connections to storage tanks and scrubber vessels with expansion joints to compensate for expansion, contraction and misalignment. Connections requiring bellows type expansion joints are as follows:
      a. Pump suction line.
      b. Pump discharge line.

c. Fill pipes.
d. Vent pipes.

3. Features:
   a. Type: Flanged bellows type with three or five convolutions.
   b. Working Pressures (maximum):
      1) Three convolutions: 125 psi.
      2) Five convolutions: 50 psi.
   c. Materials of Construction:
      1) Bellows: TFE. Bellows material shall be wrapped around flanges for corrosion protection.
      2) Flanges: Cadmium plated steel.
   d. Reinforcing rings around bellows: Plated for corrosion protection.
   e. All expansion joints in gallery piping shall have limit rods for over expansion protection. Rods shall be sized with a safety factor of 1.5 above the maximum force developed.
4. Product and Manufacturers: Provide one of the following:
   a. Unaflex, Style.
   b. Garlock, Style.
   c. Resistoflex, Model.
   d. Or equal.

D. CONTRACTOR shall supply type, grade, and strength of pipe required to meet the specified service conditions. Submit to ENGINEER for approval.

E. Painting shall conform to requirements of Section 09900, Painting.

2.2 DETAILED REQUIREMENTS

A. Workmanship: The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other defects. The pipe shall be uniform in color, opacity, density, and other physical properties.

B. Dimensions and Tolerances: Dimensions and tolerances shall be measured in accordance with ASTM D2122. The eccentricity of the inside and outside circumferences of the pipe walls shall not exceed 12%.

C. Sustained Pressure: The pipe shall not fail, balloon, burst, or weep as defined in ASTM D1598.

D. Burst Pressure: The minimum burst pressure shall be determined in accordance with ASTM D1599.

E. Marking: Markings on the pipe shall include the following and be spaced at intervals of not more than 5 feet:
   1. Pipe nominal size.
   2. Pipe Schedule.

3. Specification of plastic material.
4. Type and grade of plastic.
5. Date and place of manufacture.

F. Piping and fittings shall be manufactured with a minimum of 2% of titanium oxide for ultraviolet protection.

2.3 ADAPTERS

A. Where required to join piping of different materials CONTRACTOR shall provide the necessary adapters, as recommended by the thermoplastic pipe manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
1. Refer to Section 15051, Buried Piping Installation, for piping installation, testing, cleaning, and acceptance.
2. Request instructions from ENGINEER before proceeding if there is a conflict between Contract Documents and manufacturer's recommendations.
3. Pipe, fittings, and accessories that are cracked, damaged, not identified, or in poor condition shall be rejected.

END OF SECTION

SECTION 15070

HIGH DENSITY POLYETHYLENE PRESSURE PIPE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. The CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish, install and test high density polyethylene (HDPE) pipe and fittings for sanitary sewer force main application. in accordance with ASTM and AWWA as modified by the Contract Documents.
   2. A single pipe supplier shall be responsible for furnishing all HDPE pipe. This does not prevent multiple pipe and fitting manufacturers; however, supplier of the HDPE pipe shall direct all Work. The responsibility of the pipe supplier, at a minimum, shall include:
      a. Certify all pipe and fittings are being manufactured in full accordance with the Contract Documents.
      b. Manage the design and fabrication of the pipe and fittings.
      c. Prepare and submit all submittal information and shop drawings.
      d. Make any corrections that may be required to the submittal information and shop drawings.

B. Coordination:
   1. Review installation procedures under this and other Sections.

C. Related Sections:
   1. Section 01300, Submittals.
   2. Section 02200, Earthwork.
   3. Section 15051, Buried Piping Installation.

1.2 REFERENCES

A. ASTM A193, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

B. ASTM A194, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

C. ASTM D2774, Standard Practices for Underground Installation of Thermoplastic Pressure Piping

D. ASTM D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

E. ASTM D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing .

F. ASTM F714, Standard Specification for Polyehtylene (PE) Pipe (SDR-PR) Based on Outside Diameter.

G. ASTM F1055, Standard Specification for Electrofusion for Outside Diameter Controlled Polyethylene Pipe and Tubing.

H. ASTM F2164, Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping System Using Hydrostatic Pressure.

I. ASTM F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings .

J. ANSI/ASME B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through 24 - Metric/Inch Standard.

K. ASME B 18.2.1, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).

L. AWWA C906, Polyethylene (Pe) Pressure Pipe & Fittings 4 In (100 Mm) Thru 63 In (1,575 Mm) For Water Distribution And Transmission.

M. AWWA Manual M55, PE Pipe – Design and Installation.

N. City of Chandler Standard Detail C-408, Pipe LocatorWire and ID Tape.

O. Plastic Pipe Institute Handbook of Polyethylene Pipe, 2nd Edition.

P. Plastic Pipe Institute Technical Report TR-33, Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe.

Q. Plastic Pipe Institute Technical Note TN-44, Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects.

1.3 SUBMITTALS

A. Contractor shall submit shop drawings, product technical data, test reports and record drawings in accordance with Section 01300, Submittals.

B. Each Shop Drawing Submittal shall include a hard copy of the relevant Specification Section and shall be clearly marked to indicate whether the requirements for equipment and/or services in the Specification Section are met by writing "accept" or "deviate" next to each Paragraph. If clarifications are needed to any of the Paragraphs in the Specification Sections due to deviations, they shall be addressed next to the Paragraph as such and explained further with

any additional information necessary. If any exceptions and/or deviations are proposed to any of the Specifications, they shall be clearly noted as such in the Submittal, and an explanation of any deviation and/or exception shall be provided. The CONTRACTOR shall furnish equipment and/or services as specified if an exception and/or deviation is rejected. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Certified dimensional drawings of all pipe, fittings and appurtenances.

D. Pipe Laying Schedule Information.
   1. Pipe laying schedule, marking diagrams that indicate the unique identification number of each pipe and fitting and the location of each pipe and the direction of each fitting in the completed line. In addition, the line layouts shall include the station and centerline or invert elevation to which the pipe will be laid; all elements of curves and bends, both in horizontal and vertical alignment and the limits of concrete encasement.
   2. The pipe laying schedule shall have a sequence of laying and an explanation of all abbreviations used in the schedule. For long, straight pipe runs, the pipe laying schedule shall list the pipeline station and either the pipe centerline or invert elevation coordinated with the Drawings at least every 100 feet.
   3. Drawings showing proposed location and details for hydrostatic testing of the pipeline.
   4. Details and locations of closures for length adjustment.
   5. The method that the CONTRACTOR proposes to use for measuring deflection of pipe joints.

E. Fusion Information. Submit the following prior to performing any Work:
   1. Written fusion procedures.
   2. Certification of compliance that fusion operators have received training and comply with installation procedures per the manufacturer's recommendations. Certificates shall be submitted prior to beginning of construction.
   3. Data Logger specification and sample report. At a minimum, reports shall include fusion operator, time, date, heater temperature, pressure, and station number of joint.
   4. Log listing for all fusion operators to be used for the Work.
   5. Fusion map showing the sequence of fusions.
   6. Fusion machine(s) specification and maintenance log.
   7. Shop drawings and fusion information together as a complete package.

F. Detail drawings indicating the type, number and other pertinent details of the slings and other methods proposed for pipe support and handling during manufacturing, transport, and installation. Documentation confirming that the handling and support system has been designed and sealed by a registered

professional engineer, licensed in the State of Arizona. The recommended methods of handling and placement of the pipe shall be submitted to the Engineer as a record copy prior to transporting of any pipe to the site.

G. For record copy, detailed drawings indicating loading and shipping procedures that are designed to minimize damage to pipe

H. Pipe manufacturer's Written Quality Assurance/Control Program.

I. Sample of pipe identification tape.

1.4 MANUFACTURER QUALIFICATIONS

A. The CONTRACTOR shall submit the qualifications for the pipe manufacturers. Qualifications shall include the following:
   1. Pipe Supplier Information. Submit company name, contact name, and contact number.
   2. Years of Experience. Submit written verification that the pipe manufacturer has been manufacturing ASTM F714 pipe with similar design pressure and size as this Project for a minimum of five years.
   3. Production and Delivery Capability. Submit written verification from the pipe manufacturer/fabricator demonstrating compliance with the production and delivery schedule of the pipe as indicated in the CONTRACTOR’s preliminary construction schedule.

1.5 QUALITY ASSURANCE

A. The pipe manufacturer shall provide the services of an experienced, competent, and authorized representative to visit the site of the work to advise and consult with CONTRACTOR during joining and installation of the pipe. The manufacturer's representative shall not directly supervise CONTRACTOR's personnel, and CONTRACTOR shall remain responsible for the pipeline work.

B. Fusion joints shall be made by qualified fusion technicians who shall demonstrate fusion experience on projects completed within a year of the CONTRACTOR’s NTP date which included similar or larger installation lengths, similar pipe sizes (+/- 2 pipe sizes) and similar DRs (+/- 2 DRs).

C. Storage and handling shall meet the requirements of Product Storage and Handling Requirements section, and shall be in accordance with Chapter 7, Transportation, Handling and Storage of Pipe and Fittings of AWWA Manual M55, to ensure installation in sound, undamaged conditions. Pipe shall not be stored uncovered in direct sunlight.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe
   1. Pipe shall be 4-inch iron pipe size (IPS) and dimension ratio DR 21 with a pressure class of 100-pound per square inch, unless otherwise specified on the plans.
   2. PE4710 (ASTM F714) high density polyethylene, minimum cell classification 445574C as determined by ASTM D3350.
   3. Thermal butt fusion joints per ASTM D3261.
   4. A green stripe shall be integrated into the pipe for sewer service identification.
   5. Piping and fittings shall be manufactured with a minimum of 2% of carbon black for ultraviolet protection.

B. Heat Fusion Joints
   1. Butt fusion joints, ASTM D3261; manufactured by injection molding; pressure class of the pipe or greater.
   2. Transitions between unlike wall thickness equal to one Standard DR shall be butt fusion joints, ASTM F2620. Shall have the same pressure rating as the adjoining pipe unless otherwise specified.

C. Flanged Joints
   1. HDPE Flange Adapters: PE4710 (ASTM F714) high density polyethylene, minimum cell classification 445574C. Shall have a manufacturing standard of ASTM D3261. Shall have the same pressure rating as the adjoining pipe unless otherwise specified. Stub Ends are not allowed.
   2. Backup Rings: Convoluted Type per ANSI/ASME B16.5, Class 150, AISI 316, or 316L. Rings shall be equally or greater pressure rated than the pipe, unless otherwise specified. Plate rings are not allowed.
   3. Flange Bolts: ASTM A193 Class 2, AISI Type 316, ANSI B18.2.1, heavy hex head, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.
   4. Flange Nuts: ASTM A194, AISI Type 316, ANSI/ASME B18.2.2, heavy hex pattern. Washers shall be installed under the nuts.
   5. Dismantling Joints: Smith Blair, Model 975, AISI Type 316. All dismantling joints shall be restrained

D. Fittings
   1. PE4710 (ASTM F714) high density polyethylene, minimum cell classification 445574C.
   2. Electrofusion Type: ASTM F1055 having pressure class equivalent to the pipe or greater as required.
   3. Fabricated Type: Meet applicable AWWA C906 requirements; pressure class and cell class equivalent to the pipe or greater as required.

4. Molded Types: Shall be manufactured and tested in accordance with ASTM D3261. Shall have the same pressure rating as the adjoining pipe unless otherwise specified.
5. Other Types: Subject to review by the Engineer.
6. Bends shall have a radius to pipe outside diameter ratio of two (R/D = 2) for the cleaning pig.

E. Coal Tar Epoxy
1. High build coal tar epoxy; Ameron "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H 413 Hi Build Tneme Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy" or approved equal.

F. Conductive Tracer
1. Detection tape, 3 inches wide; aluminum foil core, 0.5 mil thick, encased in a protective inert plastic jacket; 5,000 psi min tensile strength; 2.5 lb/inch per 1,000 feet min weight; color coded in accordance with APWA Uniform Color Code; Allen Systems "Detectatape", Lineguard "Type lll", or Reff Industries "Terra Tape D".

G. Identification Tape
1. Per MAG Standard Specification Section 616.4.

PART 3 - EXECUTION

3.1 INSPECTION

A. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation, with special attention to pipe ends. All defective pipe and fittings shall be removed from the site of the work.

3.2 INSTALLATION

A. Laying Pipe: Pipe shall be protected from lateral displacement by pipe embedment material installed as specified in Section 02200, Earthwork. Pipe shall not be laid in water or under unsuitable weather or trench conditions, and shall be protected against entry of foreign matter.
1. During freezing weather, particular care shall be taken in handling and laying pipe to prevent damage by impact.
2. Whenever pipe laying is stopped, the open end of the line shall be closed with a tight-fitting end board to keep out sand and earth. The end board shall have several perforations near its center to admit water into the pipe, to prevent flotation in the event the trench is flooded. Any standing water shall be removed from the trench before the end board is removed.
3. Pipe shall be protected from extended exposure to sunlight, shall be kept as cool as possible during installation, and shall be covered with backfill immediately after installation.

4. Conductive tracer shall be installed per MAG Standard Specification Section 616.4.

B. Cleaning: The interior of all pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean until the work has been accepted.

C. Alignment: Piping shall be laid to the lines and grades indicated on the drawings. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the maximum deflection specified by the manufacturer.
   1. Unless otherwise specified or indicated on the drawings, and subject to acceptance of the Engineer, either shorter pipe sections or fittings shall be installed as required to maintain the indicated pipeline alignment or grade.

D. Cutting Pipe: Cutting shall be in accordance with the pipe manufacturer's recommendations. Cuts shall be smooth, straight, and at right angle to the pipe axis. After cutting, the end of the pipe shall be dressed to remove all roughness and foreign matter in accordance with the manufacturer's instructions.

E. Jointing: Jointing of pipe and fittings shall be performed in accordance with the instructions and recommendations of the pipe manufacturer and in accordance with ASTM F2620. Sections of HDPE pipe shall be joined above ground into continuous lengths by the thermal butt fusion method. All fusions shall be made with fusion equipment equipped with a Data Logger.
   1. Where required, electrofusion shall be performed in accordance with ASTM F1055 and the manufacturer recommended procedure.
   2. Socket fusion and extrusion welding or hot gas welding will not be acceptable.
   3. All joining procedures shall be acceptable to Engineer.
   4. Fusion equipment and operators shall be protected from cold temperatures, elevated temperatures, wind, and dust during the fusion process.

F. Connections with Existing Piping: Connections between new work and existing piping shall be made using suitable fittings per Engineer’s approval. Each connection with an existing pipe shall be made one at a time and under conditions which will least interfere with service to customers, and as authorized by the Town. Facilities shall be provided for proper dewatering and for disposal of all water removed from the dewatered lines and excavations without damage to adjacent property.

G. Flange Installation: Flange connections shall be installed in accordance with the manufacturer's recommended procedure. Flanges shall be centered and aligned to the mating component before assembling and tightening bolts. In no case shall flange bolts be used to draw the connection into alignment. Bolt threads shall be lubricated, and flat washers should be used under the nuts. Bolts shall be evenly tightened according to the tightening pattern and torque step recommendations of the manufacturer. At least 1 hour after initial assembly, flange connections shall

be re-tightened following the tightening pattern and torque step recommendations of the manufacturer. Connections shall be retightened a second time after at least 4 hours in accordance with manufacturer's recommendations. The final tightening torque shall be as recommended by the gasket manufacturer

H. Concrete Encasement: Concrete encasement shall be installed as indicated on the drawings. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section. All pipes to be encased shall be suitably supported and blocked in proper position and shall be anchored against flotation.

I. Reaction Anchorage and Blocking: All tees, plugs, and other fittings installed in piping subject to internal hydrostatic head in excess of 30 feet shall be provided with suitable reaction blocking, anchors, joint harnesses, or other acceptable means of preventing movement of the pipe caused by internal pressure.
   1. Concrete blocking shall extend from the fitting to solid undisturbed earth and shall be installed so that all joints are accessible for repair. The dimensions of concrete reaction blocking shall be as indicated on the drawings or as directed by Engineer.
   2. Reaction blocking, anchorages, or other supports for fittings installed in fill or in other unstable ground shall be provided as indicated on the drawings or as directed by Engineer.

J. Protective Coating: All steel clamps, rods, bolts, and other metal components of tapping saddles or reaction anchorages subject to submergence or in contact with earth or other fill material, and not encased in concrete, shall be protected from corrosion by two coats of coal tar paint applied to clean, dry surfaces. The first coat shall be dry and hard before the second coat is applied.

3.3 FIELD QUALITY CONTROL

A. Hydrostatic Tests: After installation, HDPE piping shall be hydrostatically tested for defective workmanship and materials per ASTM F2164.

B. Leakage: All HDPE piping with butt fusion welded fittings shall have zero leakage. Each leak that is discovered within the correction period stipulated in the General Conditions shall be repaired by and at the expense of CONTRACTOR.

C. Fusion Joint Tests. The first butt fusion joint of the project shall be tested and approved. In addition, a new fusion operator shall have a sample butt fusion joint tested and approved prior to working on the project. The ENGINEER may randomly request a fusion joint be tested at the expense of the CONTRACTOR. The CONTRACTOR shall submit testing procedures and minimum desired results conforming to manufacturer's recommendations for approval by the ENGINEER. The fusion joints may be teseted by the following:
   1. Bend Back Test (recommended for HDPE pipe thickness less than 1-inch).
   2. The CONTRACTOR may wish to use an alternative test (ie, tensile test or side-bend test).

D. Pipe Deflection Tests: Pipe shall be measured for deflection at 50 foot intervals unless otherwise required by the ENGINEER.

E. Fusion Bead Visual Inspection. Each fusion joint shall be inspected to check for fusion uniformity and alignment. A double-bead will be formed in the fusion process. Each side of the double bead shall be equally rolled over the surface of the pipe, uniformly rounded, and consistent in size around the perimeter of the joint. The width of the double bead should be 2 to 2 ½ times the bead height above the pipe surface. The v-groove depth between the beads should not be more than ½ the bead height. A fusion bead troubleshooting guide from the pipe supplier shall be available on site at all times.

END OF SECTION

SECTION 16000

GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Work and materials necessary for erecting a complete electrical and instrumentation system, tested and ready for continuous use.

B. Related Sections:
   1. Division 0, Bid Requirements, Contract Forms, and Contract Conditions.
   2. Division 1, General Requirements.
   3. Division 2, Site Construction.
   4. Division 3, Concrete.
   5. Division 11, Equipment.
   6. Division 13 Special Construction.
   7. Division 15 Mechanical.
   8. Division 17 Instrumentation and Controls.

1.2 DEFINITIONS

A. The term "Provide" means "Furnish and Install".

1.3 SYSTEM DESCRIPTION

A. Design Requirements:
   1. If any contradictions, contrasts, or inconsistency appears, the most strict criteria noted and the collective requirements in any and all of the Project documents shall apply.

1.4 SUBMITTALS

A. Intent:
   1. Organize Work so that a complete electrical, instrumentation, and control system for the facility will be provided and will be supported by accurate Shop Drawings, Record Drawings, and O&M Manuals.
   2. Submit detailed Shop Drawings and data prepared and organized by the suppliers. Provide quantity of submittal sets in accordance with the requirements of Division 1, General Requirements.
   3. Submittals shall be neatly grouped and organized by Specification Section number, and sub-section. Related information shall be highlighted and the specific product shall be marked. All Submittals shall be complete and

presented in one package. Incomplete Submittals will be returned without review. If a portion of the Project requires a fast track schedule, that portion only may be submitted earlier under a separate cover letter.

4. Work performed or equipment provided without ENGINEER approved Submittals is done at CONTRACTOR'S risk. Cost to re-work or re-supply will be born solely by the CONTRACTOR.

B. Product Data:
   1. A complete list of the equipment and materials, including the manufacturer's name, product Specification, descriptive data, technical literature, performance charts, catalog cuts, installation instructions, and spare part recommendations for each different item of the equipment specified. The above shall clearly show all the specified requirements as described in the Specifications including but not limited to specific UL and NEMA rating, technical capabilities, test result verifications, and acceptance letters.
   2. Submittals not in compliance with the Specifications must include the following information:
      a. Reason for non-compliance or variance.
      b. Calculations and Drawings for redesign of related components, including detail drawings showing internal and assembly details, with installation instructions.
      c. Proposed layout showing any modifications or exceptions to related Work made necessary by this Work, with calculations and drawings showing such modifications or exceptions.

C. Shop Drawings:
   1. Drawings containing complete wiring and schematic diagrams, control diagrams, and any other details required to demonstrate that the system has been coordinated and will operate as intended. Drawings shall show proposed layout, anchoring, support, and appurtenances of equipment, and equipment relationship to other parts of the Work, including clearances for maintenance and operations.

D. Utility Coordination:
   1. Submit copies of service entrance Shop Drawings to the utility, per utility submittal requirements, prior to submittal to the ENGINEER. Obtain written approval from the power utility company that the service entrance equipment is acceptable prior to release the order to the supplier for fabrication. Provide a copy of the approval letter from the utility with the Submittal.

E. Closeout Submittals:
   1. Provide "Record Drawings" of the electrical, control, and instrumentation work to include:
      a. Step-by-step procedure manuals for the installation, operation start-up, and maintenance of the equipment.

b. Installation, operating, troubleshooting, and maintenance and overhaul instructions in complete detail.
c. Possible breakdowns and repairs, and troubleshooting guides, as well as simplified wiring and control diagrams of the system installed. This shall provide the OWNER with comprehensive information on all systems and components to enable operation, service, maintenance and repair.
d. Exploded or other detailed views of all equipment, devices, assemblies, and accessory components shall be included, together with complete parts lists and ordering instructions.

2. Provide an "As Built" set of Plans to OWNER. Maintain at all times a marked up set of Plans showing the following information:
   a. Actual installed circuit numbers, conduit sizes, cable tray routing, number of conductors, conductor sizes (larger than #12 AWG), and all other deviations from the Design Plans.
   b. Underground conduit, duct banks, and concealed items dimensioned on the Plans from permanent, visible, building features.
   c. Actual motor size, starter size, and overload heater size, along with all other protective equipment for all 480 V and 4160 V motor circuits.
   d. Conductor identification and panel schedules.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Electrical work, including connection to electrical equipment integral with mechanical equipment, shall be performed in accordance with the latest published regulations, codes, and standards, of the following:
      a. National Electrical Code (NEC).
      b. State and local codes.
      c. Institute of Electrical and Electronic Engineers (IEEE).
      d. American National Standards Institute (ANSI).
      e. American Society for Testing and Materials (ASTM).
      f. Insulated Cable Engineers Association (ICEA).
      g. National Electrical Manufacturers Association (NEMA) Standards.
      h. Federal Occupational Safety and Health Act (OSHA).
      i. National Fire Protection Association (NFPA).
      j. National Electrical Testing Association (NETA).

1.6 DELIVERY, STORAGE, AND HANDLING

A. Electrical panels, switchgear, motor control centers, and other electrical equipment, shall be shipped in sealed dust and moisture proof plastic sheet enclosures, and the seal maintained until units are installed. Said units shall be new and free of any dirt, dust, water, grease, rust, damaged parts, or components.

1.7 PROJECT/SITE CONDITIONS

A. Verify site conditions before bidding or performing Work.

1.8 SCHEDULING

A. Maintain a Work schedule showing Work to be performed, sequence of Work, major milestones, and manpower loading. Coordinate schedule requirements with other trades. Provide adequate staff to perform the Work in the time required by the schedule.

1.9 SYSTEM START-UP

A. After installation and testing of all electrical and instrumentation equipment and systems, energize all equipment and leave ready for continuous operation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers and model numbers shown on Plans or listed in the Specifications are intended to establish a minimum standard of quality and acceptability.

2.2 MATERIALS

A. Materials, equipment, and parts comprising any unit, or part thereof, specified or indicated on the Plans, shall be new and unused, of current manufacture, and of highest grade consistent with the state of the art. Damaged materials, equipment, and parts are not considered to be new and unused and will not be accepted.

2.3 MANUFACTURED UNITS

A. The fabricator of major components and manufactured units, such as distribution panel boards, switchgear, and motor control centers, shall also be the manufacturer of the major devices therein.

B. Electrical equipment provided with mechanical equipment assemblies shall be in compliance with this Specification.

2.4 EQUIPMENT

A. Minimum sizes of equipment and electrical devices are indicated, but it is not intended to show every offset and fitting, nor every structural or mechanical difficulty that will be encountered during the installation of the Work.

B. Electrical equipment shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature of 60º C, and specifically rated for the altitude indicated on the Plans. Provide air conditioning to meet the manufacturers' operating temperature for electrical equipment not rated for operation at that temperature.

C. When applicable, the material used in the performance of the electrical work shall be listed by the Underwriters' Laboratories, Inc. (UL), for the class of service for which they are intended.

D. Provide nameplates where indicated elsewhere in these Specifications or on the Plans. Nameplates shall be black laminate with white letters and fastened to the various devices with round head stainless steel screws. Provide nameplates for each disconnecting means for service, feeder, branch, or equipment conductors indicating its purpose.

2.5 FABRICATION

A. Shop Assembly:
   1. Equipment assemblies, such as Service Entrance Sections, Switchgear, Switchboards, Control and Distribution Panels, and other custom fabricated electrical enclosures, shall bear a UL label as a complete assembly. The UL label on the individual components making up the assembly will not be considered sufficient to meet the present requirement. Whenever a generic UL label does not apply for the assembly, a serialized UL label shall be affixed to the assembly, and the serial number shall be submitted with the assembly record Shop Drawings.
   2. Custom fabricated electrical control panels, and enclosures, shall bear a UL label affixed by a local UL inspector.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Site Verification of Conditions:
   1. Verify site conditions before bidding or performing Work.

3.2 INSTALLATION

A. Coordinate Work with other trades and with certified vendor shop drawing submittals.

B. Provide equipment in accordance with the manufacturers' requirements.

C. Identify each conductor as required by the Contract Documents.

D. Equipment Access:
   1. Install equipment so it is readily accessible for operation and maintenance.
   2. Equipment shall not be blocked or concealed.
   3. Do not install electrical equipment such that it interferes with normal maintenance requirements of other equipment.

E. Equipment shall be installed plumb, square and true with the building construction, and shall be securely fastened.

F. Outdoor wall-mounted equipment and indoor equipment mounted on earth or water bearing walls, shall be provided with corrosion-resistant spacers to maintain 1/4-inch separation between the equipment and the wall.

G. Arrange for the building in of equipment during structure construction. Where equipment cannot be built-in during construction, arrange for sleeves, box-outs, and other openings, as required to allow installation of equipment after structure construction is complete.

H. Verify that equipment will fit support layouts indicated.

I. Screen or seal all openings into outdoor equipment to prevent the entrance of rodents and insects.

J. Equipment fabricated from aluminum shall not be imbedded in earth or concrete.

K. Provide all necessary anchoring devices and supports.
   1. Use supports as detailed on the Plans and as specified.
   2. Supports and anchoring devices shall be rated and sized based on dimensions and weights verified from approved equipment Submittals.
   3. Hardware shall be stainless steel.
   4. Do not cut, or weld to, building structural members.
   5. Do not mount safety switches and external equipment to other equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.\

L. Verify exact rough-in location and dimensions for connection to electrical items furnished by others.
   1. Obtain Shop Drawings from those furnishing the equipment.
   2. Proceeding without proper information may require the CONTRACTOR to remove and replace Work that does not meet the conditions imposed by the equipment supplied.

3. Provide sleeves wherever openings are required through new concrete or masonry members. Place sleeves accurately and coordinate locations with the ENGINEER.
4. Do not endanger the stability of any structural member by cutting, digging, chasing, or drilling and shall not, at any time, cut or alter the Work without the ENGINEER'S written consent.
    a. Provide additional reinforcing if required.
    b. Use proper tools and methods to cut, core drill, or make other penetrations.
    c. Restore walls, ceilings, or floors to their original condition.

M. Provide concrete foundations or pads required for electrical equipment as indicated or specified.
1. Provide a 4-inch concrete housekeeping pad for floor mounted electrical equipment. Pour on top of the finished floor or slab. Drill existing slab and epoxy rebar to anchor housekeeping pad in place.

N. Do not use equipment that exceeds the indicated dimensions except as approved in writing by the ENGINEER.

O. Do not use equipment or arrangements of equipment that reduce required clearances or exceed the space allocation.

P. Work indicated on the Plans is approximately to scale, but actual dimensions and detailed Plans should be followed as closely as field conditions permit. Field verification of scale dimensions on Plans is governed by field conditions. Installation of systems and equipment is subject to clarification as indicated in reviewed Shop Drawings and field coordination.

Q. Discrepancies indicated on different Plans, between Plans and actual field conditions, or between Plans and Contract Documents shall be promptly brought to the attention of the ENGINEER for clarification, prior to purchasing and installing equipment.

R. Adjust the alignment of equipment and conduit to accommodate architectural changes or to avoid work of other trades.

S. Provide parts and pieces necessary to the installation of equipment, in accordance with the best practice of the trade, and in conformance with the requirements of these Contract Documents.

T. Items not specifically mentioned in these Contract Documents, or noted on the Plans, or indicated on reviewed Shop Drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.

U. Layout and install electrical work prior to placing floors and walls. Provide sleeves and openings through floors and walls, required for installation of conduits. Sleeves shall be rigidly supported and suitably packed, or sealed, to prevent ingress of wet concrete. Spacers shall be installed in order to prevent conduit movement. Dimensions indicated for electrical equipment and their installation are restrictive dimensions.

V. Provide inserts and hangers required to support conduits and other electrical equipment. Coordinate inserts and hangers with other trades. Replace inserts, hangers, sleeves, or other mounting hardware which are improperly placed.

W. Perform necessary saw cutting, core drilling, excavating, removal, shoring, backfilling, and other work required for the proper installation of conduits, whether inside, or outside of the buildings and structures. Use core drills to make circular holes.

X. Electrical Utility:
   1. Coordinate the electrical utility work with the electrical utility company. Note the additional submittal requirements under Paragraph 1.4.D of this Specification. Provide equipment and material required to bring electrical service to the service location in conformance with the electrical utility requirements. Provide the following for the electrical utility company's primary (from utility power line to the utility transformer) and secondary (from utility transformer to the service) electrical lines in accordance with the electrical utility company's specifications and requirements:
      a. Conduits (verify quantity and sizes).
      b. Trenching, backfill, and compacting (verify trench size(s), backfill material, and compaction percentage requirements).
      c. Concrete pad(s) (for pad mounted transformer(s)).
      d. Cable protection along the vertical drop at the utility company's pole (if pole mounted transformer(s)).
      e. Other items required by the power utility company's specifications.

Y. Telephone Service:
   1. Coordinate with the telephone company to provide telephone service as shown on the Plans. Provide trenching, conduit, and backfill for the telephone company's communication lines from the telephone company's main distribution panel to the telephone company's connection box at this Project site, as required by the telephone company.

Z. Temporary Power:
   1. Provide and maintain temporary power and lighting systems needed for construction. Work shall include:
      a. Weatherproof panel(s) for the CONTRACTOR'S main breakers and distribution system.
      b. Conduit and cable.

2. Use ground fault interrupting equipment.
3. Connections shall be watertight, with wiring done with Type SO portable cable.
4. Route and support cables to avoid mechanical damage.
5. Remove temporary power equipment and devices upon completion of construction.

AA. Corrosion Protection:
1. Wherever dissimilar metals, except conduit and conduit fittings, come in contact, the CONTRACTOR shall isolate these metals, as required, with neoprene washers, 9 mil polyethylene tape, or gaskets. Where fastening conduit, electro plated, or equivalent fasteners and stainless steel bolts shall be used.

3.3 REPAIR/RESTORATION

A. Repair damage caused by construction or demolition work to restore damaged areas to original condition.

B. Factory finishes damaged during shipping, or construction, shall be restored to original new condition. Rust shall be removed, and bare metal surfaces shall be primed and painted to match the original surrounding finish.

3.4 FIELD QUALITY CONTROL

A. Site Tests:
1. The electrical work shall be free from improper grounds and from short circuits. Visually compare the conductor connections with connection diagrams. Perform individual circuit continuity checks using electrical circuit testers. Demonstrate proper operation of the energized electrical and mechanical devices. Correct any wiring deficiencies.

3.5 ADJUSTING

A. Calibrate and set all adjustable electrical equipment, including circuit breakers, motor circuit protectors, overload relays. Align photo cells and lights to achieve desired effects.

3.6 CLEANING

A. Relays, starters, circuit breakers, switches, contacts, insulators, mechanisms, and buses shall be free of dust, dirt, oil, moisture, metal shavings, and other debris before testing and energizing equipment. Vacuum and wipe down inside and outside of electrical enclosures and control panels.

3.7 PROTECTION

A. Once equipment is installed, it shall be protected at all times with plastic sheet covers until the area is free of dirt, dust, paint spray, water, and other trades. Provide heat to eliminate condensation.

END OF SECTION

SECTION 16001

PUMP SYSTEMS AND CONTROL PANELS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The CONTRACTOR shall furnish and install, ready to use, the complete Package Control System as indicated on the Drawings and the Contract Documents.

B. If any contradictions or inconsistencies appear, the strictest criteria noted and the collective requirements in any and all of the Contract Documents shall apply.

1.2 DEFINITION

A. The Pump Systems may include, but are not limited to, the following:
   1. Submersible Pump systems.
   2. Pump Control Panel.

1.3 SUBMITTALS

A. Provide submittals for the Pump Control Panels in accordance with Section 16000, General Electrical Requirements, and the Contract Documents.

1.4 RELATED SECTIONS

A. Related Sections may include, but are not limited to, the following:
   1. Section 16000, General Electrical Requirements.
   2. Section 16111, Conduits.
   3. Section 16123, 600 Volt Class Conductors.
   4. Section 16124, Instrumentation Class Cable.
   5. Section 16143, Terminal Blocks.
   6. Section 16161, Control Panels.
   7. Section 16195, Electrical Identification.
   8. Section 16440, Disconnect Switches.
   9. Section 16461, Transformers - Dry-Type.
   10. Section 16476, Low Voltage Circuit Breakers.
   11. Section 16477, 600 V Fuses.
   12. Section 16902, Electrical Control, Relays, and Alarms.
   13. Section 17410, Automatic Dialer

PART 2 - PRODUCTS

2.1 CONTROL SYSTEMS

A. Pump Control Panel shall be built in accordance with Section 16161. Pump Control Panel shall be assembled by a UL 508 shop.

B. Each pump control panel shall be provided with a main disconnect device. The main disconnect device shall be a thermal-magnetic circuit breaker operated by a flange-mounted, externally operable, handle. The main disconnect handle shall be padlockable in the OFF position with at least three padlocks, with the door closed or open. The panel's main breaker shall be sized such that it is loaded less than 80% of its rating. Circuit breaker shall be provided in accordance with Section 16476, Low Voltage Circuit Breakers.

C. Motor circuit protectors and starters for each motor, in accordance with Specification 16902, Electrical Controls, Relays, And Alarms.

D. Automatic motor alternation with manual override and lead selection (for the system has more than one motor) in accordance with Section 16902, Electrical Controls, Relays, and Alarms.

E. Capability to interface with other related systems/devices as described in the Contract Documents.

F. Control, delay, timer, and other relays as required and in accordance with Section 16902, Electrical Controls, Relays, And Alarms.

G. Pushbutton and switches as follows:
   1. As shown on the Drawings and in accordance with Section 17454, Control Descriptions.
   2. In accordance with Specification 16902, Electrical Controls, Relays, and Alarms.
   3. The Packaged Control Panel shall incorporate devices to visually represent all information needed to diagnose the individual malfunction alarm cause. The CONTRACTOR shall review and confirm all requirements with manufacturer(s) in order to bid a complete working package.

H. Pilot Lights as follows:
   1. As shown on the Drawings and in accordance with Section 16161, Control Panels and Specification 16902, Electrical Controls, Relays, and Alarms.
   2. The Packaged Control Panel shall incorporate devices to visually represent all information needed to diagnose the individual malfunction alarm cause. The CONTRACTOR shall review and confirm all requirements with manufacturer(s) in order to bid a complete working package.

I. Indicators as follows:
   1. Running time meters for each motor, in accordance with Specification 16902, Electrical Controls, Relays, and Alarms.

J. Enclosures And Control Panels
   1. Provide in accordance with Section 16161, Control Panels.

K. The Pump Systems shall be supplied for a single source of power (480 VAC, 3-phase). All power and control transformers shall be provided as required. Transformers shall be sized and protected by fuses as required by NEC as a minimum.

L. The Pump Systems shall include transient voltage surge suppressors in accordance with Section 16902, Electrical Controls, Relays, and Alarms.

M. The Pump Systems shall include auxiliary relays, amplifiers, and connections needed for transmission of specified information to the remote location. Auxiliary relays shall also be provided for control and status communication above and beyond the standard control panel.

PART 3 - EXECUTION

3.1 GENERAL

A. Electrical Power and Control:
   1. The CONTRACTOR shall provide electrical power for all the packaged units, including, but not limited to, all equipment, instruments, devices, controls, alarms, lights, etc., as recommended by the equipment manufacturer(s) installation instructions and recommendations, and the Contract Documents.

B. The CONTRACTOR shall review, verify, and confirm all requirements with the manufacturer in order to bid a complete working package and system. This includes, but is not limited to, package control panel, power distribution panel, transformer(s), conductors, inter/intra connections and all other Work needed for a complete working system.

C. In the situation that a system is not specified and/or the CONTRACTOR is proposing an equal system, the CONTRACTOR shall provide all necessary equipment, instruments, devices, controls, alarms, lights, conduits, conductors, inter/intra connections, etc., in order to provide a complete system. These requirements are above and beyond what is shown on the Drawings and/or specified in the Specifications. The CONTRACTOR shall be fully responsible for any and all work resulting from changes requiring more than what is indicated on the Contract Documents.

D. The CONTRACTOR shall refer to Civil, Structural, Architectural, Mechanical, Electrical, P&ID Drawings, control descriptions, and all collective Contract

Documents for complete information, requirements, implementations, and coordination in order to determine the system control logic.

END OF SECTION

SECTION 16010

ELECTRICAL: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes basic requirements for electrical work.

B. Install and wire all equipment, including pre-purchased equipment, and perform all tests necessary to assure conformance to the Drawings and Specifications and ensure that equipment is ready and safe before energizing.

C. Related Sections include but are not necessarily limited to:
   1. Division 0, Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1, General Requirements.

D. Drawings Use and Interpretation:
   1. Drawings indicate the location and arrangement of electrical equipment and the approximate location of other equipment requiring electrical work.
      a. For exact locations of building elements, refer to dimensioned architectural/structural drawings.
      b. Field measurements take precedence over dimensioned drawings.

E. Installation of all systems and equipment is subject to clarification as indicated in reviewed Shop Drawings and field coordination drawings.

1.2 AREA CLASSIFICATIONS

A. Outdoor locations may contain corrosive and hazardous areas:
   1. Corrosive and hazardous areas are identified on the Drawings.
      a. Areas not identified as such shall be considered wet.

B. Indoor locations may contain damp, wet corrosive, and hazardous areas:
   1. Damp, wet, corrosive and hazardous areas are identified on the Drawings.
      a. Areas not identified as such shall be considered unclassified.

1.3 DEFINITIONS

A. Outdoor Areas:
   1. Those locations on the Project site where the equipment is normally exposed to wind, dust, rain, snow, etc.

B. Indoor Areas:
   1. Those locations on the Project site where the equipment is normally protected from wind, dust, rain, snow, etc.

C. Shop Fabricated:
   1. Manufactured or assembled equipment for which a UL test procedure has not been established.

1.4 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Iron and Steel Institute (AISI):
      a. Steel Products Manual - Stainless and Heat Resisting Steel.
   2. American National Standards Institute (ANSI):
      a. C2, National Electrical Safety Code.
   3. American Society for Testing and Materials (ASTM):
      a. A36, Specification for Structural Steel.
      b. A153, Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   4. Factory Mutual System (FM):
      a. A Guide to Equipment, Materials and Services.
   5. Institute of Electrical and Electronics Engineers (IEEE):
      a. 141, Recommended Practice for Electrical Power Distribution for Industrial Plants.
      b. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
   6. National Electrical Manufacturers Association (NEMA):
      a. ICS 6, Enclosures for Industrial Controls and Systems.
   7. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   8. Underwriters Laboratories, Inc (UL):
      a. 508, Safety Industrial Control Equipment.
      b. 698, Industrial Control Equipment for Use in Hazardous Locations.

B. When a specific code or standard has not been cited, the applicable codes and standards of the following code-making authorities and standards organizations shall apply:
   1. American Association of State Highway and Transportation Officials (AASHTO).
   2. American Iron and Steel Institute (AISI).
   3. American National Standard Institute (ANSI).
   4. American Society for Testing and Materials (ASTM).
   5. ETL Testing Laboratories, Inc (ETL).
   6. Insulated Cable Engineers Association (ICEA).
   7. Institute of Electrical and Electronic Engineers (IEEE).
   8. Illuminating Engineering Society of North America (IES).
   9. Instrument Society of America (ISA).

10. Lightning Protection Institute (LPI).
11. National Electrical Manufacturers Association (NEMA).
12. National Fire Protection Association (NFPA).
13. Occupational, Health and Safety Administration (OSHA).
14. Underwriters Laboratories Inc (UL).

C. In case of conflict or disagreement between codes, standards, laws, ordinances, rules, regulations, Drawings, and Specifications, or within either document itself, the more stringent condition shall govern.

1.5 SYSTEM DESCRIPTION

A. Provide functional systems in compliance with manufacturer's instructions, performance requirements specified or shown on the Drawings, and modifications resulting from reviewed Shop Drawings and field coordinated drawings.

1.6 SUBMITTALS

A. Shop Drawings:
   1. See Contract Documents for other requirements.
   2. Submit shop drawings prior to purchase or fabrication of equipment. See individual Division 16, Electrical, for specific requirements.
   3. Prior to submittals of Shop Drawings, coordinate electrical equipment, particularly motor control equipment, control panels, and instrumentation, with all applicable equipment and systems interfacing with that equipment.
   4. For each product, clearly identify manufacturer by name.
   5. Provide manufacturer's technical information on products to be used, including:
      a. Product descriptive bulletin.
      b. Electrical data pertinent to the Project and necessary to assure compliance with Specifications and Drawings.
      c. Equipment dimensions, where applicable.
      d. Evidence that the products submitted meet the requirements of the standards referenced.
   6. When general data sheets are provided as part of the submittal, specifically identify the products to be used on this Project.
   7. Ensure that all submittals clearly indicate the equipment is UL or ETL listed or is constructed utilizing UL or ETL listed or UL recognized components. Where an UL standard has not been established, clearly identify that no UL standard exists for that equipment.
   8. For all equipment, provide manufacturer's installation instructions.

B. Operation and Maintenance Manuals:
   1. See Contract Documents for requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

A. See Section 16000.

B. Ensure that equipment is not used as steps, ladders, scaffolds, platforms, or for storage, either inside or on top of enclosures.

C. Protect nameplates on electrical equipment to prevent defacing.

D. Repair, restore, or replace damaged, corroded, and rejected items at no additional cost to the OWNER.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Refer to related Division 16, Electrical.
   1. All equipment of a similar type shall be by one manufacturer, unless otherwise noted in the Specifications.

2.2 MATERIALS

A. Trade names and catalog numbers may be used in the Drawings or Specifications to establish quality standards and basics of design.
   1. Other listed manufacturers in the applicable Specification Sections with equal equipment may be acceptable.
   2. If no other manufacturer is listed, then manufacturers of equal equipment may be acceptable.

B. Listed:
   1. Where UL test procedures have been established for the product type, electrical equipment shall be approved by UL or ETL and shall be provided with the UL or ETL label.

C. Structural Steel Supports:
   1. Galvanized Steel: ASTM A36.
      a. PVC coated in Class I DIV I and in corrosive areas.
   2. Stainless Steel: AISI Type 316.

2.3 FABRICATION

A. When equipment is shop fabricated for the Project, the electrical devices and enclosures utilized shall be UL or ETL listed and labeled or shall be UL recognized.

B. Shop or Factory Finishes:
   1. Interiors of other painted equipment shall be either white or light gray.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed in accordance with the requirements of the NEC.

B. Enclosures for Use with Electrical Equipment:
   1. NEMA 12: Use in unclassified indoor locations.
   2. NEMA 3R: Use with HVAC equipment or outdoor locations.
   3. NEMA 4/4X:
      a. Use in wet indoor locations.
      b. Use in wet outdoor locations except with HVAC equipment.
      c. Use in all corrosive locations.
   4. Exceptions:
      a. As modified in other Division 16, Electrical.
      b. As otherwise indicated on the Drawings.
   5. Standards:
      a. NEMA ICS-6, Enclosures for Industrial Controls and Systems.
      b. UL 508, Safety Industrial Control Equipment.
      c. UL 698, Industrial Control Equipment for Use in Hazardous Locations.

C. Coordinate the installation of electrical equipment with other trades.
   1. Arrange for the building in of equipment during structure construction.
   2. Where equipment cannot be built-in during construction, arrange for sleeves, box-outs, openings, etc., as required to allow installation of equipment after structure construction is complete.

D. Verify that equipment will fit support layouts indicated.

E. Equipment Dimensions and Clearances:
   1. Do not use equipment that exceeds the indicated dimensions.
      a. Except as approved in writing by the ENGINEER.
   2. Do not use equipment or arrangements of equipment that reduce required clearances or exceed the space allocation.

F. Install equipment in accordance with the manufacturer's instructions.

G. Equipment Access:

1. Install equipment so it is readily accessible for operation and maintenance.
2. Equipment shall not be blocked or concealed.
3. Do not install electrical equipment such that it interferes with normal maintenance requirements of other equipment.

H. Equipment shall be installed plumbed, square, and true with the building construction and shall be securely fastened.

I. Outdoor wall-mounted equipment and indoor equipment mounted on earth or water bearing walls shall be provided with corrosion-resistant spacers to maintain 1/4-inch separation between the equipment and the wall.

J. Screen or seal all openings into outdoor equipment to prevent the entrance of rodents and insects.

K. Equipment fabricated from aluminum shall not be placed in direct contact with earth or concrete.

L. Provide all necessary anchoring devices and supports.
   1. Use supports as detailed on the Drawings and as specified.
      a. Where not detailed on the Drawings or specified, use supports and anchoring devices rated for the equipment load and as recommended by the manufacturer.
   2. Supports and anchoring devices shall be rated and sized based on dimensions and weights verified from approved equipment submittals.
   3. Hardware shall be malleable type, corrosion resistant, and shall be supported by heavily plated machine screws or brass, bronze or stainless steel bolts.
   4. Do not cut, or weld to, building structural members.
   5. Do not mount safety switches and external equipment to other equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.

M. Provide concrete foundations or pads required for electrical equipment as indicated or specified.
   1. Floor-mounted equipment shall be mounted on a 4-inch high concrete housekeeping pad. Pad shall be poured on top of the finished floor or slab.

N. Material that may cause rusting or streaking on a building surface shall not be used.

O. To avoid interference with structural members and equipment of other trades, it may be necessary to adjust the intended location of electrical equipment. Unless specifically dimensioned or detailed, the CONTRACTOR may, at his discretion, make minor adjustments in equipment location without obtaining the ENGINEER'S approval.

P. Provide tagging of electrical equipment, conduits, and conductors in accordance with the Contract Documents.
   1. Each equipment item shall be provided with a nameplate identifying the equipment by the tag number shown on the Drawings.
   2. Each branch circuit and feeder shall be provided with a nameplate identifying, by name and tag number as shown on the Drawings, the load served.
      a. Do not abbreviate.
   3. Each control device shall be provided with an escutcheon defining the device function and a nameplate identifying the controlled equipment.

Q. Provide electrical danger, caution, warning or safety instruction signs in accordance with applicable safety standards.

R. Conduit and wire between temperature control thermostats and the associated HVAC equipment shall be furnished and installed with the equipment (see Division 15, Mechanical, of the Specifications).
   1. Conduit and wire between alarm or shutdown thermostats and air flow switches and the associated alarm devices or panels shall be furnished and installed as part of Division 16, Electrical.
   2. Thermostats included as part of a heat trace system shall be installed as part of Division 16, Electrical.

3.2 FIELD QUALITY CONTROL

A. Do not remove or damage fireproofing materials.
   1. Install hangers, inserts, supports, and anchors prior to installation of fireproofing.
   2. Repair or replace fireproofing removed or damaged.

B. Make all penetrations through roofs prior to installation of roofing.
   1. For penetrations required after installation of roofing:
      a. In built-up roofing (BUR), provide all curbs, cants and base flashings.
      b. In elastic sheet roofing (ESR), arrange and pay for base flashing work by authorized roofer.

C. Make all penetrations of electrical work through walls and roofs water and weather-tight.

D. Equipment furnished under this Contract for use on future work and all concealed equipment, including conduits, shall be dimensioned, on the Record Drawings, from visible and permanent building features.

E. After installation, test all electrical equipment and systems as recommended by the manufacturer and in accordance with Specification 16920, Electrical Acceptance Testing.

F. Test Equipment Interface:
   1. Verify systems coordination and operation.

3.3 CLEANING

A. Clean dirt and debris from all surfaces.

B. Apply touch-up paint as required to repair scratches, etc.

C. Replace nameplates damaged during installation.

D. Thoroughly vacuum the interior of all enclosures to remove dirt and debris.

3.4 DEMONSTRATION

A. Demonstrate equipment in accordance with the Contract Documents.

END OF SECTION

SECTION 16111

CONDUITS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish and install conduits as required and as shown on the Drawings. Materials employed shall be as shown on the Drawings.

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the ENGINEER has reviewed the submittal data.

B. Shop Drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work.

C. Proposed routing of conduits buried under floor slabs-on-grade.

D. Identify conduit by tag number of equipment served or by circuit schedule number.

E. Proposed routing and details of construction including conduit and rebar embedded in floor slabs, columns, etc. Identify conduit by tag number of equipment served or by circuit schedule number.

F. Proposed location and details of construction for openings in slabs and walls for raceway runs.

G. Refer to Section 16000, General Electrical Requirements, for further submittal requirements.

1.3 REFERENCES

A. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc-Coated.

B. National Electric Manufacturers Association (NEMA), RN-1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit.

C. Underwriters Laboratories Inc. (UL):

1. 1, Flexible Metal Conduit.
2. 6, Rigid Metal Conduit.
3. 360, Liquid-Tight Flexible Steel Conduit.
4. 467, Grounding and Bonding Equipment.
5. 514, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers.
6. 651, Schedule 40 and 80 Rigid PVC Conduit.
7. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
8. 884, Underfloor Raceways and Fittings.
9. 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

PART 2 - PRODUCTS

2.1 RACEWAYS

A. Exposed conduit in an unclassified or hazardous area shall be galvanized rigid steel (GRS) unless specifically indicated otherwise on the Drawings. Conduits in wet and corrosive areas shall be PVC coated GRS, unless otherwise indicated. Underground and/or concrete encased conduits shall be PVC, unless otherwise indicated. All wiring, except as otherwise noted, shall be in conduit. Conduit size shall not be less than the National Electrical Code (NEC) size required for the conductors therein and shall not be smaller than 3/4-inch. No underground conduit shall be less than 1-inch.

B. Condulet type fittings shall be Crouse-Hinds, Appleton, or equal with wedge nut covers. All condulets located outdoors or in wet locations shall be weathertight.

C. In unclassified areas, flexible conduit shall be grounding type, weatherproof, corrosion resistant, and watertight.

D. Couplings, connectors, and fittings shall be standard types specifically designed and manufactured for the purpose. They shall be installed to provide a firm mechanical assembly and electrical conductivity throughout.

E. Expansion fittings shall be OZ type AX with jumper for exposed locations and Type DX at structural expansion joints, Spring City, or equal. Conduits shall have expansion fittings in accordance with NEC.

F. The conduits and fittings shall be supported per NEC requirements as a minimum.

2.2 GALVANIZED RIGID STEEL (GRS)

A. Conduit and couplings shall be hot-dipped galvanized with zinc coated threads and outer coating of zinc bichromate, in accordance with ANSI C80.1 Standards, as manufactured by Jones & Laughlin Steel Corporation, Allied Tube & Conduit Corporation, Triangle PWC, or equal.

B. Steel conduit shall not be buried in earth without concrete encasement and additional corrosion protection. A half lapped rapping of 20 mil PVC based corrosion protection tape shall be used.

2.3 PVC COATED GALVANIZED RIGID STEEL (PVC-GRS)

A. PVC coated GRS conduit shall be installed where shown on the Drawings or elsewhere specified and shall conform to NEMA RN-1 and ANSI C80.1 Standards.

B. The zinc surface of the conduit shall remain intact and undisturbed on both the inside and the outside of the conduit throughout the preparation and application processing. A Polyvinyl Chloride (PVC) coating shall be bonded to the galvanized outer surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic. The thickness of the PVC coating shall be a minimum of 0.040-inch (40 mil).

C. A loose coupling shall be furnished with each length of conduit. A PVC coating shall be bonded to the outer surface of the coupling and a PVC sleeve equal to the outside diameter of the uncoated conduit shall extend beyond both ends of the coupling approximately one pipe diameter or 1-1/2-inches, whichever is smaller. The wall thickness of the coating on the coupling and the sleeve shall be a minimum of 0.040-inch (40 mil).

D. A PVC coating shall be bonded to the inner and outer surface of all conduit bodies and fittings and a PVC sleeve shall extend from all hubs. The wall thickness of the coating on conduit bodies and fittings and the sleeve walls shall be identical to those on couplings in length and thickness. The covers on all conduit bodies shall be coated on both sides and shall be designed to be completely interchangeable. The inside of conduit bodies shall remain undisturbed in the processing.

E. Type 304 stainless steel screws shall be furnished and used to attach the cover to the conduit body. All coated material shall be installed and patched according to the manufacturer's recommended installation and patching instructions.

F. Conduit straps shall be PVC coated or stainless steel.

G. PVC coated conduit and fittings shall be as manufactured by Rob-Roy, or equal.

H. PVC coated flexible conduits shall be liquid and vaportight and manufactured in accordance with UL 360 Standards.

2.4 RIGID NONMETALLIC – PVC

A. Where specifically indicated on the Drawings, or elsewhere specified, conduit may be high density Schedule 40, 90° C, heavy-duty PVC. The conduit shall be manufactured from virgin polyvinyl chloride compound which meets ASTM D1784, NEMA TC-2, ANSI C33.91, and UL 651 Standards. Smoke emissions shall be limited to less than 6 grams per 100 grams of material tested.

B. Where conduit concrete encasement is indicated on the Drawings, conduit supports shall be installed at 5 foot intervals. PVC conduit shall be manufactured by Carlon, Triangle Conduit & Cable, or equal.

2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Liquidtight flexible metal conduit shall be liquid and vaportight, oil and ultraviolet ray resistant, and manufactured in accordance with UL 360 Standards. Liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, galvanized steel core with an extruded PVC jacket. The PVC jacket shall be rated for high ambient heat applications, 90° Celsius.

B. For corrosive locations, liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, aluminum core with an extruded PVC jacket. The PVC jacket shall be impervious to corrosive liquids and vapors.

C. An external bonding conductor shall be required for flexible conduit connections containing circuits rated at 60 amps or greater and for sizes 1-1/2-inches or larger. Flexible conduit and connectors for 1-1/4-inches and smaller shall be listed for grounding.

D. Connectors for liquidtight flexible conduit shall be galvanized, furnished with a sealing ring and locknut, and suitable for wet locations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conduit runs are schematic only, and shall be modified as required to suit field conditions, subject to review and acceptance by the ENGINEER.

B. Conduit shall run continuously between outlets and shall be provided with junction boxes where connections are made. Couplings, connectors, and fittings shall be acceptable types designed and manufactured for the purpose, and shall provide a firm mechanical assembly, and electrical conductivity throughout.

C. Conduit runs shall be straight and true. Elbows, offsets, and bends shall be uniform and symmetrical. Changes in direction shall be made with long radius bends, or with fittings of the condulet type.

D. Conduit runs in buildings and structures shall be exposed except as specifically noted or accepted by the ENGINEER.

E. Conduit runs shall not interfere with the proper and safe operation of equipment, and shall not block or interfere with ingress or egress, including equipment removal hatches.

F. Exposed conduits shall be securely fastened with clamps, or straps, intended for conduit use. All exposed conduit shall be run on the walls and ceiling only and shall be parallel to the planes of the walls or ceiling. No diagonal runs will be permitted. Flexible conduit shall be used only for short lengths required to facilitate connections between rigid conduit to motors from junction boxes, or control equipment.

G. Conduit runs on water-bearing walls shall be supported 1-inch away from the wall on an accepted channel. When channel galvanizing, or other coating, is cut or otherwise damaged, it shall be field coated to original condition. No conduit shall be run in water-bearing walls, unless specifically designated otherwise.

H. Conduit shall be thoroughly reamed to remove burrs. GRS shall be reamed during the threading process, and rigid nonmetallic PVC shall be reamed before applying fittings. A zinc rich cold galvanizing shall be used to restore corrosion protection on field cut threads. Bushings and lock nuts or hubs shall be used at conduit terminations. The total number of bends in any run between pull points shall not exceed 360 degrees. Junction boxes and pull boxes shall be installed at points acceptable to the ENGINEER. Conduit ends shall be plugged to prevent the entrance of moisture or debris during construction. All spare conduits shall be adequately capped and shall contain a suitable pull string.

I. Joints shall be set up tight. Hangers and fastenings shall be secure, and of a type appropriate in design, and dimensions, for the particular application.

J. Conduit runs shall be cleaned and internally sized (obstruction tested) so that no foreign objects, or obstructions remain in the conduit prior to pulling in conductors.

K. After installation of complete conduit runs 2-inches and larger, conduits shall be snaked with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85% of the nominal diameter of the conduit. Conduits through which the mandrel will not pass shall not be used.

L. Expansion fittings shall be installed across all expansion joints and at other locations where necessary to compensate for thermal expansion and contraction.

M. Provide trenching, backfill, and compaction for conduits installed underground.

N. Unless approved in advance by the ENGINEER, all conduits which transition from underground to aboveground will utilize galvanized rigid steel conduit for the bend from horizontal to vertical and for the extension above the ground. Factory 90 degree GRS bends shall be used. GRS bends and conduits shall be half lapped with 20 mil PVC tape in non-corrosive areas and shall be PVC coated rigid steel in corrosive areas. Tape wrapping shall extend a minimum 6-inches above top of slab or above finished grade.

O. Liquid tight flexible metallic conduit 1-1/2-inch and larger shall be provided with grounding style bushings and shall have an external ground wire sized and installed in accordance with the NEC.

END OF SECTION

SECTION 16123

600 VOLT CLASS CABLE

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section covers the furnishing and installation of 600 volt class cables and conductors, terminations and splicing, and pulling lubricants.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

1.3 REFERENCES

A. Insulated Cable Engineers Association/National Electrical Manufacturers Association (ICEA/NEMA):
   1. S-68-516/WC 8, ethylene-propylene rubber-insulated wire and cable for the transmission and distribution of electrical energy.
   2. S-61-402/WC 5, thermoplastic-insulated wire and cable for the transmission and distribution of electrical energy.
   3. S-66-524/WC 7, cross-linked thermosetting-polyethylene-insulated wire and cable for transmission and distribution of electrical energy.

B. Underwriters Laboratory, Inc.
   1. 44, rubber insulated wires and cables.
   2. 83, thermoplastic-insulated wires and cables.
   3. 486A, wire connectors and soldering lugs for use with copper conductors.
   4. 486B, wire connectors for use with aluminum conductors.
   5. 510, insulating tape.

C. National Electric Code.

D. Insulated Cable Engineers Association.

PART 2 - PRODUCTS

2.1 ACCEPTED MANUFACTURERS

A. Conductors and Multi Conductor Cables (MCC), subject to compliance with Contract Documents, the following manufacturers are acceptable: American

Insulated Wire Corporation, Cablec Corporation, Okonite Company, Southwire Company, or equal.

2.2 CONDUCTORS

A. Wire sizes shall be American Wire Gauge (AWG) sizes with Class B stranded construction. No. 2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape. Conductors sized No. 1 and larger shall be Type 2, rated for 90° C. For indoor installations, all circuit conductors, #6 or smaller shall be "THWN" stranded copper. All other conductors shall be "XHHW" stranded copper. All circuits that run outdoors, whether exposed or underground shall be “XHHW” stranded copper for all conductor sizes.

B. Individual or multiple conductor cables for power, control, and alarm circuits of 480 volts or less shall be insulated for not less than 600 volts and shall have insulation type as indicated on the Drawings. "THHW" shall conform to ICEA S-61-402/NEMA WC 5 and UL 83 and "XHHW" shall conform to ICEA S-66-524/NEMA WC 7 and UL 44. Where wire size is not indicated, they shall be of the size required by the NEC, except that no wire external to panels and motor control centers shall be less than No. 12 AWG, unless specifically noted on the Drawings. Panel control wiring shall not be less than No. 14 AWG.

C. All wiring shall be as indicated on the Drawings. Wires shall be new and shall be soft drawn copper with not less than 97% conductivity. The wire and cable shall have size, grade of insulation, voltage, and manufacturer's name permanently marked on the outer covering at not more than 2 foot intervals. All wires shall conform to the latest Standards of the ASTM, and ICEA, and shall be tested for their full length by these Standards. Insulation thickness shall be not less than that specified by the National Electrical Code.

2.3 TERMINATIONS AND SPLICES

A. Cable shall be rated 600 volts. Other parts of cable systems such as splices and terminations shall be rated at not less than 600 volts. Splicing shall join conductors mechanically and electrically to provide a complete circuit prior to installation of insulation.

B. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, Type I, Class 1, Grade B, Style G, or Type II, Class 1 of FS W-S-610 and conforming to the applicable requirements of UL 486A.

C. Splices in wires No. 8 AWG and larger shall be made with noninsulated, solderless, pressure type connector, Type II, Class 2 of FS W-S-610, conforming

to the applicable requirements of UL 486A and UL 486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket.

D. Insulated conductor splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

E. Bare conductor splices in wet locations or below grade shall be of the exothermic type.

2.4 PULLING LUBRICANT

A. All cables shall be properly coated with pulling compound such as ClearGluide, Aqua Gel, Polywater, or equal before being pulled into conduits so as to prevent mechanical damage to the cables during installation. "Yellow 77" is not acceptable.

B. Other lubricants to be substituted must be accompanied by a statement from the cable manufacturer as to its acceptable use with the cable being installed.

2.5 IDENTIFICATION

A. All conductors shall be numbered with "tube sleeve" type tags with heat impressed letters and numbers.

B. Color code all wiring as follows:
   1. Lighting and Power Wiring:

Conductor	**120/208 VAC**	**480VAC**	**24V DC**	**120 VAC Control/ Power**
Phase 1	Black	Brown	Blue	Red
Phase 2	Red	Orange	(-) Blue w/ white stripe	
Phase 3	Blue	Yellow		
Neutrals	White	White		White

   2. Color code ends of feeder phase conductors only.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The pulling tension and side-wall pressures, as recommended by the cable manufacturer, shall not be exceeded.

B. As far as practical, all circuits shall be continuous from origin to termination without splices in intermediate pull boxes. Sufficient slack shall be left at the termination to make proper connections. In no case shall a splice be pulled into the conduit. Conductor splicing shall not be permitted without the ENGINEER'S approval.

C. Install all cables in conduit.

D. Each feeder and branch circuit shall be installed in its own individual conduit, unless combining feeder and branch circuits is permitted as defined in the following:
   1. As specifically indicated on the Drawings.
   2. For lighting, multiple branch circuits may be installed in a conduit as allowed by the NEC and with the wire ampacity derated in accordance with the requirements of the NEC. Conduit fill shall not exceed the limits established by the NEC.
   3. When field conditions dictate and written permission is obtained from the ENGINEER.

E. Feeder and branch circuits shall be isolated from each other and from all instrumentation and control circuits.

F. Control circuits shall be isolated from all other feeder, branch and instrumentation circuits, except as noted below:
   1. 12 VDC, 24 VDC and 48 VDC control circuits may be combined in common conduit.
   2. 125 VDC control circuits shall be isolated from all other DC and AC control circuits.
   3. 120 VAC control circuits shall be isolated from all DC control circuits.

G. Make splices only at pull or junction boxes.
   1. Crimp or indented-type connectors are not allowed, except for control circuits landed on terminal strips.

3.2 TESTING

A. In accordance with Specification 16920 Electrical Acceptance Testing.

END OF SECTION

SECTION 16124

INSTRUMENTATION CLASS CABLE

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section covers cable use for process signal and controls.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with Contract Documents, the instrumentation cable shall be as manufactured by Belden, Okonite, or equal.

2.2 INSTRUMENTATION CABLE

A. Instrument cable shall be Type TC, and have the number of individually shielded twisted pairs indicated on the Drawings and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be No. 16 AWG minimum. Shielded, grounded instrumentation cable shall be used for all analog signals.

B. The jacket shall be flame retardant with 90° C temperature rating. The cable shield shall be a minimum of 2.3 mil aluminum or copper tape overlapped to provide 100% coverage and a tinned copper drain wire.

C. The conductors shall be bare soft annealed copper, Class B, 7 strand minimum concentric lay with 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90° C temperature rating. One conductor within each pair shall be numerically identified.

D. Pairs shall be assembled with a nominal 2-inch lay and shall then be group shielded with a minimum of 1.3 mil aluminum or copper tape overlapped to provide 100% coverage. All group shields shall be completely isolated from each other.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Feeder and branch circuits shall be isolated from each other and from instrumentation and control circuits. Instrumentation cables shall be installed in separate raceways from other cables and wiring. This includes portions running through manholes. Instrumentation cable shall be continuous between instruments or between field devices and instrument enclosures. There shall be no intermediate splices or terminal boards, unless otherwise shown on the Drawings.

B. Maintain electrical continuity of the shield when splicing twisted shielded pair conductors. Drain wires shall be terminated inside enclosures at grounded terminal blocks. Only one end of each instrument loop cable drain wire shall be grounded. Ground drain wire of shielded conductors at one end only.

C. Terminate instrumentation and control wiring, including spare wires, at control panels and motor control centers on terminal boards mounted inside the equipment.
   1. Contractor shall supply terminal boards as required.
   2. Do not field wire directly to devices.

END OF SECTION

SECTION 16130

OUTLET, PULL, AND JUNCTION BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes outlet, pull and junction boxes.

B. Related Sections include but are not necessarily limited to:
   1. Division 0, Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1, General Requirements.
   3. Section 16000, General Electrical Requirements.
   4. Section 16111, Conduits.
   5. Section 16141, Wiring Devices.
   6. Section 16170, Grounding.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Refer to Section 16000, General Electrical Requirements.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Refer to the Contract Documents and Section 16000, General Electrical Requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

A. See Section 16000, General Electrical Requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Sheet Metal Boxes for Indoor and Non-classified Areas:
      a. Hoffman Engineering Co.
      b. Rittal.
   2. Boxes for Outdoor and Corrosion Areas:
      a. Hoffman Engineering Co.
      b. Rittal.

3. Hazardous Location Boxes (Class I, II & III):
    a. Appleton Electric Co.
    b. Crouse-Hinds.
    c. Killark.
    d. O-Z/Gedney.
4. Raintight and Watertight Boxes:
    a. Appleton Electric Co.
    b. Crouse-Hinds.
5. Terminal Boxes:
    a. Hoffman Engineering Co.
6. Boxes in Sidewalk:
    a. Appleton Electric Co.
    b. Crouse-Hinds.
    c. O-Z/Gedney.
7. Boxes in Earth:
    a. Carlon Electric Products.
8. Exposed Switch and Receptacle Boxes:
    a. Appleton Electric Co.
    b. Crouse-Hinds.
    c. Killark.

B. Submit requests for substitution in accordance with the General Conditions.

2.2 MATERIALS

A. Pull and Junction Boxes for Offices and other Dry Architecturally Finished Areas:
    1. Material: 14 gauge, galvanized steel.
    2. Concentric knockouts on all four sides.
    3. Flat cover fastened with screws.
    4. NEMA 1 Classification.
    5. UL listed.

B. Pull and Junction Boxes for General Use Indoors in Unclassified Areas:
    1. Material: 14 gauge galvanized steel with seams continuously welded, ground smooth and no knockouts.
    2. Zinc rich coating on all seams.
    3. Stainless steel captivated cover screws threaded into sealed wells.
    4. Flat door with oil resistant gasket.
    5. NEMA 12 Classification.
    6. UL listed.

C. Pull and Junction Boxes for Outdoor and Corrosive Areas:
    1. Material: 316 Stainless Steel.
    2. Stainless Steel boxes:
    3. Seams continuously welded, ground smooth, no knockouts.
    4. Rolled lip around all sides.

5. Hinged door.
6. Captivated stainless steel door screws.
7. Flat door with oil-resistant gasket.
8. NEMA 4X Classification.
9. UL listed.

D. Pull and Junction Boxes for Hazardous Areas:
   1. Material: Cast gray iron alloy or copper-free cast aluminum.
   2. Drilled and tapped openings or tapered threaded hub equipped.
   3. Flat bolted down or threaded cover with neoprene gasket.
   4. Stainless steel hex head screws.
   5. Explosion proof, UL listed for Class 1, Groups C and D.

E. Pull and Junction Boxes for Sidewalks:
   1. Cast iron box and cover, hot-dip galvanized.
   2. Flange for flush mounting.
   3. Checkered cover with neoprene gasket, pry bar slots, and stainless steel screws.
   4. UL listed.
   5. Drilled and tapped holes.
   6. Watertight NEMA 4 Classification.

F. Large Pull and Junction Boxes (100 cubic inches and larger):
   1. Located in offices and other dry architecturally finished areas where EMT is utilized:
      a. NEMA 1 gasketed without knockouts.
   2. Located in general use areas:
      a. NEMA 12 construction:
         1) Welded steel.
         2) Furnished with gray enamel inside and out over phosphatized surfaces.
   3. Located in wet and corrosive areas:
      a. NEMA 4X with stainless steel screws.
      b. Type 304 L welded stainless steel:
   4. Constructed of 14 gauge steel with seams continuously welded, ground smooth, no knockouts.
   5. Rolled lip around all sides.
   6. Rigid handles for covers larger than 9 sq. ft. or heavier than 25 lbs.
   7. Split covers when heavier than 25lbs.

G. Terminal Boxes:
   1. Galvanized 16 gauge steel box provided with plain blank screw cover, subpanel, and terminal points.
   2. Refer to Drawing for dimensions and number of terminals.
   3. Terminal blocks shall be screw-post barrier-type, white center marker strip.
   4. Rated 20 ampere, minimum 600 V.

H. Fiberglass Cable-Pulling Enclosure:
   1. Use: Access points to facilitate pulling of electrical cables in buried conduit runs.
   2. Size and quantity: As shown on Drawings.
   3. Type: Rectangular fiberglass composite, suitable for direct burial pedestrian traffic on top, -50° F, chemical, sunlight, and weather resistant.
   4. Provide matching top with "ELECTRIC" logo.

I. Outlet Boxes:
   1. Use: Installation of wiring devices.
   2. Boxes for Exposed Wiring:
      a. Cadmium plated, cast, ferrous metal, with threaded hubs.
   3. Boxes for Concealed Wiring:
      a. Code gage, hot-dip galvanized steel.
      b. Include bar hangers for metal stud partitions.
      c. Provide barriers between switches in boxes with 277 V switches on opposite phases.
      d. Use extension and plaster rings where required.
      e. Provide grounding screw.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Use locknut and bushing for boxes in non-classified areas.

B. Use cast metal boxes with threaded conduit hubs in hazardous areas.

C. Use Type FS and FD boxes in wet areas and where exposed rigid steel conduit is required.

D. Use epoxy resin coated, stainless steel, cast aluminum or fiberglass boxes for corrosive areas.

E. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.

F. Use outlet boxes sized to accommodate quantity of conductors enclosed.

G. Use boxes sized to accommodate conduit tying into box.

H. Install pull boxes or junction boxes in conduit runs where indicated or required to facilitate pulling of wires or making connections.
   1. Make covers of boxes accessible.

I. Install pull boxes or junction boxes rated for the area classification.

J. Install rigid conduit squarely into boxes which do not have hubs or are drilled and tapped.

K. Install with locknut on the outside and bushing on inside.

L. Install conduit into boxes with hubs, or that are tapped, using thread lubricant.

M. Do not use back-to-back boxes on this Project.

N. Seal all points of conduit entry into fiberglass cable-pulling enclosures for a waterproof installation.

O. Support outlet boxes for incandescent fixtures and other ceiling-mounted devices in lay-in acoustical tile ceilings by bar hangers anchored to ceiling construction members which do not interfere with tile removal.

END OF SECTION

SECTION 16140

PORTABLE GENERATOR CONNECTION PANEL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install a generator connection panel for use with portable generators.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code (NEC).
   2. UL Standard No. 857, Busways.
   3. UL Standard No. 1773, Termination Boxes.
   4. UL Standard No. 886, Electrical Outlet Boxes and Fittings for Use in Hazardous Locations.

1.3 SUBMITTALS

A. Shop Drawings: Submit for review the following:
   1. Manufacturer's technical information for the proposed portable generator connection panel. Including, but not limited to, all device cut-sheet information, generator connection panel dimensions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Generator Connection Panel: Provide connection panel based upon location in accordance with NEMA requirements and as required for the area classification specified in Section 16050, General Provisions.
   1. Material and Construction:
      a. One hinged double door front cover, free standing, enclosure.
      b. Front double door hinged covers with 3-point Locking Tee Handle.
      c. Bottom front hinged cover door for generator cable entry or install Myers Hubs with plugs.
      d. NEMA 3R, manufactured from 12 gauge A60 UL Galvanneal steel and painted ANSI 61 Gray Enamel.

e. Neoprene gaskets. Gaskets shall be of an approved type designed for the purpose. Improvised gaskets are not acceptable.
f. Stainless steel cover bolts.
g. Conduit holes as needed. Coordination with ENGINEER is required.
h. Portable Generator Connection Panel shall be UL listed and identified as such with an appropriate nameplate mounted on the inside of the panel.

2. Single Pole Cam-Type Connectors:
   a. UL Listed, CSA certified, NEMA 3R, 30 Amp, 600V rating.
   b. 4/0 cable receptive, female threaded stud style panel receptacle
   c. Colors of Brown, Orange, Yellow, White and Green corresponding to Phase A, Phase B, Phase C, Neutral and Ground, respectively.
   d. Female protective cap in the same color as the associated receptacle. Secured near receptacle for easy removal.
   e. Manufacturer:
      1) Leviton, 16-Series.
      2) Or Equal.
3. Standoff Insulators:
   a. UL recognized, 2700V rating.
   b. 2-1/4" height with ½" x 13 x 5/8" deep thread size.
   c. Manufacturer:
      1) Glastic, 2015-Series.
      2) Or Equal.
4. Copper Bus:
   a. 99.9% conductivity bar-type copper, ¼" x 4". Length as required.
   b. Bus bar shall be capable of carrying its rated current continuously without exceeding a temperature rise of 65 degrees C based on a 40 degree C ambient.
   c. Multiple bus bars may be used, as required, to increase ampacity.
   d. Spacer plates, of the same material and size, shall be used as necessary for proper construction.
   e Manufacturer.
      1) Stormcopper.
      2) Or Equal.
5. Conductor Lugs:
   a. 2-Hole Copper-to-Copper with tin-plated finish.
   b. ¼" stud size. Barrel size as required.
   c Manufacturer:
      1) Grainger - Part Number 3LM08.
      2) Thomas & Betts - Part Number 54275.
      3) Or Equal.
6. Product and Manufacturer: Provide one of the following Generator Connection Panels.
   a. EATON – Rollup Generator Termination Box.
   b. Or Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Generator Connection Panel shall be provided and installed as shown on the drawings. The connection panel shall also be installed in fully accessible location. Sufficient access and working space to be provided with enough clearance to permit OWNER to place trailer mounted generator in front of connection panel.

B. Securely fasten Terminal Box to concrete pad.

C. Perform the following minimum tests and checks before energizing equipment.
   1. Perform insulation resistance tests on each conductor from generator connection panel to MCC or switchpanel. Perform phase-to-phase and each conductor phase-to-ground for a period of one minute at 1500 volts DC.

D. The manufacturer shall submit the test results to the ENGINEER to confirm that the connection panel assembly has been tested to substantiate conformance with the applicable ANSI and NEMA Standards.

END OF SECTION

SECTION 16141

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Light switches, receptacles, device plates, dimmers, plug-in strips and tele-power poles.

B. Related Sections include but are not necessarily limited to:
   1. Division 0, Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1, General Requirements.
   3. Section 16000, General Electrical Requirements.
   4. Section 16130, Outlet, Pull, and Junction Boxes.
   5. Section 16170, Grounding.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Refer to Section 16000, General Electrical Requirements.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Refer to the Contract Documents and Section 16000, General Electrical Requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Light Switches (except explosion proof):
      a. Hubbell.
      b. Slater.
      c. P&S.
      d. Arrow Hart.
      e. General Electric.
      f. Leviton.

2. Explosion-Proof Light Switches:
    a. Crouse-Hinds.
    b. Appleton Electric Co.
    c. Killark.
3. Door Switches:
    a. General Electric.
    b. Slater.
    c. P&S.
    d. Arrow Hart.
    e. Micro-switch.
4. Receptacles (except explosion proof):
    a. Hubbell.
    b. Slater.
    c. P&S.
    d. Arrow Hart.
    e. General Electric.
    f. Leviton.
5. Explosion-Proof Receptacles:
    a. Crouse-Hinds.
    b. Appleton Electric Co.
    c. Killark.
6. Welding Receptacles:
    a. Crouse-Hinds.
    b. Appleton Electric Co.
7. Tele-power Poles:
    a. Wiremold.
    b. Walker.
8. Dimmers:
    a. Lutron.
    b. General Electric.
    c. P&S.
9. Plug-in Strip:
    a. Wiremold.
    b. Walker.

B. Submit requests for substitution in accordance with the General Conditions.

2.2 MATERIALS

A. Light Switches for Unclassified Areas:
    1. Toggle type, quiet action, specification grade with grounding terminal.
    2. Back and side wired.
    3. Solid silver cadmium oxide contacts.
    4. One-piece switch arm rated 20 A, 120/277 VAC.
    5. UL listed.
    6. Color: Ivory.

7. Wall plate: Type 304 stainless steel.
8. Type: As indicated on Drawings.

B. Receptacles for Unclassified Areas:
1. Straight blade, grounding type, specification grade.
2. Back and side wired with wrap-around bridge.
3. Rated 20 A, 125 VAC.
4. UL listed.
5. Color:
   a. For use on normal power: Ivory.
   b. For use on UPS systems: Red.
   c. For use on isolated ground systems: Orange.
6. Wall plate: Type 304 stainless steel.
7. Type: As indicated on Drawings.

C. Light Switches for Wet Areas:
1. Presswitch type, quiet action, specification grade, with grounding terminal.
2. Back and side wired.
3. Solid silver cadmium oxide contacts.
4. One-piece switch arm rated 20 A, 120/277 VAC.
5. UL listed.
6. Color: Ivory.
7. Wall plate: Gray weatherproof presswitch type.
8. Type: As indicated on Drawings.

D. Receptacles for Wet Areas:
1. Straight blade, grounding type, specification grade.
2. Back and side wired with wrap around bridge.
3. Rated 20 A, 125 VAC.
4. UL listed.
5. Color: Ivory.
6. Wall Plate: Weatherproof, cast aluminum, UL listed, WDL open and closed.
7. Type: As indicated on Drawings.

E. Ground Fault Circuit Interrupter Receptacles:
1. Straight blade, grounding type, specification grade.
2. Rated 20 A, 125 VAC.
3. UL listed.
4. Test and reset buttons.
5. Wall plate: Indoor or weatherproof as required.
6. Feed-through type.

F. Light Switches for Corrosive Areas:
1. Corrosion-resistant NEMA 4X enclosure with switch consisting of:
   a. NEMA 4X Stainless Steel enclosure.

b. Stainless Steel gasketed wall plate with built-in toggle lever switch with stainless steel shaft.
c. Grounding bushing.
d. Rated 20 A, 125 VAC.
e. UL listed.
f. Type: As indicated on Drawings.
g. Color: Yellow.

2. Optional: Corrosion-resistant enclosure and switch consisting of:
a. Cast copper-free aluminum "FS" or "FD" ridge type hub box.
b. Toggle type, quiet action, specification grade with grounding terminal.
c. Rated 20 A, 125 VAC with solid silver cadmium oxide contacts.
d. UL listed.
e. Neoprene gasket.
f. Cast aluminum cover with stainless steel screws and lever to activate switch.
g. Type: As indicated on Drawings.
h. Color: Yellow.

G. Receptacles for Corrosive Areas:
1. Corrosion-resistant straight blade, grounding type, specification grade.
2. Back and side wired with wrap-around bridge.
3. Rated 20 A, 125 VAC.
4. UL listed.
5. Color: Yellow.
6. Box: "FS" or "FD" ridge type cast hub box of copper-free aluminum.
7. Gasket: Neoprene.
8. Wall plate: Weatherproof, cast aluminum, UL listed, WDL open or closed.
9. Type: As indicated on Drawings.

H. Explosion-proof Light Switches for Use in Hazardous Areas:
1. Explosion-proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2 areas, Groups E, F, and G.
2. EDS factory sealed.
3. Malleable iron body and cover.
4. Aluminum sealing chamber.
5. Front operated handle with stainless steel shaft.
6. Rated 20 A, 125 VAC.
7. With grounding screw.
8. Type: As indicated on Drawings.

I. Explosion proof Receptacles for Use in Hazardous Areas:
1. Explosion-proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2, Groups F and G.
2. Factory-sealed malleable iron receptacle with spring-loaded cover.
3. Malleable iron mounting box.
4. Rated 20 A, 125 VAC.

5. "Dead-front" construction requiring plug to be inserted and rotated to activate receptacle.
6. Type: As indicated on Drawings.

J. Welding Receptacles:
1. 60 A, 480 V, 3-pole, 4-wire, grounding type.

K. Plug-In Strip: Surface steel raceway plug-in strip with single 15 A, 125 V, 3-wire grounding-type receptacles spaced 18-inch on center.
1. Prewired with two #12 TW and one #12 TW green insulated ground.
2. Minimum 1-1/4-inch wide by 3/4-inch deep.
3. Suitable fittings and snap-in cover.
4. Finish:
   a. Stainless steel.
5. Receptacle Color:
   a. For use on normal power: Ivory.
   b. For use on UPS systems: Red.
   c. For use on isolated ground systems: Orange.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount devices where indicated on the Drawings and as scheduled in Section 16010, Electrical: Basic Requirements.

B. Surface-mount receptacles and light switches in concrete construction.

C. In masonry and metal stud construction, recess-mount receptacles and light switches unless device precludes recessed mounting or unless otherwise noted on the Drawings.

D. Where more than one receptacle is installed in a room, they shall be symmetrically arranged.

E. Set switches and receptacles plumb and vertical to the floor.

F. Set recess-mounted switches and receptacles flush with face of walls.

G. Do not connect dimmers to loads in excess of 80% of the rating of the dimmer.

H. Provide blank plates for empty outlets.

END OF SECTION

SECTION 16142

WEATHERPROOF WHILE IN USE OUTLET ENCLOSURES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. These Specifications encompass outlet enclosures used on outlet devices where outlets are required to be weatherproof and/or physically protected while in use or idle.

B. These safety outlet enclosures shall be used in locations where attachment plugs will be connected permanently, or for an indefinite period of time, in potentially wet or weather exposed environments.

C. They are also to be used where outlets are subject to contamination, corrosion, or damage.

1.2 DESCRIPTION

A. The safety outlet enclosure shall consist of a suitable style outlet/receptacle plate with a hinged safety cover.

B. The safety outlet enclosure shall have cord port(s) capable of allowing an appropriate size electrical cord(s) to pass through when safety cover is closed.

C. The safety outlet enclosure shall have a latching mechanism to allow the enclosure to maintain weatherproof integrity. The latch shall be a tamper resistant (locking/security) style in areas where security is needed.

D. The safety outlet enclosure shall be sufficient depth to allow full closure with attachment plug(s) in use.

1.3 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and the Contract Documents, prior to installation.

1.4 MANUFACTURER

A. Manufacturer shall be Taymac Corporation, or equal.

PART 2 - PRODUCTS

2.1 WEATHERPROOF WHILE IN USE OUTLET ENCLOSURES

A. The enclosures shall be used in outdoor locations, where attachment plugs will be connected permanently, or for an indefinite period of time, in potentially wet or weather exposed environments, or as indicated on the Drawings.

B. They are also to be used where outlets are subject to contamination, corrosion, or damage.

C. The enclosure shall consist of a suitable style outlet/receptacle plate with a hinged safety cover, and shall be of sufficient depth to allow full closure with attachment plugs in use.

D. The enclosure shall have cord ports capable of allowing an appropriate size electrical cords to pass through when safety cover is closed.

E. The enclosure shall have a latching mechanism to allow the enclosure to maintain weatherproof integrity. The latch shall be a tamper resistant, and locking style, in areas where security is needed, as shown on the Drawings.

F. The enclosure shall be Underwriters Laboratories (UL) listed per UL Standard 514C for non-metallic boxes, flush device boxes and enclosures, and conform to National Electric Code (NEC), Article 410.57 Paragraphs a and b, Article 110.3 and Article 110.11, pertaining to damp, wet or possible corrosive installations.

G. Body materials shall be of a flame resistant, self extinguishing, ultraviolet inhibiting, impact resistant, polycarbonate resin such as GE Lexan 943A, or Mobay Makrolon 6457. Material must meet UL Standard 94.

H. Gasket materials shall be of sufficient thickness to form a weatherproof seal under normal mounting conditions. Thicknesses; 3/16-inch for base plate and 1/8-inch for covers. Material is to be closed cell neoprene foam by Monarch Rubber A5032, or equivalent, self extinguishing and flame retardant. Material must meet UL Standard 94 HF1.

I. Mounting hardware shall be stainless steel, and of sufficient length to properly secure the device, and ensure seal to mounting surface.

J. The enclosures shall be installed over a weatherproof box and outlet in conformance with the manufacturer's instruction. Cover shall be mounted to insure that access holes for the portable line cords will be located at the lower end of the cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 16143

TERMINAL BLOCKS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section covers terminal blocks for control and other wiring.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

1.3 MANUFACTURERS

A. Terminal blocks shall be Entrelec, Phoenix Contact, Allen-Bradley, or equal.

B. Surge protection blocks shall be Phoenix Contact, Termitrab or equal.

C. Power distribution blocks shall be Gould, Allen-Bradley Corporation, or equal.

PART 2 - PRODUCTS

2.1 TERMINAL BLOCKS

A. Terminal blocks shall mount on standard DIN rail, and be of the size required for conductors therein. A minimum of 25% spares shall be provided in each terminal box. No more than two conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power, and signal commons. Terminal blocks shall be UL rated for 600 volts and 30 amps, minimum.

B. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive two-color bodies, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every two instrument cables terminated. Grounding terminal blocks shall be UL rated for 600 volts, and 20 amps, minimum.

C. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.

D. DIN mount fuse holders shall have blown fuse indicators for DC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be UL listed and rated for 600 volts. Fuse sizes shall not exceed the UL current rating for the fuse holders.

E. DIN rail shall be prepunched, zinc bichromate plated steel. Symmetrical DIN rail shall be 35mm by 7.5mm, minimum.

F. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.

2.2 SURGE PROTECTION BLOCKS (SPB)

Analog inputs and outputs shall be terminated at surge protection blocks (SPB). The SPBs shall be designed for a working voltage of 32 volts, and shall be fused with separate terminal blocks.

A. SPBs shall provide full hybrid line to line protection, and shall have a GDT rating of 10,000 A (8/20μs pulse waveform).

B. SPBs shall be UL94 V-2 listed.

2.3 POWER DISTRIBUTION BLOCKS (PDB)

A. PDBs shall be electro-tin plated and manufactured from high strength 6061-T6 aluminum alloy.

B. PDBs shall be UL Recognized rated 90º C and CSA Certified.

C. PDBs shall provide flexibility in using the connector as an in line splice or to reduce conductor size.

D. PDBs shall be rated for 600 volts and dual rated for copper and aluminum conductor.

E. PDBs shall have the sizes and ratings as shown on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Each terminal block and fuse holder shall be identified with the circuit number, or conductor number, corresponding to the identification appearing on the Shop Drawings for the equipment or system.

B. Terminal block and fuse holder markers shall be computer printed plastic-type, with permanent markings.

C. End clamps and end sections shall be installed on each terminal block and fuse holder assembly.

D. Terminal blocks for DC voltages shall be blue and AC voltages shall be gray.

END OF SECTION

SECTION 16160

ENCLOSURES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Specification includes enclosures to house electrical controls, instruments, terminal blocks, and serve a junction boxes where shown on the Drawings.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

1.3 MANUFACTURERS

A. Enclosures shall be manufactured by Hammond, Hoffman, Rittal, or equal.

PART 2 - PRODUCTS

2.1 STEEL

A. Enclosures shall be fabricated from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.

B. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket. All wires entering or leaving the enclosure shall terminate on terminal strips. All wires and terminals shall be clearly identified as specified elsewhere in these Specifications.

C. Finish shall be white enamel interior, light gray enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Drawings should be checked for special conditions.

2.2 NEMA RATING

A. Unless otherwise indicated on the Drawings, enclosures shall be NEMA 12 for indoors and NEMA 4X for corrosive areas and outdoor installations. NEMA 4X enclosures shall be 316 stainless steel, unless noted otherwise. NEMA 4X enclosures shall also be used in wet or wash down areas.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Enclosures shall be installed as indicated on the Drawings and according to manufacturer's instructions.

B. Enclosures shall be properly grounded and shall include ground straps connected to hinged doors and accessories.

END OF SECTION

SECTION 16161

CONTROL PANELS

PART 1 GENERAL

1.1 SCOPE

A. Contract Documents illustrate and specify functional and general construction requirements of the panel components and do not necessarily show or specify all components, wiring, and accessories required for a completely integrated system.

B. Provide all labor, materials, equipment, documentation including drawings and incidentals as shown on the Drawings, specified and required to design, furnish, install, calibrate, test, start-up, program, configure, commission and place into satisfactory operation all panels, intermediate termination panels and/or enclosures including panel components and instruments.

C. Conform the design and construction of panels to the specifications herein.

1.2 COORDINATION

A. Coordinate the installation of all items specified herein and required to ensure the complete and proper interfacing of all the components and systems.

B. All control loops to function as described in Section 17000, Control Descriptions and depicted on the CONTRACT DRAWINGS.

1.3 DEFINITIONS

A. **Intermediate Termination Panel (ITP)**: An Intermediate Termination Panel is any junction box that has terminals to terminate wires and no electrical or electronic powered devices. These panels act as interim termination points for field wiring to be connected to the control systems equipment. Please note that junction boxes and pull boxes are different. ITP's are sometimes referred to as junction boxes. However, pull boxes are not allowed to have any wire splicing devices, including terminal blocks.

B. **Local Control Panel (LCP)**: A Local Control Panel is an industrial piece of equipment that contains electrical or electronic devices, in addition to wire terminals. Typically, it is a local panel connected to a specific piece of equipment to provide control and/or monitoring of that equipment. A local control panel contains voltages of 120VAC or below.

C. **Motor Control Panel (MCP)**: An Motor Control Panel is an industrial piece of

equipment that houses components for the power distribution and starting of motors. The components may include motor starters and variable frequency drives.

1.4 QUALITY ASSURANCE

A. Reference Standards: Construction of panels and the installation and interconnection of all equipment and devices mounted within also comply with applicable provisions of the following, except where otherwise shown or specified.
   1. National Fire Protection Association 79
   2. National Electrical Code (NEC) 2011.
   3. National Electrical Manufacturer's Association Standards (NEMA).
   4. American Society for Testing and Materials (ASTM).
   5. Operational Safety and Health Administration (OSHA) Regulations.
   6. State and local code requirements.
   7. Where any conflict arises between codes or standards, the more stringent requirement applies.
   8. All panel devices shall bear the label of the Underwriters' Laboratory (UL), Inc. or be UL Recognized. Some products certified by UL are components that are intended to be used in the manufacture of a complete listed product. These components cannot bear the UL symbol, but may use a special Recognized Component Mark.
      a. The UL/UR listed number shall be documented on the Bill of Materials on the drawings.
   9. The assembled LCP's and MCP's are to be conformed to meet UL 508A requirements and labeling.

B. Panel to be designed, schematics drawn and assembled by the manufacturer. Utilize one of the following Panel Manufacturers:
   1. Zak Controls, 4970 East Beverly Rd., Phoenix AZ 85044 – (602) 267-0100.
   2. RDC Electrical, 3411 South 44th St., Phoenix, AZ 85308 – (602) 437-0760.
   3. Keller Electrical Industries, Inc., 1881 East University Dr., Phoenix AZ 85034 (602) 437-3015.

1.5 SUBMITTALS

A. General:
   1. Reference Section 01330, Submittals Procedures.
   2. Panels shall be furnished in accordance with the requirements as shown on the Drawings, and as specified in Division 16, Section 16050 and Division 17000, Sections 17456 and 17453, 17460 and 17461.
   3. Generate drawing package utilizing AutoCAD versions 2004 through 2008. If utilizing a newer AutoCAD version, submit files saved at version 2008.
   4. Submit legible hard copies of the panel drawing package printed on 11" x 17" sheets.
   5. Submit manufacturer's technical data sheets and product literature for the panel and all components utilized. Cleary identify exact equipment and material that is

being supplied on the manufacturer's data sheets.

6. Submit a sample nameplate with the submittal.
7. Identify general location of all conduit entry points on the Front Elevation drawing of the documentation package.
8. Submit calculations and recommended cooling and heating load requirements. Utilize the Hoffman Temperature Calculation tool at: http://www.hoffmanonline.com/product_catalog/tools/index.aspx?cat_1=34&cat_2=375&SelectCatID=375&CatId=375.
9. Submit location and tube routing details for air conditioner drain line. Coordinate drain location with ENGINEER.

1.6 O&M Manuals

A. Comply with the requirements of Section 01782, Operation and Maintenance Data.

B. Provide an electronic copy of the panel drawing package on a separate CD. Panel Drawings are to be provided electronically in AutoCAD version 2004 through 2008. If utilizing a newer AutoCAD version, submit files saved at version 2008.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturers requirements for Transportation and Handling of Materials and Equipment.

B. Comply with manufacturers requirements for Storage of Materials and Equipment.

C. Provide a hard copy of the panel drawings, size 11" x 17", inside the panel upon delivery.

PART 2 - PRODUCTS

2.1 PANEL ENCLOSURES

A. General:
   1. Conform panels and enclosures to the NEMA requirements as stated in Specification 16160, Enclosures.
   2. All outdoor panels shall be provided with sunshade structures. Sunshade structures shall be constructed as shown on CONTRACT DRAWINGS.
   3. Sizes shown on contract drawings are estimates. Furnish panels and enclosures sized to house all equipment, instruments, front panel mounted devices, power supplies, power distribution panels, wiring and other components installed within.
   4. Size the panel to provide 20% spare free space capacity.
   5. Use stainless steel fasteners throughout.
   6. Provide interior mounting panels and shelves constructed of minimum 12 gage

steel.

7. Provide 12”x12’ print pocket in panels with a 24” or larger door. Mount on inside door where no door mounted devices are located. If there is not enough room for a 12”x12” print pocket, provide a sized pocket to fit available room.
8. Provide enclosure mounting supports as required for floor, frame, or wall mounting. Indoor wall mount panels utilizing stainless steel unistrut. Outdoor wall mount panels utilizing pcv coated unistrut.

B. Construction Features:
   1. General Construction Features - Provide the following convenience accessories inside of each panel.
      a. One or more 120 VAC light fixtures with a minimum 40 watt lamp or LEDs with a snap switch for on/off control.
      b. Provide grounding studs or lugs for metal panels and doors.
      c. Provide all electrical components and devices, support hardware, fasteners, and interconnecting wiring required to make the panels and/or enclosures complete and operational.
      d. Provide oil resistant gasket completely around each door or opening.
      e. For panels located in the field or outdoors that have door mounted devices which do not meet the NEMA rating for the area, provide a window kit that includes a hinged door with a clear plastic window and an oil resistant gasket to encompass all non-NEMA rated panel instruments for this area.
      f. Provide full height doors.
      g. Provide panels with no extra holes or knockouts unless shown on CONTRACT DRAWINGS.

C. Environment
   1. General:
      a. Provide the following panel(s) with an air conditioner, heat exchanger or ventilation fan based on the submitted calculations for cooling and/or heating load requirements.
         1) As Required by cooling and/or heating calculations.
      b. Provide a heater for all panels located outdoors to maintain a minimum temperature of 68°F.
      c. Provide a separate supplementary protector for the cooling or heating equipment.
      d. Provide thermostats to automatically control heating and cooling requirements.
      e. Provide a high temperature switch, for alarm purposes, in all panels that require air conditioners, heat exchangers or ventilation fans. The contact shall be wired to alarm to the Process Control Information System.
         1) Products and Manufacturers:
            a) Hoffman ATEMNC.
            b) Or Equal.
   2. Air Conditioner:
      a. Coordinate utilization of air conditioners with the ENGINEER.
      b. Provide an automatically controlled closed loop air conditioner with filtered and adjustable air louvers to maintain temperature inside each enclosure below the

maximum operating temperature rating of the lowest rated component.

c. Provide a condensation drain line for each air conditioner.
d. Coordinate space requirements for maintenance.
e. Provide NEMA 4X for outdoor locations.
f. Coat heating and cooling elements including external housing that are in contact with Plant's ambient environment with Heresite, or equal, for protection from hydrogen sulfide corrosion with hydrogen sulfide levels up to seven ppm.
    1) Coordinate application of coating with the ENGINEER.
g. Product and Manufacturer:
    1) Hoffman (McClean).

3. Heat Exchanger:
    a. Coordinate utilization of heat exchangers with the ENGINEER.
    b. Provide an automatically controlled heat exchanger to maintain temperature inside each enclosure below the maximum operating temperature rating of the lowest rated component.
    c. Coordinate space requirements for maintenance.
    d. Products and Manufacturers:
        1) Hoffman
4. Ventilation Fan:
    a. Coordinate utilization of ventilation fans with the ENGINEER.
    b. Provide automatically controlled ventilation fans with filter to maintain temperature of indoor enclosures below the maximum operating temperature of the lowest rated component.
    c. Products and Manufacturers:
        1) Hoffman.
        2) Or Equal.
5. Heater:
    a. Provide adequately sized automatically controlled 120 VAC heaters to maintain temperature inside each enclosure above 40°F to a maximum of 80°F when the outside temperature is 0°F through 40°F.
    b. Maintain a minimum four inch clearance or minimum clearance recommendations from the manufacturers from any device.
    c. Product and Manufacturer:
        1) Hoffman.
        2) Or Equal.

D. Identification:
1. Provide laminated plastic nameplates with a white background and black lettering for identification of panels and components.
2. Construct nameplates with 1/16" plastic and with beveled edges.
3. Nameplate Mounting
    a. Indoor panels: Mount nameplates to the panel utilizing glue.
    b. Outdoor panels: Mount nameplates to the panel utilizing glue and with two self-sealing ¼" stainless steel screws by APM Hexseal.
    c. Glue Product and Manufacturer
        1) Gorilla Glue

2) Or Equal

4. Provide nameplates according to Table 2.1.C.5 and Section 3.1.B:

Nameplate Specifications			
Type	Size	Font	Font Size
Manufacturer Nameplate	*1½" x 6"	Arial	1/8"
Panel Nameplate	*2" x 7"	Arial	1/2"
Device Nameplate	*1½"x 2½"	Arial	3/16"

Table 2.1.C.5 Nameplate Specifications

*** This is a minimum height size requirement. Size nameplates large enough to display the information required to clearly identify the panel.**

2.2 PANEL DEVICES:

A. General:
   1. Provide DIN rail mounted devices where practical.
   2. All devices mounted on the exterior of the panel shall match the NEMA rating of the panel.

B. Internal Component Labeling:
   1. Provide a device label for devices mounted inside the panel that conforms to the criteria below:
      a. Instruments: Provide label with the instrument loop number as shown on the CONTRACT DRAWINGS. Place label below the instrument on the backplane.
      b. Supplementary Protector: Label each supplementary protector with CB and the number assigned in the supplementary protector schedule. Place label on the backplane.
      c. Fuses: Label each fuse with FU and the number assigned in the fuse schedule. Place a label on the backplane that includes the fuse number and the fuse size.
      d. Control Relays: Label each relay with CR and the number assigned in the panel drawings. Place label below the relay on the backplane.
      e. Terminal Strips: Label each terminal strip with the terminal strip type. (ex. TB1, TB2, ATB). Place label above the terminal block or at first terminal on the backplane.
      f. Door Mounted Devices: Provide a label on the interior of the front panel door for every panel device. The label should contain the same information as shown on the front panel nameplate. Place the label below the device.
      g. Wireway Covers: Label wireways with the voltage that is being routed through it. For example; "24 VDC" for DC voltage or "120VAC" for AC voltage. Place label on wireway cover. Coordinate label size to fit on wireway cover.

h. Identify internal components with permanent adhesive plastic labels.
   1) Product and Manufacturer:
      a) Brady USA Inc.
      b) Or Equal.
   2) Provide device label size and fonts per Table 2.2.B.1:

Device	Label Size	Font Size	# Points	Brady Part #
(Wireways) 24VDC	1”x 4”	Arial	48 Points	PTL-42-422
(Wireways) 120VAC	1”x 4”	Arial	48 Points	PTL-42-422
Misc. Device Labels	1”x 1”	Arial	16 Points	PTL-19-423
Panel Door Devices	1” x 1.5”	Arial	8 Points	PTL-31-423

Table 2.2.B.1 Panel Interior Device Label

C. DIN Rail:
   1. General: DIN rail is the metal rail used to mount various electrical components in a panel.
   2. Mount all internal components on DIN Rail.
   3. DIN Rail for terminal blocks shall be raised DIN rail to match the height of the wireways.
   4. Product and Manufacturer, Provide one of the following:
      a. Phoenix Contact.
      b. Or Equal.

D. Control Circuit – Supplementary Protectors:
   1. Provide single pole supplementary circuit protectors with the following features, 120 Volt AC, DIN rail mounted and UL 1099 listed with auxiliary contacts.
   2. Provide end caps, marking strips, insulated side jumpers and other accessories.
   3. Product and Manufacturer, Provide one of the following models where “xx” is the appropriate rating.
      a. Phoenix Contact, TMC 1-M1-xxA
      b. Allen-Bradley, 1492-SP1Bxxx
      c. Idec, NRC-11-0-L-xxA-AA

E. Air Conditioner or Heater Supplementary Protectors:
   1. Provide supplementary protectors with the following features, 120 Volt AC, DIN rail mounted and UL 489 listed with auxiliary contacts.
   2. Product and Manufacturer, Provide one of the following:
      a. Allen-Bradley, Bulletin 1489.
      b. Or Equal.

F. Control Relays:
   1. Type: General purpose, plug-in type rated for continuous duty.

2. Construction Features:
    a. Coil Voltages: 120 VAC.
    b. Contacts:
        1) Silver cadmium oxide rated not less than ten amperes resistive at 120 VAC or 28 VDC continuous.
        2) For switching low energy circuits (less than 200 ma) fine silver, gold flashed contacts rated not less than three amperes resistive at 120 VAC or 28 VDC continuous shall be provided.
        3) Number of contacts:
            a) Minimum: Two double pole/double throw contact sets
            b) Maximum: Four double pole/double throw contact sets.
    c. Relays shall have a clear plastic dust cover.
    d. Socket type to be blade.
    e. Relays shall not have an LED indicator.
3. Product and Manufacturer: Provide one of the following:
    a. Type R and/or Type K, as manufactured by Square D Company.
    b. Type RH and/or Type RY, as manufactured by IDEC.
    c. Potter & Brumfield.

G. Time Delay Relay:
1. Type: Dial adjustable, plug-in type time delay relay providing delay-on-make, delay-on-break one shots or interval operation.
2. Construction Features:
    a. MOS digital circuit with transformer coupled power.
    b. Switch selectable ranges.
    c. Minimum Setting: Three percent of range; except 50 ms for one second range.
    d. Contacts:
        1) Type: DPDT.
        2) Rating: Seven amps resistive at 120 VAC, seven amps at 24 VDC.
    e. Housing:
        1) Plug-in design with dust and moisture resistant molded plastic case.
    f. Power Input: 120 VAC.
3. Product and Manufacturer: Provide one of the following:
    a. Manufactured by Automatic Timing and Controls Company.
    b. Manufactured by IDEC.

H. Selector Switches, Pushbuttons and Indicating Lights:
1. General:
    a. Selector switches, pushbuttons and indicating lights shall be supplied by one manufacturer and be of the same series or model type.
    b. Type: Heavy duty, oil tight.
    c. Mounting: Flush mounted on panel front, unless otherwise noted.
    d. NEMA rated to match panel in which mounted.
2. Selector Switches:

a. Type: Provide selector switches with number of positions as required to perform intended functions as shown on the Drawings and specified.
b. Contacts:
1) Provide number and arrangement of contacts as required to perform intended functions specified, but not less than one single pole, double throw contact.
2) Type: Double break, silver contacts with movable contact blade providing scrubbing action.
3) Rating: Compatible with AC or DC current with devices simultaneously operated by the switch contacts, but not less than ten amperes resistive at 120 volts AC or DC continuous.
c. Switch Operator: Standard black knob.

3. Pushbuttons (Standard or Illuminated):
a. Momentary Type: Provide momentary, booted type pushbuttons as required to perform intended functions specified and shown on the Drawings. Boot color to be red for stop buttons and black for other functions.
b. Maintained Type: Provide maintained, push/pull, "Mushroom" type, red in color, to perform intended functions as specified, and as shown on the drawings.
1). Emergency Stop button shall be red and the base of the button shall be yellow.
c. Contacts: Comply with the requirements specified for selector switches.

4. Indicating Lights:
a. Type: Compact, integral non-transformer type.
b. Lamps: 120 VAC, long life (20,000 hours minimum).
c. Common, push-to-test circuitry shall be provided for each panel to simultaneously test all indicating lights on the panel using a single pushbutton.
d. Button and Lens Colors:
1) Red for indication of open, on, or running.
2) Green for indication of closed, off (ready), or stopped.
3) YELLOW for indication of equipment malfunction, process trouble or alarms.
4) White for indication of electrical control power on.

5. Rotary Cam Switches:
a. Provide rotary cam switches with number of positions and poles as required performing the signal switching function specified and shown on the Drawings.
b. Contacts:
1) Gold-flashed contacts housed in mechanical contact blocks with number and arrangement of contacts as required performing intended function.
2) Contact Rating: Compatible with AC or DC through-put current of signals and devices simultaneously operated by the switch contacts, but not less than 20 amperes at 600 VAC or 250 VDC continuous.
c. Switch Operator: Standard black knob.

6. Product and Manufacturer: Provide one of the following:
a. Square D.

b. Allen-Bradley Co.
c. General Electric.

I. Potentiometer:
1. Type: Industrial potentiometer operator, direct acting, 3/4 to full turn; and standard 3-wire potentiometer.
2. Required Features:
a. NEMA rated to match panel in which mounted.
b. Resistance Range: 0 to 10,000 Ohms.
c. Resistance Element: Wire wound or conductive plastic.
d. Power Rating: Two watts.
e. Mounting: Flush mounted on panel front, unless otherwise noted.
f. Provide legend plate for indication of position (0 to 100 percent).
3. Product and Manufacturer: Provide one of the following:
a. Square D.
b. Allen-Bradley Co.
c. General Electric.

J. Power Supply:
1. General
a. Panel power supply source, type, voltage, number of circuits and circuit ratings shall be as shown on the Contract Drawings.
b. Panels shall be provided with an internal 120 VAC with number of circuits and separate supplementary protectors sized as required to distribute power to the panel components.
2. 24VDC Power Supplies:
a. General:
1) Single unit and multiple unit power supplies, located in panels, as required.
2) Single Unit Required Features:
a) Solid state circuitry
b) Surface mounting
c) Input Power: 120 VAC, ± 10 percent, 60 Hz.
d) Output Power: 24 VDC or as required.
e) Line/Load Regulation: 0.05 percent.
f) Ripple: 0.25 mv RMS.
g) Overload Protection: Internal preset or fused.
3. Product and Manufacturer: Provide one of the following:
a. Acopian Corporation.
b. Power One.
c. Lambda.
d. Sola.
4. If redundant power supplies are required: Provide one of the following:
a. Lambda DPL-PU/E.
b. Phoenix Contact Quint-Diode/40.
c. Puls.

d. Or Equal.

K. Wire:
1. General:
   a. Provide internal wiring of Type MTW stranded copper wire with thermo-plastic insulation with no nylon jacket rated for 600 V at 90°C for single conductors.
   b. No utilization of Type THHN for panel wiring.
   c. For DC panel signal wiring, use #16 AWG shielded minimum.
   d. For AC power wiring, use #14 AWG minimum. For AC signal and control wiring, use #16 AWG minimum. For wiring carrying more than 15 amps, use sizes required by NEC and NFPA 79 Standards.
   e. Identify wires at each end using heat shrink labels with permanent number codes using a Brady LS2000 Labeling System, or equal.
   f. Panels conform to the wire color code as shown in Table 2.2.K.1.f Wire Color Code and NFPA 79 Standards.
2. Product and Manufacturer: Provide one of the following:
   a. Carol.
   b. Belden.
   c. Anixter.

WIRE COLOR CODE TABLE (Inside Panels)			
TYPE	FUNCTION	INSULATION COLOR	WIRE SIZE
AC POWER - HOT	120VAC	**BLACK	#14
AC POWER - NEUTRAL	120VAC	WHITE	#14
AC GROUND	120VAC	GREEN	#14
AC CONTROL	120VAC	**RED	#16
ISOLATED DC GROUND	GROUND	GREEN W/YELLOW	#16
DC POWER	SOURCE	BLUE	#16
DC POWER	COMMON	WHITE /BLUE	#16
CONTROL	FOREIGN VOLTAGES	YELLOW	#16
LOW VOLTAGE AC	24 VAC SOURCE	BROWN	#16
LOW VOLTAGE AC	24 VAC COMMON	BROWN W/WHITE	#16
*AC POWER	480 VAC PHASE A	BROWN	Size to FLA
*AC POWER	480 VAC PHASE B	ORANGE	Size to FLA
*AC POWER	480 VAC	YELLOW	Size to FLA

	PHASE C		
TEMPORARY	TEMPORARY	PURPLE	Size to FLA

Table 2.2.K.1.f Wire Color Code

*** - For Motor Control Panels (MCP's) that are permitted to contain 480 VAC**

**** - Black 120 VAC wires are hot unless powered down via supplementary circuit protector. Red 120 VAC wires are hot based on the control logic state.**

L. Single Shielded Pair Cable:
   1. Tinned copper, nineteen strand, PVC insulated conductors, No. 16 AWG minimum, twisted with aluminum-polyester shield, stranded tinned 16 AWG copper drain wire and PVC black or gray outer jacket. Wire conductor colors shall be black (-neg) and red (+pos). 600 Volt Tray Cable (TC) rated.
   2. Product and Manufacturer: Provide one of the following:
      a. Belden Company (No. 9342).
      b. Okonite Company.
      c. Dekoron Wire and Cable Company.

M. Wire Terminations:
   1. Terminate all field and internal component wiring using insulated ferruled connectors attached with manufacturer's recommended tool.
   2. Excessive stripping of the wire so as to allow bare wire outside the insulated ferrule is not permitted.
   3. Utilize insulated double ferruled connectors wherever two wires terminate on the same terminal block connection.
   4. Product and Manufacturer: Provide one of the following:
      a. Phoenix Contact – Clipline.
      b. Thomas & Betts.
      c. Weidmuller.

N. Terminal Blocks:
   1. General:
      a. Numerically code terminals utilizing terminal block manufacturer's marking system. Information must be printed directly on the terminal label. Sticky back labels are not permitted.
      b. Terminal blocks must be DIN rail mountable with screw clamp connections. Spring cage connections are not permitted.
      c. Double level terminal blocks are permitted for use with signals on Analog Terminal Block (ATB) only.
      d. Terminals used for analog signals on ATB shall be colored blue.
      e. Terminal block jumpers must be connected via screw clamp. Screw clamped comb jumpers are permitted. Plug in jumpers are not permitted.
   2. Product and Manufacturer: For each terminal strip type provide one of the following:

a. Power Terminal Block (PTB).
   1) Phoenix Contact, Type UK 5 N, Color Gray, Model # 30 04 36 2.
   2) Allen Bradley, Type 1492-J4, Color Gray, Model # 1492-J4.
   3) Weidmuller, Type WSU 4, Color Dark Beige, Model # 1020100000.
b. Field Wiring Discrete Signal Terminal Blocks (TB1 and TB2).
   1) Phoenix Contact, Type UDK 3, Double Connection, Color Gray, Model # 27 75 37 5.
   2) Weidmuller, Type WDK 2.5V, Double Connection, Double Level, Internal Connection, Color Dark Beige, Model # 1905060000.
c. Field Wiring Analog or Internal Wiring DC Power (ATB) - Single Level Terminal Blocks:
   1) Phoenix Contact, Type UK 3N BU, Color Blue, Model # 30 01 51 4
   2) Allen Bradley, Type 1492-J3-B, Color Blue, Model # 1492-J3-B.
   3) Weidmuller, Type WDU 2.5 BL, Color Blue, Model # 1020080000.
d. Field Wiring Analog or Internal Wiring DC Power (ATB) - Double Level Terminal Blocks. Alternating double and single level ATB terminal blocks are permitted.
   1) Phoenix Contact, Type MBKKB 2,5 BU, Double Level, Color Blue, Model # 27 71 09 4.
   2) Allen Bradley, Type 1492-JD3-B, Double Level, Color Blue, Model # 1492-JD3-B.
   3) Weidmuller, Type WDK 2.5 BL, Double Level, Color Blue, Model # 1021580000.

O. Surge Protection:
1. Provide DC surge protection with integrated varistor for all analog signal loops that are terminated to Programmable Logic Controllers.
2. Provide maintenance free, self-restoring surge protection to protect the electronic instrumentation system from surges propagating along the signal and power supply lines. Device shall be removable without interrupting the circuit
3. Provide a separate surge protector for the positive and a separate surge protector for the negative polarity of each loop.
4. Mount the surge protectors on the ATB.
5. Ground the surge protectors to the panel DC ground bus.
6. Label the surge protectors in sequential order starting with the ATB signals.
7. Required Features:
   a. Amp Rating: Compatible with working voltage and current of device being protected.
   b. Voltage Rating: Compatible with the working voltage of protected device.
   c. Reaction Time: nanosecond range
8. Product and Manufacturer: Provide one of the following:
   a. Phoenix Contact
   b. Advanced protection Technologies
   c. EDCO.
   d. Or Equal.

P. Wireways:
   1. General:
      a. Mount wireways using stainless steel bolts. Drill and tap the sub-panel to accommodate the bolts.
      b. Color to be Gray or White throughout the entire panel. Provide only one color.
      c. All wireways to include cover.
      d. Wireway covers to be labeled as per section 2.2.B
   2. Product and Manufacturer: Provide one of the following:
      a. Panduit.
      b. Thomas & Betts.
      c. Or Equal.

Q. Motor Starters and Overload Relays:
   1. Refer to Specification Section 16474. Motor Control Equipment.

PART 3 - EXECUTION:

3.1 EXTERIOR PANEL:

A. Component Layout:
   1. Arrange associated control and indication devices for a particular part of the process in close proximity to each other.
   2. Mount indicating lights above control switches and push buttons.
   3. Standard component spacing is 3 ½" center to center and 3 ½" above and below. It is acceptable to use more space if required, but spatial consistency must be maintained.
   4. Maximum height for panel exterior-mounted devices is 6'-0" from the floor. Minimum height for panel exterior-mounted devices is 3'-0" from the floor.
   5. Locate alarm horn at the top of the panel. The alarm horn may be located above 6'-0" device height limitation.
   6. Unless otherwise noted; route field wiring through the bottom of the enclosure. Provide watertight conduit openings.

B. Exterior Panel Nameplates:
   1. General:
      a. Refer to Section 2.1.D for material and size requirements.
      b. Provide specific panel identification on nameplates derived from the CONTRACT SPECIFICATIONS and DRAWINGS.
      c. Obtain ENGINEER approval for panel identification for panels that are not identified in the CONTRACT SPECIFICATIONS and DRAWINGS.
   2. Panel Manufacturer Identifier and Power Requirements Nameplate (NP-1)
      a. Mount nameplate in the upper left corner of the panel front.
      b. Provide the following information for each circuit feeding the panel.
         1) The first line indicates the name of the manufacturer, location and phone

number of who assembled the panel.

2) The following lines:
   a) Include panel voltage, current, phase, frequency, short circuit current rating for each panel feed.
   b) Provide switchboard name and circuit number for each circuit feeding the panel.
   c) Refer to figure 3.1.B.2

WILSON & SONS, CHANDLER, AZ 85226 - (480) 555-1234

120 VAC, 0.5 AMPS, 1Ø, 60HZ, SCCR 5KA, FED FROM LP-34, CIRCUIT 6

120 VAC, 7.5 AMPS, 1Ø, 60HZ, SCCR 8KA, FED FROM LP-34, CIRCUIT 8

Figure 3.1.B.2

Panel Manufacturer Identifier and Power Requirements Nameplate (NP-1)

3. Panel Identification Nameplate (NP-2)
   a. Mount panel identification nameplate in the top, center of the panel.
   b. Provide the following information:
      1) The first line of text is an abbreviation of the panel as shown on the CONTRACT DRAWINGS.
      2) The second line of text on the nameplate is used to spell out the process abbreviation.
      3) Refer to figure 3.1.B.3.

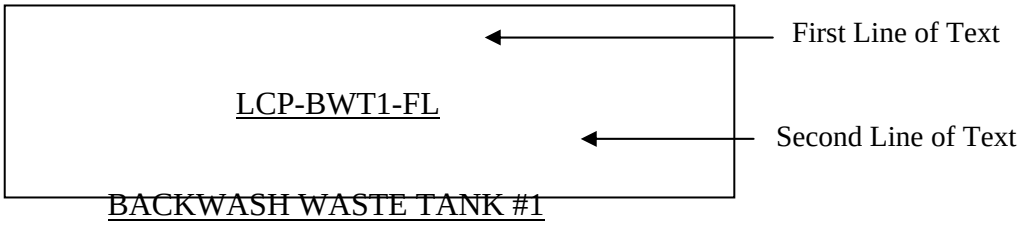

Figure 3.1.B.3

Panel Identification Nameplate (NP-2)

4. Panel Component Nameplates
   a. Mount nameplates above all control and indicating devices.

b. Provide the following information:
   1) The first line indicates the instrument device loop identifier and number as shown on the DRAWINGS.
   2) The second line identifies the system equipment that the component is associated with.
   3) The third line identifies the control position, condition of the equipment or the alarm state being monitored.
   4) Refer to figure 3.1.B.4

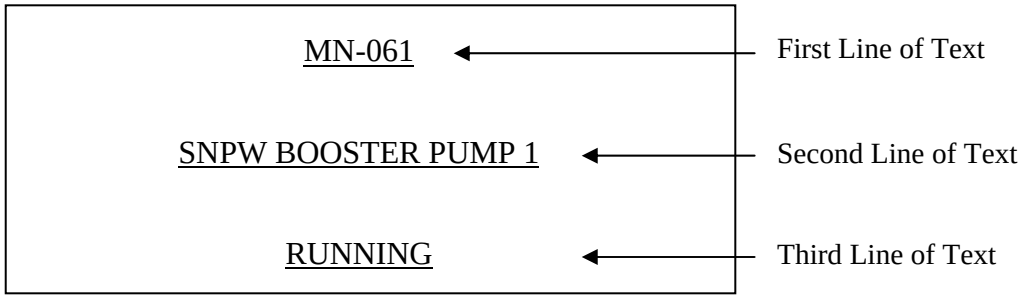

Figure 3.1.B.4

Panel Component Nameplates

3.2 INTERIOR PANEL

A. General:
   1. All Wall Mounted Panels - Where conduit enters the panel, maintain a minimum of 4" clearance from any device or wireway to allow room for routing of field wiring.
   2. Concrete Pad or Floor Mounted LCP's and MCP's – Where conduits enter the panel through the concrete pad, maintain a minimum of 6" clearance from any device or wireway to allow room for routing of field wiring. Where conduit enters the panel sides or top, maintain a minimum of 4" clearance from any device or wireway to allow room for routing of field wiring.
   3. Elevated Floor Mounted LCP's and MCP's - Where conduit enters the panel, maintain a minimum of 4" clearance from any device or wireway to allow room for routing of field wiring.
   4. Concrete Pad, Floor Mounted or Elevated Floor Mounted ITP's - Where conduits enter the panel through the top or bottom, maintain a minimum of 6" clearance from any device or wireway to allow room for routing of field wiring.
   5. Locate and install all devices and components so that connections can be easily made and that there is ample room for servicing each item.
   6. Maintain a minimum 2'0" clearance between components mounted on side panels and components mounted on the opposing side panel.
   7. Components mounted on the back panel are to be unobstructed by any components mounted on side panels.

8. Adequately support and restrain all devices and components mounted on or within the panel to prevent any movement.

B. Panel Incoming Power:
   1. Panel power fed from lighting panels, or other sources with fused or circuit breaker protection, shall be wired to the Power Terminal Blocks (PTBs). Power sources entering the panel are to be provided with a separate neutral and ground. The PTBs shall have a separate terminal for the hot and neutral for each circuit. The ground to be terminated to the AC ground bar.
   2. Mount the PTBs near the top left corner of the panel.
   3. Multiple power sources may be required for each panel. Power requirements are identified on the CONTRACT DRAWINGS. The following additional power sources may be required for the panel.
      a. Control Logic Power and Light Fixture
      b. Air Conditioning
   4. Arrange the terminal strip in an orderly manner with circuit conductors grouped together. For instance, terminate the hot and neutral conductors on consecutive terminals. Label terminals and internal wiring as H1 and N1 (Control Logic), H2 and N2 (Air Conditioning). Identify each additional source in sequential order beginning with H3 and N3.
   5. Terminate all incoming power on one side of the terminal strip.

C. AC Power Distribution:
   1. Identify the wire extending from the PTB to the supplementary protector as H1 and H2, etc. Using H1 as an example; the wire terminated to the line side of the supplementary protector is labeled H1, the wire terminated to the load side of the supplementary protector is labeled as L1-1.
   2. If L1-1 passes through an additional supplementary protector to feed panel components, this supplementary protector can be shown on the drawings in a horizontal or vertical position on a schematic rung and the wire terminated to the line side of the supplementary protector is labeled L1-1. The wire terminated to the load side of the supplementary protector is labeled L1 – (the Supplementary Protector #) and the wire color is black.
   3. If the panel controls multiple pieces of equipment, such as two pumps with separate control circuits, provide a supplementary protector for each control circuit.
   4. Powering 120 VAC field 4-wire instruments from the panel is not permitted.

D. DC Power Distribution:
   1. Mount DC power supplies near the top right of the panel. Mount fuses associated with the power supply in close proximity to the power supplies.
   2. Identify terminals used for DC power distribution as PTB-DC.
   3. Provide a fuse for each analog loop that loop power is provided by a power supply located in the panel.

E. Grounding:

1. AC Ground:
   a. Provide the AC ground bus bar with cage type or screw terminals installed near the bottom of the back panel with extended mounting bolts.
   b. Provide adequate metal to metal contact between the AC ground bus bar and the back plane.
   c. Connect all AC power sources and devices to ground at this ground bus.
   d. Connect all panel enclosure doors to the AC ground bus.
   e. Connect all side panels to the AC ground bus.
   f. Provide a connection point on the ground bus for connection to the ground grid system.
2. DC Ground:
   a. Install the isolated DC grounding bus bar with cage type or screw terminals installed near the bottom of the back panel at a minimum distance of 6" from the AC ground bus.
   b. The isolated grounding bus bar consists of two non-conductive mounting blocks with a single copper grounding bar attached between them.
   c. Connect all shields (SH) requiring loop grounding in the panel from the analog signal terminals to the DC grounding bus bar.
   d. To avoid ground loops, connect analog cable signal shields to ground at one location only, preferably in the LCP, MCP or ITP; not in the field. Maintain consistency for the termination point of signal shield for all analog signals.
   e. Provide a connection point on the ground bus for connection to the ground grid system.
   f. Figure 3.2 illustrates a typical ground system within a panel. The illustration depicts the physical terminations of the ground wires in the panel**.** Ground Conductor AWG size to ground grid system shall be as stated in Specification 16170, Grounding and Bonding.

GROUNDING SYSTEM DIAGRAM

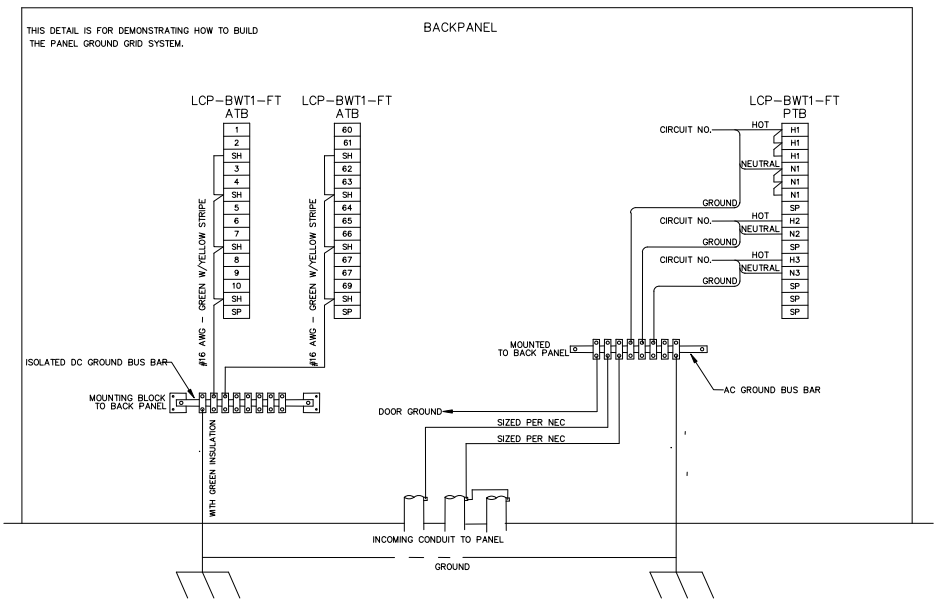

Figure 3.2

Typical Grounding Systems

F. Circuit Protection:
   1. Provide an isolating supplementary protector for each group of control logic. For example: the start, stop and reset control circuit for Pump #1 has a dedicated supplementary protector supplying power to the control logic. Pump #2 requires a separate isolating supplementary protector for the control logic.
   2. Provide an isolating supplementary protector for each component requiring 120 VAC power.
   3. A supplementary protector is not required for control circuits powered from a fused control power transformer in an MCP.
   4. Size supplementary protector to handle the connected load.
   5. Mount supplementary protector next to the PTBs near the top left corner of the panel.
   6. Provide an auxiliary contact for each supplementary protector. Wire each auxiliary contact from the supplementary protector in series to one "Power fail' relay. Send one Power Fail status to the Process Control Information System.

G. Internal Panel Wiring:
   1. Route all internal wiring using wireways. Terminate all internal wires on one side of the terminal blocks. The opposite side of the terminal block shall remain available for field wires.
   2. Where wires pass through panel walls, provide suitable bushings to prevent cutting or abrading of insulation.
   3. Adequately support and restrain all wiring runs to prevent sagging or other movement. Wires extended from the control logic to the panel door devices are to be wrapped in plastic protective wire wrap designed for this purpose.
   4. Wire splicing is not allowed at any time.
   5. Utilize two wires (hot and return leg) with field wiring for each field input. It is not acceptable to utilize one common Hot for multiple field inputs.
   6. Terminate wires with a non-insulated ferrule type crimp connector. Excessive stripping of the insulation to allow bare wire strands between the insulation and the ferrule is not permitted.
   7. Orientate wire labels on the individual conductor or cable so that wire labels are legible without having to twist or move the connectors. Securely heat shrink the labels around the conductor. Label wires or cables with the number assigned in the panel documentation. Refer to Section 2.2.K.1.e for wire label materials.
   8. DC wiring for analog and discrete field or Process Control Information System (PCIS) signals that enter or leave the panel are to be terminated on the Analog Terminal Block (ATB).
   9. AC wiring for discrete field signals that enter or leave the panel are to be terminated on the Terminal Block 1 (TB1).
   10. AC wiring for discrete Process Control Information System signals that enter or leave the panel are to be terminated on Terminal Block 2 (TB2).

11. The terminal blocks (TB1, TB2 or ATB) can be mounted on the left or right side panels.
12. Provide a minimum of 10% spare terminal DIN rail space per terminal strip.
13. Signals from the field that enter the panel and only pass through the panel from the field to the Process Control Information System require internal wiring from TB1 to TB2.
14. Arrange all control wiring associated with a particular piece of process equipment together on adjacent terminal blocks.
15. Identify wire number by the schematic rung numbers. Label TB1 and TB2 terminals with the rung number associated with the internal wire number connected to the terminal. Label ATB terminals in sequential order starting with the number 1. Identify analog shield terminations with an "SH" on the terminal block.
16. Multi-conductor cables of two pair or more shall have the outer cable insulation removed before entering the wireway.
17. Route all DC power and analog signals at a minimum of six inches from AC power and controls. When the six inch minimum distance is not available, provide a metallic barrier that extends 3" beyond the tallest wireway between the analog and discrete wireways.

H. Wireways:
1. Mount wireways from the internal panel components and terminal blocks with a minimum 2" spacing.
2. Arrange wireways to maintain a six inch minimum distance between analog and discrete circuit wiring.
3. Provide wireways for all field wiring. Arrange wireways to allow field wiring to enter from the top or bottom of the panel.
4. Align wireways between back and side panels.
5. Install a wireway on both sides of each terminal strip.
6. Size wireways to prevent conductor fill from exceeding 50% of the interior cross-sectional area of the wireway.
7. In addition to the above requirements, for ITP's, wireways are not to be common for two terminal strips. Each terminal strip shall have a dedicated wireway on each side of the strip.

I. Control Logic:
1. The Start commands are to be designed utilizing normally open contacts from pushbuttons and/or the Process Control Information System and shall be of a momentary signal that will require a seal circuit to maintain operation. Constant signals from positions switches are not allowed unless noted on the CONTRACT DRAWINGS.
2. All system failure, safety logic control devices or normal operations that are intended to cause the equipment to stop are to be wired in series with the start seal circuit. The unsealing of the start command on any fault or normal operation that causes the equipment to stop will require another start command to reseal.

3. Provide interlocks for the control functions of Local and Computer Modes in series with the Start and Stop logic. Provide a closed switch or relay contact to the Process Control Information System to identify when the equipment is in Computer Mode.
4. Provide control logic of voltage 120 VAC.
5. Use power relays when control relay contacts are insufficient for the designated load.
6. Terminate the "Hot" conductor on the common of the switch or relay contact.
7. Control alarm logic shall be wired in a fail safe mode from the field device to the panel circuitry to alarm when a field wire has failed.

3.3 PANEL DRAWING DOCUMENTATION

A. General:
   1. Files of the title block, panel symbols for front and internal sub-panel elevations, terminal strips, control schematics, analog loops, etc. are available in hard copy and AutoCAD .dwg format from the OWNER upon request through the ENGINEER via Example Panel Drawing Packages and Drawing Templates.
   2. Provide drawing copies in the following format:
      a. Hard Copy - B Size - 11" X 17"
      b. Hard Copy - D Size - 22" X 34"
      c. Soft Copy in .DWG
   3. The panel drawing documentation package consists of the following drawings types arranged in the following order.
      a. Cover Sheet.
      b. Symbols and Legends 1 – Exterior and Interior Panel Symbols.
      c. Symbols and Legends 2 – Schematic Symbols.
      d. Front Panel Elevation.
      e. Interior/Sub Panel Layout.
      f. Terminal Strip Drawings.
      g. Control Schematics.
      h. Analog Loop Diagrams.
      i. Point to Point Discrete Wiring Diagrams.
   4. Drawing Scale:
      a. Provide Front Elevation and Interior/Sub Panel Layout Drawings proportionately correct and to scale. Create all drawings on a D Size layout.
   5. Border and Title Block:
      a. Provide each drawing with a border and title block information.
      b. Utilize the border and title block as provided in the Drawing Templates referenced in Section 3.3.A.1.

B. Panel Drawing Types:
   1. General:
      a. Provide a complete documentation package for each panel consisting of the drawings in the order listed in Section 3.3.A.3.
   2. Cover:

a. Cover sheet for the panel documentation shall include the following information.
    1) Located on the left half of the sheet to include the Manufacturers Name, Address, Phone Number, Web Address, Project Reference Number and UL508A Certification Number.
    2) Located on the right half of the sheet include the following, "Customer Name" "Department" and the project title, Project number, the panel full title, the panel abbreviation, the facility area in which the panel exists, submittal date, volume number and sheet count.

3. Symbols & Legends:
    a. Utilize the Symbols and Legend sheets as provided by the OWNER upon request from the ENGINEER.
    b. Additional symbols may be added if an existing symbol on the Symbol and Legend sheets does not exist.
4. Front Elevation Drawing:
    a. The Front Elevation drawing illustrates the arrangement of the panel and position of the devices on the front face of the panel.
    b. Provide panel dimensions in inches. Provide dimensions for height, width, and depth. If the panel is small in size, the Front Elevation Drawing and Internal layout Drawing can be combined on one drawing.
    c. Provide the nameplate schedule on the Front Elevation drawing.
    d. Device Callouts:
        1) Device callout hexagons are utilized to reference a device to the bill of materials. Place the bill of material item number inside the hexagon.
        2) Provide a leader from the hexagon that will point to the device.
        3) For a typical of multiple devices of the same type, only one device callout is necessary.
    e. Provide air conditioning heating and cooling information as provided by the Hoffman Temperature Calculation tool at: http://www.hoffmanonline.com/product_catalog/tools/index.aspx?cat_1=34&cat_2=375&SelectCatID=375&CatId=375
5. Interior Sub Panel Layout:
    a. General:
        1) The Interior Sub Panel Layout drawing identifies the individual interior components and their physical location.
        2) Draw all components within the panel to scale.
        3) Include all interior sub panels if the panel has sub panels on the side walls.
    b. Provide the following information on the Interior Sub Panel Layout Drawing. Utilize the formats provided on the Drawing Templates. The information can be shown on a second sheet if needed to drawing clutter.
        1) Bill of Materials:
            a) Include the devices on the Front Panel Elevation and the Interior Sub Panel(s) Elevation.
            b) Include items that are not specifically shown on the Front Panel Elevation or the Interior Sub Panel Layout drawing, such as wire

size, color and type, on the bill of materials.

c) The utilization or insertion of Microsoft Excel files for the Bill of Materials is not allowed.

2) Fuse Schedule.

3) Supplementary Protector Schedule.

c. Label and identify all devices, including terminal strips, relays, fuses, timers, power supplies and other special components on the drawing.

d. For unique devices not shown on the Symbols and Legend Sheets, use rectangles and squares with the appropriate dimensions of the device.

e. Device Callouts:

1) Device callout hexagons are utilized to reference a device to the bill of materials. Place the bill of material item number inside the hexagon.

2) Provide a leader from the hexagon that will point to the device.

3) For a typical of multiple devices of the same type, only one device callout is necessary.

6. Terminal Strip Drawing:

a. General:

1) Terminal Strip Drawings provides locations for wiring terminations from field devices and other equipment external to the panel.

2) Display the wiring connections exactly as they are physically installed. For example, if field wiring is terminated to the left side of the terminal strip, the terminal strip drawing displays the wiring connections to the left side of the terminal block.

3) There are 5 different types of terminal strips and each has a specific function. The following is a brief description of each:

a) For LCP's and MCP's:

i. Power Terminal Block (PTB) – Power supply/supplies to the panel (120 VAC or higher). Identify terminal block number with the wire number assigned in the control logic drawings. Identify power sources with the originating panel, voltage and circuit number.

ii. Field Wiring Discrete Signal Terminal Blocks (TB1) – Discrete field inputs and outputs to/from the panel. Identify terminal block number with the rung number assigned in the control logic drawings.

iii. Field Wiring Discrete Signal Terminal Blocks (TB2) – Discrete inputs and outputs to/from the Process Control Information System. Identify terminal block number with the rung number assigned in the control logic drawings.

iv. Field Wiring Analog (ATB) or Internal Wiring DC Power Terminal Blocks - Field or Process Control Information System Analog inputs and outputs to/from the panel, including 4-20 mA, 1-5 VDC, thermocouple or Resistance Temperature Detectors (RTD's). Identify terminal block number with consecutive numbers starting with number 1. The shield wire terminal block is to be label "SH".

b) For ITP's:
i. TB-A thru Z – Discrete field inputs and outputs to/from the panel.
ii. ATB-A thru Z – Analog inputs and outputs to/from the panel.

4) It is acceptable, if space available, to combine TB1, TB2, ATB and PTB on a single terminal strip drawing.
5) Identify spare terminals with an "SP" inside the rectangle.
6) Display terminals in the order they appear in the panel.
7) Place field wire labels on each line extending toward the terminal. Obtain this information from the cable and conduit schedules. If wire labels are unavailable, place seven "X's" where wire tag normally resides. Provide this information prior to final deliverable of the Operations & Maintenance Manuals.
8) Signal description consists of 3 lines of text. Center the text next to the terminals.
a) The 1st line of text lists the Equipment Name.
b) The 2nd line of text is for the Signal Function.
c) The 3rd line of text is the Signal Loop Number, if applicable.

7. Control Schematic:
a. General:
1) Control Schematics show the controls associated with pieces of process equipment and provide a visual depiction of the majority of control wiring.
b. Control Schematic Components:
1) Power Rail:
a) Represent the power rail with two parallel vertical lines that extend vertically down the schematic.
b) Each drawing includes two sets of power rails separated by 2.5".
c) Identify each power rail with the wire number such as L1 at the top and bottom of each power rail.
d) The left power rail represents the "Hot" side of the power source. The right power rail represents the "Neutral" side of the power source.
2) Power Source:
a) Identify power source(s) with the originating panel, voltage and circuit number between the "Hot" terminal and "Neutral" terminal on the first rung of the portion of the schematic for each source.
b) Indicate the terminals from the PTB providing the source and neutral powering the rail.
c) A supplementary protector or fuse is displayed in the power rail directly below the power source (Hot) terminal. Label the supplementary protector or fuse with the supplementary protector or fuse number and current rating.
d) Power layout for LCP's:
i. In the first portion of the schematic, display power to the general purpose receptacle and panel light.
ii. In the second portion of the schematic, display power to the air conditioner and/or heater.

iii. In the third portion of the schematic, display the power to the control logic.
iv. See Sections 3.2.B Panel Incoming Power and 3.2.C AC Power Distribution.

e) Power layout for MCP's:
i. The first portion is for the typical 480 VAC motor control circuit with starter and disconnect, the next sections are the same as for the LCP's.

3) Rung Number:
a) Rung numbers are used to identify the location and cross referencing of devices within the schematic and provide a practical means of labeling conductors and terminals within the panel.
b) Rung numbers are a sequential series of numbers starting with number 1. Locate the numbers vertically along the left side of the "Hot" power rail.
c) Rungs are to be spaced on 0.5" centers based on a D Sized drawing.

4) Wire Numbering:
a) On the downstream side of the first device on a rung, the wire number takes the rung number appearing to the left of the power rail. If a second device is located in the circuit, the wire number to the right of the second device takes the rung number, but is appended with an "A". The wire number to the right of the third device is appended with a "B", and so on.
b) When the electrical connection originated on the previous rung, the wire numbers continue to use the previous rung number as the base.
c) Connections to the power neutral rail take on the power neutral rail's wire number N#.

5) Electrical Connections:
a) Represent electrical connections as a solid small circle where two or more wires interconnect.
b) Represent electrical connections as a hollow small circle where wires terminate to a device.

6) Electrical Wiring:
a) Electrical wires or circuits are represented by horizontal rungs that connect terminal blocks, relays, contacts and all other components used in the electrical schematic.
b) Space the schematic electrical wiring every other rung at a minimum.
c) Identify each wire with the rung number as the wire number.
d) Label each wire with the conductor insulation color below each electrical wire. Refer to Table 2.2.K.1.f.
e) Indicate electrical wiring that is external to the panel with dashed lines.

7) Device Labeling:
a) Device symbols in the schematic for field devices, pilot lights, switches, push buttons etc. requires two lines of text above the device

and one line of text below the device to describe the usage of the device.

i. The first line of text above the device is the name of the equipment the device is associated with.
ii. The second line of text above the device is the control function of the device.
iii. The line of text under the device is the loop number.

b) Relay and timer symbol labels are to be identified with consecutive number starting with the number 1 or the rung number. For relay coils and contacts, identify the relay base terminal connection. Normally open or normally closed contacts refer to the de-energized or "off the shelf" state.

c) Symbols in the schematic for contacts of relays, timers, etc. require two lines of text above the contact and two lines of text below the contact to describe the usage and coil reference of the contact.

i. The first line of text above the contact is the name of the equipment the device is associated with.
ii. The second line of text above the device is the control function of the device.
iii. The first line of text under the device is the relay or timer number to reference the relay or timer in the schematic.
iv. The second line of text under the device is the rung number of the relay or timer to reference where the relay or timer is located in the schematic. If using the rung number for the relay or timer coil, the rung number under the contact is not required.
v. For relays and timer contact references, at the right of the neutral power rail, the schematic rung number location of all associated contacts is shown. If the contact is normally closed, underline the reference number. If a contact is unused, "SP" is shown.

8) Field Contacts:

a) Show Field Contacts connected to their respective TB1 or TB2 Terminals.

b) The connection lines from the contact to the terminal are dashed to designate they originate from outside the panel.

9) Selector Switches:

a) Always show the switch in the far-left position, the switch contacts are shown as either opened or closed in this state. If they're in the closed state, the contact is shown closed, indicated by a line shown below and touching the two side small circles. If the contact is open in this position, a line is drawn above the two side small circles, but not touching them.

b) Show each position of the switch directly above its respective location on the switch. This indicates whether it is a two, three, four, or more position (pole) switch, and shows what the nameplate on each position will read.

c) To indicate which positions the contact is closed, show a contact legend in parenthesis below and to the right of the contact. If the contact is closed in a position, an "X" is shown in the order of the contact position in which it is closed. If the contact is open in a position, an "O" is shown.
d) When a selector switch is continued onto another sheet or further down on the same sheet, the continuation note is shown below the selector switch. Where the switch is continued, the same note appears, but on the top of the contact.

10) Push Buttons:
a) Represent the push button contact in its "off the shelf" state.

11) Terminals:
a) Terminal numbers are dependent upon the specific rung number that they appear in the schematic logic. As a horizontal electrical connection is followed from left to right, the first terminal number takes on the number of the rung. The second terminal number also takes the rung number but is appended by the letter A, the third by the letter B, and so on.

12) Programmable Logic Controller:
a) Panels that contain a Programmable Logic Controller (PLC) require connection information for the PLC I/O modules.
i. Utilize the PLC drawings as provided in the Drawing Templates referenced in Section 3.3.A.1.a.
b) Module Layout:
i. Represent the module with a 1 1/2" wide vertical rectangle with a length suitable to encompass a maximum of 16 channels or 8 analog per section based on type of module. Two cards can be shown per sheet.
ii. Display field wiring (inputs) including TB1 and field device connections with a description on the left side of the module symbol.
iii. Label the module with model number, input voltage, rack number and slot number above the module symbol.
iv. Number each screw terminal per manufacturer's data.
v. Display the associated PLC register address with each signal.
vi. Identify the positive and negative legs of the analog cable.
vii. Include all required jumpers for signal type and all 120VAC and 24VDC power requirements.

13) 480 Volt Equipment:
a) Provide the motor horsepower, full load amps and motor identification.

14) Contact Development:
a) The last sheet of the control schematic displays contacts for internal panel relay contacts that connect with external field equipment or the Process Control Information System (PCIS).

b) Organizes into two sections. The first section lists all contacts extending to the PCIS. Title this section "Contacts to PCIS". The second section lists all contacts extending into the field equipment external to the panel. Title this section "Contacts to Field". Group multiple contacts related to a single piece of equipment together.
c) Each contact includes a signal description and its associated relay number and relay rung number location. Device signals require the appropriate symbol from the Schematic Legend Sheet.

8. Analog Loop Diagrams:
   a. General:
      1) The analog loop diagram only displays the portion of the instrument loop that passes through a particular panel.
      2) The analog loop diagram displays the connections between field instruments, panels and the PCIS.
      3) Analog loop diagrams are reserved for analog signals and control loops, but may be used to show complex connections for a particular instrument or device.
      4) Divide each loop into three different segments.
         a) The left segment is "FIELD" connections. This segment provides information on terminations external to the panel (i.e., connected panels, instrument transmitters). If the first segment is another panel, the panel name replaces the "FIELD" label.
         b) The center segment is the internal panel wiring and controls.
         c) The right segment information represents output or input signals to downstream panels or the PCIS.
      5) Identify shield grounding location.
      6) Identify surge protection devices for each signal. Include surge protection for positive and negative leads. Utilize the surge protection block symbol from the legends and symbols sheet.
      7) Identify the cable number, wire color and polarity for each cable in the loop.

3.4 INSTALLATION

A. Install equipment in conformance with NEC. Mounting panels on handrails is not allowed.

B. Unless otherwise noted, install indoor free standing panels on 4-inch concrete pad. Extend pad 4-inches beyond outside dimensions of base, all sides. Lay grout after panel sills have been securely fastened down.

C. Unless otherwise noted, install outdoor free standing panels on a reinforced concrete pedestal:
   1. Minimum Thickness: 8-inches with No. 4 steel reinforcing bars at 12-inches on centers, each way.
   2. Minimum Size: 4-inches larger than outer dimensions of base, all sides.

3. Provide excavation and backfill work in conformance with Section 02260, Excavation Support and Protection.
4. Provide concrete work in conformance with Section 03300, Cast-In-Place Concrete.
5. Seal the contact surface between the panel base along the outside perimeter of the panel using RTV sealant.
6. Install anchor bolts and anchor in accordance with Section 05190, Mechanically Anchoring and Fastening to Concrete and Masonary.

D. Elevated Panels with floor stands:
1. When installing conduits through bottom, utilize bushings to retain the NEMA rating of the panel.

E. Install each item in accordance with manufacturer's recommendations and in accordance with the Contract Documents.

3.5 RECORD DRAWINGS:

A. Maintain a set of red-line panel drawings to reflect changes or deviations that occur during installation, start-up and commissioning and incorporates these deviations into the final Operation & Maintenance Manual.

3.6 SPARE PARTS AND TEST EQUIPMENT

A. Furnish and deliver the spare parts and test equipment as outlined below, identical and interchangeable with similar parts furnished under this Specification.

B. Pack spare parts in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. The following constitutes the minimum spare parts:
1. Five of each type of control relay for each 40 or less furnished for this Contract.
2. One replacement power supply for each type and size furnished for this Contract.
3. One per ten (two, if fewer than twenty) of each type of panel mounted instrument including lights and pushbuttons.
4. One dozen of each type and size of fuse used in panels and instruments.

D. The following constitutes the minimum test and calibration equipment:
1. All tooling required to insert, extract and connect any internal or external connector, including edge connectors.
2. All special calibration equipment required for system calibration.

3.7 TESTING AND ADJUSTMENTS:

A. Perform system testing and make any adjustments necessary in accordance with this Section and Section 17000, Instrumentation.

B. Perform power supply, voltage adjustments to tolerances required by the appurtenant equipment.

C. A Factory Acceptance Test shall be conducted before the panel is shipped to the site. The Factory Acceptance test shall be witnessed by the ENGINEER and OWNER. The Factory Acceptance Test Report shall be utilized to document the test.
   1. All Control Panels require the Factory Acceptance Test to be witnessed by ENGINEER and OWNER:
   2. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to perform factory testing, before shipment, at the manufacturer's facility to verify that system components are functioning properly and that they meet the functional and performance requirements of the Contract Documents.
   3. Submit information on factory testing procedures to verify that testing shall fulfill the requirements as specified herein. Submittal shall be made at least two months in advance of any scheduled testing and shall include dates of scheduled tests.
   4. Notify ENGINEER, in writing, at least four weeks before expected initiation of tests. OWNER and ENGINEER may elect to be present at CONTRACTOR'S facilities during operational test of system equipment, either for individual units or as an integrated system. Presence of OWNER and ENGINEER during testing does not relieve CONTRACTOR from conforming to the requirements of the Contract Documents and shall in no way imply acceptance of the equipment.

D. System Hardware Operational Testing
   1. All input/output devices and components shall be tested to verify operability and basic calibration.
   2. All system hardware components equipment shall be tested to verify proper operation of the equipment as stand alone units. Test shall include, but not be limited to, the following:
      a. AC/DC power checks.
      b. Power fail/restart tests.
      c. Diagnostics checks.
      d. Test demonstrating that all specified equipment functional capabilities are working properly.
      e. All system components shall be tested to verify that communication between units is working properly.

3.8 MANUFACTURER'S SERVICE

A. Provide the services of qualified factory-trained service representative to check and approve the installation of the panel(s).

B. The factory trained service representative shall be provided for installation supervision, start-up and testing services. The representative shall make a minimum of 2 visits to the site to approve the completed installation and to perform start-up

testing of the equipment. The representative shall coordinate each visit with the ENGINEER prior to arrival on the site. The representative shall test operate the system in the presence of the ENGINEER and verify that the equipment conforms to requirements. The representative shall revisit the job site as often as necessary until the installation and testing is entirely satisfactory.

C. The factory trained service representative shall be provided for operation and maintenance personnel training services. The representative shall make a minimum of 1 visits to the site to perform the services as described under Section 01782, Operations and Maintenance Data. The representative shall coordinate each visit with the ENGINEER prior to arrival on the site.

D. For the factory trained service representative, all costs, including travel, lodging, meals and incidentals, shall be considered as included in the bid price.

E. Warranty: Standard Manufacturers and General Contractor Warranties.

END OF SECTION

SECTION 16170

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1, General Requirements, Specification Sections apply to this Section.

1.2 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product Data: For the following:
   1. Ground rods.
   2. Grounding conductors and cables.
   3. Connector products.

C. Submit Shop Drawings identifying each ground rod location, distance between Ground Rods and ground rod assemblies and other grounding electrodes. Identify each by letter in alphabetical order, add a key legend including GPS coordinates.

D. Qualification Data: For firms and persons specified in Paragaph 1.4 of this Specification.

E. Field Test Reports: Submit written test reports to include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   1. Comply with UL 467.

B. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.

C. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Grounding Conductors, Cables, Connectors, and Rods:
      a. Apache Grounding/Erico, Inc.
      b. Chance/Hubbell.
      c. Copperweld Corp.
      d. Dossert Corp.
      e. Erico, Inc.; Electrical Products Group.
      f. Framatome Connectors/Burndy Electrical.
      g. Galvan Industries, Inc.
      h. Kearney/Cooper Power Systems.
      i. Korns: C. C. Korns Co.; Division of Robroy Industries.
      j. O-Z/Gedney Co.; a business of the EGS Electrical Group.
      k. Raco, Inc.; Division of Hubbell.
      l. Superior Grounding Systems, Inc.
      m. Thomas & Betts, Electrical.

2.2 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Sections 16123 and 16124, Conductors and Cables.

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of

green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

E. Grounding Electrode Conductors: Stranded cable.

F. Underground Conductors: Bare, tinned copper, stranded, unless otherwise indicated.

G. Bare Copper Conductors: Comply with the following:
   1. Solid Conductors: ASTM B3.
   2. Assembly of Stranded Conductors: ASTM B8.
   3. Tinned Conductors: ASTM B33.

H. Copper Bonding Conductors: As follows:
   1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4-inch in diameter.
   2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
   3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8-inches wide and 1/16-inch thick.
   4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8-inches wide and 1/16-inch thick.

I. Grounding Bus: Bare, annealed copper bars of rectangular cross-section, with insulators.

2.3 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic welded type, in kit form, and selected per manufacturer's written instructions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel.
   1. Size: 3/4-inch in diameter by 120-inches long.

B. Ground Rods: Sectional type; copper-clad steel.
   1. Size: 3/4-inch in diameter by 120-inches long.

PART 3 - EXECUTION

3.1 APPLICATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

E. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.

F. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Use insulated spacer, space 1-inch from wall and support from wall 6-inches above finished floor, unless otherwise indicated.
   2. At doors, route the bus up to the top of the door frame, across the top of the doorway, and down to the specified height above the floor.

G. Underground Grounding Conductors: Use copper conductor, No. 4/0 AWG minimum. Bury at least 24-inches below grade or bury 12-inches above duct bank when installed as part of the duct bank.

3.2 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits.
   1. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:
   2. Feeders and branch circuits.
   3. Lighting circuits.
   4. Receptacle circuits.
   5. Single-phase motor and appliance branch circuits.
   6. 3-phase motor and appliance branch circuits.
   7. Flexible raceway runs.
   8. Armored and metal-clad cable runs.

C. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

D. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power distribution units.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a non-metallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Non-metallic Raceways: Install an equipment grounding conductor in non-metallic raceways unless they are designated for telephone or data cables.

H. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-inch by 2-inch by 12-inch grounding bus.
   2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

I. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch circuit conductors.

3.3 COUNTERPOISE

A. Ground the steel framework of the building with a driven ground rod at the base of every corner column and at intermediate exterior columns at distances not more than 60 feet apart. Provide a grounding conductor (counterpoise), electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Use tinned-copper conductor not less than No. 4/0 AWG for counterpoise and for tap to building steel. Bury counterpoise not less than 18-inches below grade and 24-inches from building foundation.

3.4 INSTALLATION

A. Ground Rods: Install at least three rods spaced at least one rod length from each other, and located at least the same distance from other grounding electrodes.
   1. Drive ground rods until tops are 2-inches below finished floor or final grade, unless otherwise indicated.
   2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

F. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

G. Bond each aboveground portion of gas piping system upstream from equipment shut-off valve.

H. Install test wells as indicated on the Contract Documents.

3.5 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean bare metal at points of contact.
3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

F. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

G. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

H. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.6 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

A. Duct Banks: Install a grounding conductor with at least 50% ampacity of the largest phase conductor in the ductbank.

B. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth to 4-inches above handhole or manhole floor. If necessary, install ground

rod before manhole is placed and provide a No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2-inches above to 6-inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 4/0 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18-inches below grade and 6-inches from the foundation.

3.7 FIELD QUALITY CONTROL

A. See Specification 16920, 3.1, Qualifications, for Independent Third Party Testing organization requirements.

B. Testing: Perform the following field quality control testing:
   1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
   2. Test completed grounding system at each location where a maximum ground resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method according to IEEE 81.
   3. Provide Drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
      a. Equipment Rated 500 kVA and Less: 10 ohms.
      b. Equipment Rated 500 to 1,000 kVA: 5 ohms.

c. Equipment Rated More Than 1,000 kVA: 3 ohms.
d. Substations and Pad-Mounted Switching Equipment: 5 ohms.
e. Manhole Grounds: 10 ohms.

4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 16190

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Supports, anchors, sleeves, and seals are indicated on the Drawings, schedules, and specified in other Sections of these Specifications.

B. Types of supports, anchors, sleeves and seals specified in this Section include the following:
   1. One-hole conduit straps.
   2. One-hole conduit straps with clamp backs.
   3. Two-hole conduit straps.
   4. Conduit hangers.
   5. I-beam clamps.
   6. Channel clamps.
   7. Round steel rods.
   8. Drop-in anchors.
   9. Wedge type anchor bolts.
   10. Lead expansion anchors.
   11. Toggle bolts.
   12. Wall and floor seals.
   13. Cable supports.
   14. U-Channel strut system.
   15. Sleeves.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following: Abbeon Cal Inc., Ackerman Johnson Fastening Systems Inc., Elcen Metal Products Co., Ideal Industries, Inc., Josyln Mfg and Supply Co., McGraw Edison Co., Rawlplug Co. Inc., Star Expansion Co., U.S. Expansion Bolt Co., Allied Tube and Conduit Corp., B-Line Systems,

Inc., Greenfield Mfg Co., Inc., Midland-Ross Corp., O-Z/Gedney Div; General Signal Corp., Power-Strut Div.; Van Huffel Tube Corp., and Unistrut Div; GTE Products Corp., and Robroy Industries.

2.2 GENERAL

A. Provide supporting devices that comply with manufacturers standard materials, design, and construction, in accordance with published product information, and as required for complete installations, and as specified herein.

2.3 SUPPORTS

A. Provide supporting devices of types, sizes, and materials indicated, and having the following construction features:
   1. One-Hole Conduit Straps: For supporting electrical metallic tubing, and liquidtight flexible conduit; zinc plated steel, stainless steel or galvanized steel; snap-on, heavy duty.
   2. One-Hole Conduit Straps with Clamp Backs: For supporting rigid metal conduit, and intermediate metal conduit; cast galvanized steel.
   3. Two-Hole Conduit Straps: For supporting electrical metallic tubing, rigid metal conduit, and intermediate metal conduit; zinc plated steel, stainless steel or galvanized steel.
   4. Conduit Hangers: For supporting electrical metallic tubing, rigid metal conduit, and intermediate metal conduit; zinc plated steel, stainless steel or galvanized steel.
   5. I-Beam Clamps: Electroplated zinc or hot-dipped galvanized malleable iron.
   6. Channel Clamps: Electroplated zinc or hot-dipped galvanized steel.
   7. Round Steel Rod: National coarse thread, electroplated.

2.4 ANCHORS

A. Provide anchors of types, sizes, and materials indicated, with the following construction features:
   1. Lead Expansion Anchors: For CMU walls, 1/4-inch-20 threads, set tool required.
   2. Toggle Bolts: Electroplated steel, size as required.
   3. Drop-in Anchors: Stainless steel, size as required.
   4. Anchor Bolts: Stainless steel, size as required.
   5. Half-round head, non-removable anchor bolts shall not be used.

2.5 SEALS

A. Provide seals of types, sizes, and materials indicated, with the following construction features:
   1. Wall and Floor Seals: Provide factory-assembled watertight wall and floor seals, of types and sized indicated; suitable for sealing around conduit, pipe,

or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.

2. Conduit sealing bushings shall be manufactured by O-Z/Gedney, Model CSMI, or equal.
3. The conductor sealing bushings shall be manufactured by O-Z/Gedney, Model CSBG, or equal.

2.6 CONDUIT CABLE SUPPORTS

A. Provide cable supports with insulating wedging plug for non-armored type electrical cables in risers; construct 2-inch rigid metal conduit; 3-wires, type wire as indicated; construct body of malleable-iron casting with hot-dip galvanized finish.

2.7 U-CHANNEL STRUT SYSTEM

A. Provide U-channel strut system for supporting electrical equipment, 12 gauge hot-dip galvanized steel, of types and sizes indicated; construct with 9/16-inch diameter holes, 8-inch o.c. on top surface, with the following fittings that mate and match with U-channel:
   1. Fixture hangers.
   2. Channel hangers.
   3. End caps.
   4. Beam clamps.
   5. Wiring stud.
   6. Thinwall conduit clamps.
   7. Rigid conduit clamps.
   8. Post bases.
   9. U-bolts.

2.8 PIPE SLEEVES

A. Provide pipe sleeves from the following:
   1. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.

2.9 PVC COATED U-CHANNEL STRUT SYSTEM

A. Provide PVC Coated U-channel strut system for supporting electrical equipment, 20 mil PVC coated steel, of types and sizes indicated; construct with 9/16-inch diameter holes, 8-inch o.c. on top surface, with all stainless steel hardware, and the following fittings that mate and match with PVC coated U-channel:
   1. PVC coated strut nut.
   2. PVC coated pipe straps.
   3. Touch up compound (gray).

2.10 STAINLESS STEEL U-CHANNEL STRUT SYSTEM

A. Provide stainless steel U-channel strut system for supporting electrical equipment, of types and sizes indicated; construct with 9/16-inch diameter holes, 8-inch o.c. on top surface, with all stainless steel hardware, and the following stainless steel fittings that mate and match with stainless steel U-Channel:
   1. Fixture hangers.
   2. Channel hangers.
   3. End caps.
   4. Beam clamps.
   5. Wiring stud.
   6. Post bases.
   7. Rigid conduit clamps.
   8. U-bolts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install hangers, anchors, sleeves, and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA and NEC for installation of supporting devices.

B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.

C. Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of two or more parallel runs of conduits to be supported together on channel type hangers where possible. Install supports with spacing indicated and in compliance with NEC requirements.

D. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form watertight seal.

E. Comply with manufacturer’s recommendations for touch up of field cut ends or damaged PVC coated U-channel and fittings.

F. Remove burrs and apply a cold zinc galvanizing paint to field cut galvanized U-channel strut.

END OF SECTION

SECTION 16195

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Electrical identification work specified in this Section covers the following:
   1. Buried cable warnings.
   2. Electrical power, control and communication conductors.
   3. Operational instructions and warnings.
   4. Danger signs.
   5. Equipment/system identification signs.

1.2 SUBMITTALS

A. Submittals to the ENGINEER shall include the following:
   1. Manufacturers data on electrical identification materials and products.
   2. Samples of each color, lettering style, and other graphic representation required for each identification material or system.

1.3 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering electrical identification products maybe incorporated in the Work include, but not limited to, the following:
   1. Brady, W.H. Co.
   2. Ideal Industries, Inc.
   3. Panduit Corp.
   4. Or equal.

1.4 QUALITY COMPLIANCE

A. Comply with applicable requirements of UL Std. 969, "Marking and Labeling Systems", pertaining to electrical identification systems.

B. Comply with applicable requirements of NEMA Std. No's WC-1 and WC-2 pertaining to identification of power and control conductors.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is installer's option, but provide single selection for each application.

2.2 COLOR-CODED CONDUIT MARKERS

A. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, extending 360 degrees around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretensioned snap-on. Except as otherwise indicated, provide lettering that indicates voltage of conductor(s) in conduit. Provide 8-inches minimum length for 2-inch and smaller conduit, 12-inches length for larger conduit.

B. Unless otherwise indicated or required by governing regulations, provide white markers with black letters.

C. Tag all conduits at the ends and in all intermediate boxes, chambers, hand holes and other enclosures.

D. Each conduit tag shall include the conduit number as shown on the conduit block diagrams on the Drawings.

2.3 CABLE AND CONDUCTOR WIRE MARKERS

A. Cable and conductor wire markers shall be self laminating vinyl on white background, printed using a Seton printer, a Brady TLS2200 printer or equal. Handwritten wire markers are not acceptable.

2.4 SELF-ADHESIVE PLASTIC SIGNS

A. Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., 208 V, EXHAUST FAN, RECTIFIER.

B. Unless otherwise indicated or required by governing regulations, provide white signs with black lettering.

2.5 LETTERING AND GRAPHICS

A. Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper

identification and operation/maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install electrical identification products as indicated, in accordance with manufacturer's written instructions and requirements of NEC.

B. Where identification is to be applied to surfaces that require finish, install identification after completion of painting.

C. Comply with governing regulations and requests of governing authorities for identification of electrical work.

3.2 CONDUIT IDENTIFICATION

A. Where electrical conduit is exposed in spaces with exposed mechanical piping that is identified by a color-coded method, apply color-coded identification on electrical conduit in manner similar to piping identification. Except as otherwise indicated, use white as coded color for conduit.

3.3 CABLE/CONDUCTOR IDENTIFICATION

A. Apply cable/conductor identification, including voltage, phase and feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present, except where another form of identification (such as color-coded conductors) is provided. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for Project's electrical work.

3.4 EQUIPMENT/SYSTEM IDENTIFICATION

A. Install engraved plastic-laminate sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication-control-signal systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2-inch high lettering on 1-1/2-inch high sign (2-inch high where two lines are required), white lettering in black field. Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work:
   1. Panelboards, electrical cabinets and enclosures.

2. Access panel/doors to electrical facilities.
3. Major electrical switchgear.

B. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with brass or stainless steel screws, except use adhesive where screws should not or cannot penetrate the substrate.

3.5 CIRCUIT IDENTIFICATION

A. The 3-phase wires shall be identified at the switchgear, panelboards and motor control centers as Phases A, B, and C. At 277/480 V, Phase A shall be brown, Phase B shall be orange, and Phase C shall be yellow. The neutral shall be gray.

B. In addition to color coding all conductors, each conductor shall be identified in each pull box, manhole, panelboard, cable tray, or termination with circuit identification markers. This identification is applicable to all power, control, alarm, and instrumentation conductors and these markings shall be recorded on the Record Documents. Markers shall be slip-on PVC sleeve type as manufactured by Brady, Seton, or equal.

C. Markers for other cabling shall be B-292 vinyl as manufactured by Brady, Seton, or equal.

D. Exposed medium voltage conduits shall be labeled at 50 foot intervals with 1-inch letters stating the voltage - example – "12,470 volts". Labels shall be vinyl plastic as manufactured by Brady, Seton, or equal.

3.6 AUTOMATIC EQUIPMENT WARNING SIGNS

A. Permanent warning signs shall be mounted at all mechanical equipment that may be started automatically or from remote locations. Signs shall be in accordance with OSHA Regulations and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to the ENGINEER.

B. Warning signs shall be 7-inches high by 10-inches wide, colored yellow and black, on not less than 18 gauge vitreous enameling stock. Sign shall read:

CAUTION
THIS EQUIPMENT STARTS
AUTOMATICALLY
BY REMOTE CONTROL

3.7 HIGH VOLTAGE WARNING SIGNS

A. Permanent and conspicuous warning signs shall be mounted on all equipment, doorways to equipment rooms, pull boxes, manholes, where the voltage exceeds 600 volts.

B. Signs shall be in accordance with OSHA regulation, and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to the ENGINEER.

C. Signs shall be 7-inches high by 10-inches wide, colored red and white, on not less than 18 gauge vitreous enameling stock. Sign shall read:

WARNING
HIGH VOLTAGE
KEEP OUT

3.8 CONDUCTOR FASTENERS

A. Glue-on type conductor fasteners shall not be used in any panels, panelboards, switchboards, switchgear, motor control centers, or other enclosures containing electrical devices and/or conductors.

END OF SECTION

SECTION 16282

SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install surge protective devices (SPD) as a minimum for all 480 VAC and above panelboards, switchboards and motor control centers above 1,000 amp rating and where shown on the Drawings.
   2. These Specifications describe the electrical and mechanical requirements for a system of electrical surge protective device filter components integrating both surge suppression and electrical high frequency noise filtering.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Referenced Standards. Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ANSI/IEEE (C62.41-1991 and C62.45-2002).
   2. National Electrical Code (NEC) 2011 version.
   3. NFPA (70 [NEC], 75 and 78).
   4. UL Standard No. 248-1, 1283 and 1449 Third Edition.
      a. Each system component shall be UL Standard No. 1283, Listed as an Electromagnetic Interference Filter.
      b. Each system component shall be UL Standard No. 1449, Third Edition, listed as a Surge Protective Device.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Electrical and mechanical drawings for each type of unit that shows electrical ratings, dimensions, weights, mounting provisions, connection details and layout diagrams.
   2. Provide complete copy of Warranty; refer to requirement of paragraph 2.2.G of this Specification.

3. Provide verification that the SPD complies with the required UL Standard No. 1449 VPRs.
4. Provide actual let through voltage test data in the form of oscillograph results for the ANSI/IEEE C62.41 6kV/3kAcombination wave tested in accordance with ANSI/IEEE C62.45.
5. Provide spectrum analysis of each unit based on MIL-STD-220A test procedures between 50 kHz and 200 kHz verifying the device's noise attenuation exceeds 50 dB at 100 kHz.

B. Operation and Maintenance Manuals:
1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information. Provide complete copy of Warranty. Refer to requirements of paragraph 2.2.G of this Specification.
2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01730, Operation and Maintenance Data.

PART 2 - PRODUCTS

2.1 GENERAL

A. Unit Operating Voltage: The operating voltage shall be as shown on the Drawings.

B. Maximum Continuous Operating Voltage (MCOV): The MCOV shall be greater than 115 percent of the nominal system operating voltage.

C. Protection Modes: For a wye configured system, the device must have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G). For a delta configured system, the device must have suppression elements between line to line (L-L) and line to ground (L-G).

D. The maximum UL Standard No. 1449 VPR for the device must not exceed the following:
1. Line to Neutral: 1200 volts.
2. Line to Ground: 1200 volts.
3. Neutral to Ground: 1200 volts.
4. Line to Line: 2000 volts.

E. Surge Current Capacity: For branch applications, total surge current per phase (based on an 8x20 microsecond waveform) that the device is capable of surviving shall not be less than 250 kA per phase, or 125 kA per mode on L-G, L-N and N-G modes (Wye system); L-L and N-G (Delta system).

F. Let through voltage at the Motor Control Center Stabs: Upon request, the manufacturer must provide suppression test results measured at the motor control center bucket stabs.

2.2 DESIGN

A. Each circuit shall include arrays of fused Metal Oxide Varistors (MOV) to suppress voltage surges.

B. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating SPD modules which do not provide a balanced impedance path to each MOV shall not be acceptable.

C. Electrical Noise Filter: Each unit shall include a high performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 55 dB at 100 kHz using the MIL-STD-220A insertion loss test method. The unit shall be complimentary listed to UL Standard No. 1283. Products not able to demonstrate noise attenuation of 55 dB @ 100 kHz shall be rejected.

D. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings.

E. Safety and Diagnostic Monitoring. Each unit shall be equipped with 200 kAIC internal fuses. Each unit shall provide the following three levels of monitoring:
   1. Continuous monitoring of fusing system.
   2. Internal infrared sensor system for monitoring individual MOVs (including neutral to ground). The system must be capable of identifying open circuit failures not monitored by conventional fusing systems.
   3. Thermal detection circuit shall monitor for overheating in all modes due to thermal runaway.

F. A green/red solid state indicator light shall be provided on each phase. The absence of a green light and the presence of a red light; shall indicate which phase(s) have been damaged. Fault detection will activate a flashing trouble light. Units will not be accepted if they cannot detect open circuit damage, thermal conditions, and over current.

G. Warranty: The manufacturer shall provide a full five year warranty from the Date of Shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and National Electrical Code.

H. Product and Manufacturer: Provide one of the following:
   1. Joslyn Electronic Systems Company.
   2. Square "D" Company.
   3. Liebert.
   4. Current Technology.

2.3 ACCESSORIES

A. The unit must be equipped with surge event counter and audible alarm.

B. Remote Status Monitor. The SPD device must include Form C dry contacts (one N.O. and one N. C.) for remote annunciation of unit status to Computer Control System. The remote alarm shall change state if any of the three monitoring systems described detect a fault condition.

C. Push-To-Test Feature. Each suppression unit shall incorporate an integral test feature which verifies the operational integrity of the unit's monitoring system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Suppressors shall be installed inside the motor control center at the manufacturer's factory.

B. To facilitate removal and inspection, the suppressor shall be mounted within a standard motor control center bucket.

C. The suppressor shall be mounted in a standard 12-inch NEMA 1 compartment. Conductor length between the suppressor and the stab shall be less than 5-inches. All units shall be internally fused with 200 kAIC. All status indicators and monitors shall be mounted on the front of the motor control center compartment for easy visibility.

END OF SECTION

SECTION 16440

DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section covers electrical disconnecting switches.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy-duty safety switches with a quick-make, quick-break operating mechanism, with full cover interlock, and indicator handle. The disconnect switches shall be furnished with fuses of the size indicated on the Drawings. One set of spare fuses shall be furnished for each fused disconnect switch. Disconnect switches shall be NEMA Type HD heavy duty construction, UL 98 listed.

B. Enclosures shall be rated NEMA 12 for indoor use and NEMA 3R for outdoor use, unless otherwise indicated on the Drawings.

C. Disconnect switch handle shall be padlockable.

D. Disconnect switches in the corrosive areas, as indicated on the Drawings, shall be NEMA 4X, 304 stainless steel.

E. Disconnect switches shall be as manufactured by Square D, Cutler Hammer, Allen-Bradley, General Electric, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Disconnect switches shall be installed as indicated on the Drawings.

B. Provide grounding per NEC and Section 16170, Grounding and Bonding.

3.2 TESTING

A. Test in accordance with Specification 16920, Electrical Acceptance Testing.

END OF SECTION

SECTION 16461

TRANSFORMERS - DRY TYPE

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section covers dry type transformers used for low voltage, single- and 3-phase, power distribution and lighting.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

1.3 QUALITY ASSURANCE

A. ANSI C57.12.01, Dry Type Transformers.

B. ANSI C89.2, Dry Type Transformers.

C. NEMA ST-20, Dry Type Transformers.

D. UL 506, Specialty Transformers.

PART 2 - PRODUCTS

2.1 DISTRIBUTION - LOW VOLTAGE LIGHTING AND POWER

A. Transformers shall be premium high efficiency quiet type, and shall be installed where indicated on the Drawings. The primary winding of the transformers shall have two 2-1/2% taps above and below normal.

B. The transformers shall have a BIL of 10 KV with a temperature class of 185° C for transformers up to 25 KVA, and a temperature class of 220 C for larger transformers.

C. The sound level shall not exceed 44 dBa measured at 5 feet from the transformer after installation. Core and coil assemblies 30 KVA and larger shall be mounted on rubber vibration isolators, designed to reduce harmonics generated noise.

D. Transformers shall be types manufactured by Cutler-Hammer, Square D, Hevi-Duty, or equal.

2.2 FERRO RESONANT ISOLATION TRANSFORMERS

A. Ferro resonant isolation transformers shall be provided where indicated on the Drawings. Regulation shall be +3% for an input range of +10%. Common mode noise rejection shall be better than 120 dB with transverse mode noise rejection better than 60 dB. Voltage spike attenuation shall be better than 250:1.

B. Isolation transformers shall be as manufactured by Shape Magnetronics, Control Concepts, Inc., or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Transformers shall be installed as indicated on the Drawings, and in accordance with the manufacturer's instructions and recommendations. CONTRACTOR shall provide painted metal wall brackets, when required.

B. Grounding shall be provided per NEC and Section 16170, Grounding.

3.2 TESTING

A. Test in accordance with Specification 16920, Electrical Acceptance Testing.

END OF SECTION

SECTION 16470

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1, General Requirements, Specification Sections apply to this Section.

1.2 SUMMARY

A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 volt and less for the following types:
   1. Lighting and appliance branch-circuit panelboards.
   2. Distribution panelboards.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio frequency interference.

D. RMS: Root mean square.

E. SPDT: Single-pole, double throw.

F. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Dimensioned Plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Enclosure types and details for types other than NEMA 250, Type 1.

b. Bus configuration, current, and voltage ratings.
c. Short-circuit current rating of panelboards and overcurrent protective devices.
d. UL listing for series rating of installed devices.
e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined for the Project. Include the following:
1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event".
3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in Paragraph 1.5 of this Specification.

E. Field Test Reports: Submit written test reports and include the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1, General Requirements. In addition to requirements specified in Section 01700, Contract Closeout, include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Panelboards, overcurrent protective devices, controllers, contactors, and accessories:
      a. Eaton Corp., Cutler-Hammer Products, or pre-approved equal.

2.2 FABRICATION AND FEATURES

A. Enclosures: Flush and surface mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
   1. Outdoor Locations: NEMA 250, Type 3R, with intrusion switch.
   2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   3. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

B. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

C. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

D. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

E. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

F. Bus: Hard-drawn copper, 98% conductivity.

G. Main and Neutral Lugs: Mechanical-type suitable for use with conductor material.

H. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

I. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.

J. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

K. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.

L. Split Bus: Vertical buses divided into individual vertical sections.

M. Gutter Barrier: Arrange to isolate individual panel sections.

N. Feed-through Lugs: Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

2.3 PANELBOARD SHORT CIRCUIT RATING

A. Fully rated to interrupt symmetrical short circuit current available at terminals.

2.4 LOAD CENTERS

A. Overcurrent Protective Devices: Bolt-on, full-module circuit breaker.

B. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

2.5 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Front-mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.6 DISTRIBUTION PANELBOARDS

A. Doors: Front-mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.

B. Main Overcurrent Protective Devices: Circuit breaker.

C. Branch Overcurrent Protective Devices shall be one of the following:
   1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
   2. For Circuit Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.7 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
      Instantaneous trip.
      a. Long- and short-time pickup levels.
      b. Long- and short-time time adjustments.
      c. Ground-fault pickup level, time delay, and I2t response.
   4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let through ratings less than NEMA FU 1, RK-5.

B. Molded Case Circuit Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
   1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
   2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
   3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: To test functions of solid-state trip devices without removal from panelboard.

C. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mounting Heights: Top of trim 74-inches above finished floor, unless otherwise indicated.

C. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

D. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

E. Install filler plates in unused spaces.

F. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 16075, Electrical Identification.

B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Prepare for Acceptance Tests as follows:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24 hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20% between phase loads within a panelboard is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.
   1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
   2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and circuit breaker trip ranges.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION

SECTION 16476

LOW VOLTAGE CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The CONTRACTOR shall furnish and install low voltage circuit breakers, as indicated on the Drawings and specified herein.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents, prior to installation.

1.3 QUALITY ASSURANCE

A. The breaker manufacturer's facilities shall be ISO 9001 certified.

PART 2 - PRODUCTS

2.1 GENERAL

A. Circuit breakers shall be as manufactured by Square D, Cutler-Hammer, Allen-Bradley, General Electric, or equal.

B. Circuit breaker frame, trip, short circuit, and interruption ratings shall be as indicated on the Drawings, except that they shall be coordinated with the ratings of the equipment actually furnished, and shall be modified where necessary to suit the equipment. Circuit breakers to be used in motor control centers shall be as indicated on the Drawings. Where no indication of type is given on the Drawings, circuit breakers protecting motors shall be motor circuit protectors and other circuit breakers shall be molded case type.

C. Circuit breaker for mounting in motor control centers or for separate mounting shall be of the air-break type, quick-make and quick-break, 600 volt, with number of poles as indicated on the Drawings.

D. Each pole of the circuit breaker shall provide inverse time delay and instantaneous circuit protection.

E. The breakers shall be operated by a handle and shall have a switching mechanism that is mechanically trip free from the handle, so that the contacts

cannot be held closed against short circuits, and abnormal currents. Tripping due to overload, or short circuit shall be clearly indicated by the handle automatically assuming a position between the manual ON and OFF positions. Latch surfaces shall be ground and polished. Poles shall be constructed so that they open, close, and trip simultaneously.

F. Breakers must be completely enclosed in a molded case. Non-interchangeable trip breakers shall have their covers sealed; interchangeable trip breakers shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes. The minimum interrupting ratings of the circuit breakers shall be at least equal to the available short circuit current at the line terminals.

G. Circuit breakers shall conform to the applicable requirements of NEMA Standards Publication No. AB1.

H. Molded case circuit breakers shall be ambient temperature compensating that provides inverse time delay overload and instantaneous short circuit protection by means of a thermalmagnetic element. Compensation shall be accomplished by a secondary bi-metal that will allow the breaker to carry rated current between 25° C and 50° C with tripping characteristics that are approximately the same throughout this temperature range.

I. On breakers with interchangeable, thermal, adjustable magnetic trip, the accessibility and position of the adjustment knob shall not be changed from those on the standard breaker.

J. Unless mounted in a switchboard, or panelboard, circuit breakers shall be housed in a NEMA rated enclosure as described elsewhere in these specifications.

K. Provide circuit breakers with shunt trip mechanisms where shown on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Circuit breakers shall be installed as indicated on the Drawings and per manufacturer's instructions.

END OF SECTION

SECTION 16477

600 V FUSES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section covers the requirements for protective fusing on this Project. The CONTRACTOR shall furnish and install fuses and fuse holders per the Drawings and equipment manufacturer's recommendations.

B. This Specification includes the general requirements for various types of fuses whether they are shown on the Drawings or not. If fusing is required by codes or manufacturers recommendations, but not shown on the Drawings, this Specification shall apply to the type of fusing provided by the CONTRACTOR.

C. Types of fuses specified in this Section include the following:
   1. Class L time-delay.
   2. Class L fast-acting.
   3. Class RK1 time-delay.
   4. Class RK1 and Class J current-limiting.
   5. Class RK5 time-delay.
   6. Class K5 time-delay, noncurrent-limiting.
   7. Class T current-limiting.

1.2 QUALITY ASSURANCE

A. The fuse manufacturer's facilities shall be ISO 9001 certified.

1.3 CODES AND STANDARDS

A. UL Compliance and Labeling: Comply with applicable provisions of UL 198D, "High-Interrupting-Capacity Class K Fuses". Provide over-current protective devices which are UL listed and labeled.

B. NEC Compliance: Comply with NEC as applicable to construction and installation of fusible devices.

C. ANSI Compliance: Comply with applicable requirements of ANSI C97.1, "Low-Voltage Cartridge Fuses 600 Volts or Less".

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data on fuses, including specifications, electrical characteristics, installation instructions, furnished specialties, and accessories in accordance with Section 16000, General Electrical Requirements, and the Contract Documents. In addition, include voltages and current ratings, interrupting ratings, current limitation ratings, time-current trip characteristic curves, and mounting requirements.

1.5 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering fusible devices which may be incorporated in the work include, but are not limited to, the following:
   1. Bussmann.
   2. Gould-Shawmut.
   3. Reliance.
   4. Or equal.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics indicated, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.

2.2 CLASS L TIME-DELAY FUSES

A. Provide UL Class L time-delay fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting transformers, motors, and circuit-breakers.

2.3 CLASS L FAST-ACTING FUSES

A. Provide UL Class L fast-acting fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting service entrances and main feeder circuit-breakers.

2.4 CLASS RK1 TIME-DELAY FUSES

A. Provide UL Class RK1 time-delay fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting motors and circuit-breakers.

2.5 CLASS RK1 CURRENT-LIMITING FUSES

A. Provide UL Class RK1 current-limiting fuses rated 250 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers.

2.6 CLASS J CURRENT-LIMITING FUSES

A. Provide UL Class J current-limiting fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating.

2.7 CLASS RK5 TIME-DELAY FUSES

A. Provide UL Class RK5 time-delay fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting motors.

2.8 CLASS K5 ONE-TIME FUSES

A. Provide UL Class K5 one time fuses rated 250 volts, 60 Hz, with 100,000 RMS symmetrical interrupting current rating for protecting non-inductive loads.

2.9 CLASS T FUSES

A. Provide UL Class T fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protection of physically small devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fuse types and sizes shall be as indicated on the Drawings. Fuses shall be installed in accordance with the National Electric Code (NEC) requirements and the manufacturer's written instructions.

B. Install fuses in proper fuse holders.

C. Where fuses are installed in the motor starters, fuses shall be sized to match the actual motor full load current.

D. Where fuses are installed in disconnect switches at HVAC units, the fuse sizes shall be sized to meet the HVAC manufacturer's requirements.

E. Fuses for control transformers shall be sized in accordance with the National Electrical Code.

F. Fuses shall be installed with the labels clearly visible.

3.2 FIELD QUALITY CONTROL

A. Prior to energizing fusible devices, test devices for circuit continuity and for short circuits.

3.3 SPARE PARTS

A. Furnish three spare fuses of each size and type.

END OF SECTION

SECTION 16500

LIGHTING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install lighting fixtures.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. National Electrical Code (NEC).
   2. UL Standard #57, Electric Lighting Fixtures
   3. UL Standard #844, Electric Lighting Fixtures for Use in Hazardous Location.
   4. UL Standard #1570, Fluorescent Lighting Fixtures.
   5. UL Standard #1571, Incandescent Lighting Fixtures.
   6. UL Standard #1572, High Intensity Discharge Lighting Fixtures.
   7. Illuminating Engineering Society (IES).
   8. All applicable local lighting ordinances

B. Miscellaneous:
   1. Lamps are identified for each luminaire in the Lighting Fixture Schedule on the Drawings.
   2. Lighting fixtures and electrical components:
      a. UL labeled, complete with lamps.
      b. Rated for area classification as indicated.
   3. Location of lighting fixtures on Drawings are intended to be used as a guide.
      a. Field conditions may affect actual locations.
      b. Coordinate with other trades to avoid conflicts in mounting of fixtures and other equipment.
   4. The quality standard is established by the fixture listed in the Lighting Fixture Schedule.
      a. This quality standard includes, but is not necessarily limited to construction features, materials of construction, finish, and photometrics.

1.3 SUBMITTALS

A. The following shall be submitted to the ENGINEER for review:
   1. Acknowledgment that products submitted meet requirements of standards referenced.

2. Manufacturer's technical information on products to be used including photometric performance curves for the fixture and ballast data.
3. Acknowledgment that products submitted are UL or ETL listed.
4. When general data sheets constitute part of the submittal, identify the products to be used on this Project.
5. Manufacturer's installation instructions.
6. Identification of fixtures by Lighting Fixture Schedule.
7. UL nameplate data (voltage, wattage, etc.).
8. Finishes, colors, and mounting type.
9. Pole, fixture, and accessories.
10. Pole wind loading.

B. CONTRACTOR shall submit shop drawings, manufacturer's data sheets, and a complete wiring diagram detailing all connections to the electrical system in accordance with Section 16000, General Electrical Requirements, and other requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Lamps shall be manufactured by General Electric, North American/Phillips, Sylvania, or equal.

B. Lighting fixtures shall be provided as indicated on the Lighting Fixture Schedule on the Drawings.

C. Lighting ballasts shall be manufactured by General Electric, Advance, Jefferson, Universal, Bodine, Lithonia, or equal.

2.2 MATERIALS

A. General:
   1. Lamps:
      a. See Lighting Fixture Schedule on Drawings for wattage, voltage, and number required.
   2. All Fixtures:
      a. There shall be no live parts normally exposed to contact.
      b. When intended for use in wet area:
         1) Mark fixtures "suitable for wet locations".
      c. When intended for use in damp areas:
         1) Mark fixtures "suitable for damp locations" or "suitable for wet locations".

d. In wet or damp area, install fixtures so that water cannot enter or accumulate in the wiring compartment, lampholder, or other electrical parts.
e. Gasket Seals: Urethane foam.
f. Diffusers: UV stabilized acrylic plastic.

3. Underground Wiring:
   a. Provide all wiring runs with separate green grounding conductor.
   b. Ground all pole bases.
4. Pole Wiring from Base to Ballast:
   a. No. 12 Type XHHW.
   b. Each phase shall be protected by a 30 A, 600 V, Type Tron waterproof fuseholder, Bussman "Limitron" type fuse, size rating 3-times load current.

B. Incandescent Lamps:
1. Types:
   a. 30-135 Watts: Energy efficient.
   b. 200-500 Watts: Standard.
2. Inside frost.
3. Base: Aluminum or brass.
4. PAR/Halogen.

C. Fluorescent Lamps:
1. Rapid start.
2. Cool white (F32T8/41K-85CRI and F96T12/41K-70CRI/HO/ES).
3. Energy efficient or standard as noted on the Lighting Fixture Schedule.

D. High-Pressure Sodium Lamps:
1. Bulb Finish: Clear.
2. Any burning position.

E. Metal Halide Lamps:
1. Bulb Finish: Clear.
2. Any burning position.

F. Furnish a minimum of two lamps, or 10% spare lamps, of each type and wattage, whichever is greater.

2.3 FIXTURES

A. Fluorescent Lighting Fixtures:
1. Ballast:
   a. Rapid start, high power factor type.
   b. CBM/ETL certified.
   c. Sound rating A.

d. Two internal automatic-resetting thermal switch devices for coil and capacitor.

2. Internal Wiring: AWM, TFN or THHN.
3. Channel and End Plates: 22 gage steel.
4. Steel Door Frame and Socket Track: 20 gage steel.
5. Channel Cover: 24 gage steel.
6. Emergency Ballast:
   a. Integral rechargeable nickel-cadmium battery, battery charger, and automatic transfer circuitry.
   b. Charging indicator light.
   c. Test switch.
   d. Provide a minimum of 900 lumen output for 90 minutes upon loss of normal power.
   e. Mounted integral to the fixture.
   f. UL 924 listed.
7. Provide fixtures with emergency ballasts with permanent caution labels warning that the fixture is fed from an unswitched source.
   a. Provide emergency ballast also with a similar caution label.

B. HID Lighting Fixtures:
   1. Ballasts for High Pressure Sodium Lighting Fixtures:
      a. Type: Regulating.
      b. Ballast Design Center Variance: Maximum 5% from rated lamp wattage.
      c. Lamp Wattage Regulation Spread at the Lamp Voltage: Maximum 10% for ±10% line voltage variation.
      d. Ballast primary current during starting not to exceed normal operating current.
      e. Lamp Current Crest Factor: Maximum 1.8 for ±10% line voltage variation at any lamp voltage, from nominal through life.
      f. Power factor shall not drop below 90% for ±10% line voltage variations at any lamp voltage, from nominal through life.
      g. Capacitor Variance: Tolerance of ±6% which will not cause more than a ±8% variation in regulation throughout rated lamp life for nominal line voltage.
      h. Capable of operation with an open circuit condition for a maximum of six months without significant loss of ballast or starting circuitry life.
   2. Ballasts for Metal Halide/Mercury Vapor Lighting Fixtures:
      a. Type: Auto-regulator.
      b. Voltage Input Range: ±10%.
      c. Lamp Regulation Spread: 20% maximum.
      d. Power Factor: 90% to 95%.
      e. Input Voltage Dip (4 sec.): 40% to 50%.
      f. Crest Factor of Lamp Current: 1.6 to 2.0.
   3. Ballasts for Exterior HID Lamps:
      a. UL approved.

b. High power factor designed for -20° F temperature starting.

4. Fixtures for Non-hazardous Locations:
   a. Type: Industrial low bay.
   b. Ballast Housing: Die-cast.
   c. Filter: Activated charcoal.
   d. Refractor: UV stabilized molded acrylic.

2.4 MISCELLANEOUS ELECTRIC DEVICES

A. Photoelectric control units shall meet the following requirements:
   1. Cadmium sulfide photocell.
   2. Aluminum weatherproof enclosure.
   3. 30 amp rated contacts.
   4. 120 volt AC power.
   5. The photoelectric control unit shall be Tork Model 2100, or equal.

B. Motion sensors shall meet the following requirements:
   1. 110 degrees field of view, 60 foot range.
   2. Adjustable time setting from 15 seconds to 15 minutes.
   3. Operating temperature of -20° F to +130° F.
   4. Complete outdoor, weather proof sensor with complete mounting hardware.
   5. UL listed.
   6. The motion sensor(s) shall be manufactured by Leviton Model 50500-H or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lamps in all luminaires.

B. Replace all failed fluorescent, incandescent, metal halide, mercury vapor, and high pressure sodium lamps with new lamps prior to final acceptance by OWNER.

C. Surface and flush mounted fixtures shall be solidly connected to a junction box. Suspended fixtures shall be hung utilizing pendant mounting or stainless steel chains and hooks. Each suspended fixtures, shall be electrically connected by a length of Type SO flexible cord. Three conductor No. 14 AWG, minimum, with a twist-lock receptacle mounted in an individual junction box. Plugs and receptacles shall be as manufactured by Hubbell, General Electric Company, or equal.

D. Provide mounting brackets and/or structural mounting support for fixtures.
   1. Do not support fixture from conduit system.

2. Do not support fixture from outlet boxes.

E. Install with approved mounting hardware following manufacturer's recommendations.

F. Pole mounted fixtures shall be mounted on steel or aluminum poles as indicated on the Drawings. All metal poles shall be bonded to the facility ground system. Poles shall have adequate handholes and weatherproof receptacles where indicated.

G. All anchor bolts and nuts shall be stainless steel. CONTRACTOR shall paint all steel poles with aluminum paint or other color in accordance with these Contract Documents.

H. Fixture mounting heights and locations indicated on the Drawings are approximate and are subject to revision in the field where necessary to avoid conflicts and obstructions.

3.2 ADJUSTING AND CLEANING

A. Wipe all lighting fixture reflectors, lenses, lamps, and trims clean after installation and prior to acceptance of Project by OWNER.

END OF SECTION

SECTION 16902

ELECTRICAL CONTROLS, RELAYS, AND ALARMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section includes the following:
   1. Pushbutton and selector switches.
   2. Relays.
   3. Alarms.
   4. Intrinsic safety barriers.
   5. Wireways.
   6. Watt-hour transducers.
   7. Elapsed time meters and time clocks.
   8. Temperature Switches.
   9. Motor Starters and Overload Relays.

1.2 RELATED SECTIONS

A. Section 16000, General Electrical Requirements.

B. Section 16160, Enclosures.

1.3 REFERENCES

A. NEMA ICS 1, General Standards for Industrial Control Systems.

B. NEMA ICS 2, Standards for Industrial Control Devices, Controllers and Assemblies.

C. NEMA ICS 6, Enclosures for Industrial Controls and Systems.

D. NEMA ST 1, Standard for Specialty Transformers (Except General Purpose Type).

1.4 SUBMITTALS

A. Data: A complete list of equipment and material including manufacturer's descriptive data and technical literature, performance charts, catalog cuts and installation instructions, spare parts data for each different item of equipment specified. The data shall include a complete Bill of Materials.

B. Drawings: Containing complete wiring and schematic diagrams, control diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout, anchorage, support and appurtenances of equipment and equipment relationship to other parts of the work including clearances for maintenance and operations.

C. Submit Shop Drawings in accordance with the Contract Documents and NEMA ICS 1 Specifications indicating control panel layouts, wiring connections and diagrams, dimensions, support points.

1.5 PROJECT RECORD DOCUMENTS

A. Submit record documents in accordance with the Contract Documents.

B. Accurately record actual locations of control equipment. Revise diagrams included in Drawings to reflect actual control device connections.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation data in accordance with the Contract Documents.

B. Include instructions for adjusting and resetting time delay relays, timers, and counters.

C. Submit maintenance data in accordance with the Contract Documents.

D. Include recommended preventative maintenance procedures and materials.

PART 2 - PRODUCTS

2.1 PUSHBUTTONS AND SELECTOR SWITCHES

A. Pushbuttons, pilot lights, selector switches, and potientiometers shall be of the full size NEMA-rated type, 30mm, heavy-duty industrial, oil tight, 120 volt, with interchangeable pilot lights, plug-in construction, double break silver contacts, chrome plated lock rings, with modular contacts, and NEMA rating equal to that of the enclosure on which devices are installed. All components shall be flush mounted on front of panel, unless otherwise noted.

B. Provide individual legend plates for indication of switch, pushbutton, and light function (e.g., Open, Closed, Hand-Off-Auto). A list shall be submitted for review and approval.

C. Pilot lights shall be 30mm high intensity LED type. Pilot lights shall have clear lenses and LED lamps colored as shown on the Drawings. Common, remote

push-to-test circuitry shall be provided for each control panel to simultaneously test all indicating lights on the panel using a single pushbutton when there are 10 or more lights on the panel. Control panels with less than 10 lights shall utilize individual push-to-test lights and control circuitry.

D. Pushbuttons shall be 30mm, maintained or momentary as required and as shown on the Drawings. Provide extended head pushbutton for all stop functions, mushroom head for emergency stop functions, and flush head pushbuttons for all other functions. Where indicated on the Drawings pushbuttons shall be illuminated type. Provide locking mechanism for all lock out functions. Selector switches shall have black knob operator, be maintained contact type unless noted otherwise, number and arrangement as required to perform intended functions specified but not less than one double pole, double throw, double break contact per switch. Contact rating shall be compatible with AC or DC throughput current of devices simultaneously operated by the switch contact but not less than 10 amperes resistive at 120 volts AC or DC continuous.

E. Potentiometers shall be provided with operators and resistive elements of the type and quantity indicated on the Drawings and as required with legend plates indicating percent of span.

F. The above devices shall be manufactured by Cutler Hammer or approved equal.

2.2 RELAYS

A. Timing relays shall be heavy duty, have 250 V/5A rated contacts, solid state design, poles as required per application, -10°C to +60°C, have timing repeatability of ±2.0% of setting, and be UL listed. The range shall be determined from the control descriptions and or schematic drawings. Provide mounting accessories, as required. The timing relays shall be manufactured by Allen Bradley, Square D, Cutler Hammer, or equal.

B. Control relays shall be of the plug-in socket base type with dust-proof plastic enclosures, with silver-cadmium oxide contacts rated 250 volt, 10 amperes, with contact arrangement and operating coils of the proper voltage as required by the control circuit sequence. Relays shall have indicating lamp to show energized state. Each relay shall have a minimum of two double pole, double throw contacts, or as required. Control relays shall be Allen Bradley, Square D, Cutler Hammer, or equal.

C. Alternating relays shall be UL listed, 120 VAC, with contacts rated for 10 amperes at 250 VAC, life expectancy of 100,000 operations, load indicating LEDs, and switch for load locking and load selecting options. Alternating relays shall be manufactured by Time Mark Models 261, 271, and 471, Diversified Electronics Model ARA, A.T.C. model "AR", or equal.

2.3 ALARMS

A. Audible alarms shall be UL listed, 120 VAC, with solid state circuitry, vibrating horn, non-metallic corrosion resistant housing, with required mounting hardware, suitable for outdoor use capable of producing 100 dB at 10 feet. The audible alarm shall be manufactured by Federal Signal model 350, Edwards Model 870-EX, or equal.

B. Rotating beacons for interior and/or exterior locations shall be UL listed, 120 VAC, with motor and cooling fan, rotating lights at 60 times per minute minimum, capable of producing 36,000 candlepower with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Federal Signal Model 371L or equal.

C. Rotating beacons for corrosive and/or hazardous locations shall be UL listed, 120 VAC, with solid state circuitry, rotating lights at 60 times per minute minimum, suitable for outdoor use capable of producing 36,000 candlepower with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Edwards Model 52EX, or equal.

D. Strobe beacons shall be UL listed, NEMA 4X, 120 VAC, flashing at 80 times per minute minimum, producing peak candlepower of 520,000, effective candlepower of 165, with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Federal Signal model 151XST, Edwards Model 92EX, or equal.

2.4 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers shall permit connection of devices located in a hazardous area to other devices located in a safe area. Intrinsic safety barriers shall be EMC compliant, 10 to 35 VDC, 35 mA output current, hazardous area terminals identified by blue labels, terminals accommodating conductors up to 12 AWG, ambient temperature rating of -20° C to +60° C. The intrinsic safety barriers shall be manufactured by MTL Inc., Ronan Engineering Co., R. Stahl Inc., A.T.C., or equal.

2.5 WIREWAYS

A. Wireways shall be PVC, snap-in slot design, with non-slip cover. Safe area wireways shall be light gray and marked "Safe Area Wiring". Hazardous area wireways shall be intrinsic blue and marked "Hazardous Area Wiring". The wireways shall be manufactured by Panduit Corporation or equal.

2.6 WATTHOUR TRANSDUCERS

A. Watt-hour Transducers for active or reactive power shall be DIN rail and surface mount, single-phase or three-phase with balanced or unbalanced load, electrically isolated input and output signals, 4 to 20 mA output signal, 0 to10 mA to 0 to10 A input current, 0 to 10 V to 0 to 600 VAC input voltage, 16 to 500 Hz selectable frequency. The watthour transducers shall be manufactured by Sineax Model PQ502, or equal.

2.7 ELAPSED TIME METERS AND TIME CLOCKS

A. Elapsed time meters shall be self powered, non-reset, solid state counter which provides silent, accurate and noise immune operation. Elapsed time meters shall require no external power, five year minimum battery life, 120 VAC power, accessories for panel mounting, nameplate below LCD display reading "HOURS", liquid crystal display with 6 digits approximately 2-inches high with 50,000 hour minimum display life and indication of sufficient battery power. The elapsed time meters shall be manufactured by Durant, Automatic Timing and Controls, a Division of Sycon Corp., or equal.

B. Time clocks shall be microprocessor based, have 24 hour time control, up to 24 operations per day, programmable from panel face keys, skip-a-day feature allowing schedule to be skipped for one to seven days, SPDT switch contact rated at 15 amps at 120 VAC, with battery carryover to maintain time and program during power outage for 275 hours. The time clocks shall be manufactured by Tork, Paragon Electric Company, or equal.

2.8 TEMPERATURE SWITCHES

A. Temperature switches shall be self powered, accurate and noise immune operation. Temperature switches range shall be 30 degrees – 140 degrees. Temperature switches shall require no external power, accessories for panel mounting. Alarm contact shall be rated 120VAC, 15 amperes. The temperature switches shall be manufactured by Hoffman, or equal.

2.9 MOTOR STARTERS AND OVERLOAD RELAYS

A. NEMA 1 minimum motor starter size. Starter units completely draw-out type in Sizes 1 and 2 and draw-out type after disconnecting power leads only in Sizes 3 and 4.

B. Motor starters shall include a magnetic contactor, NEMA rated with encapsulated magnet coils. Wound coils not acceptable.

C. Provide motor starters and overload relays by Square D Company, Cutler Hammer, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasteners shall be Type 304 stainless steel.

B. Install devices in strict accordance with NEC requirements and per manufacturer's recommendation.

C. Coordinate with other trades as necessary during installation of these devices.

3.2 ACCEPTANCE

A. All installations are subject to evaluation in accordance with NEC requirements and manufacturers recommendations. CONTRACTOR shall remove the unacceptable work and correct work at no charge to OWNER.

END OF SECTION

SECTION 16920

ELECTRICAL ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Requirements for electrical acceptance testing of electrical equipment and materials.
   2. It is the intent of the tests described herein to assure that all electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.
   3. Acceptance testing performed by equipment vendors at the point of manufacturer must conform to all requirements of this specification. Testing performed at the point of manufacture which conforms to generally accepted industry practices is also acceptable so long as adequate test result documentation is provided.

B. Scope:
   1. All of the Acceptance Tests are required to be performed whether they are described in this Section or other applicable Sections. At a minimum, the following electrical systems are to be tested:
      a. Service entrance section.
      b. Main distribution panel.
      c. Motor control centers.
      d. Switchgear, low and medium voltage.
      e. Panelboards, power and lighting/receptacle.
      f. Transformers, dry type and oil filled.
      g. Feeders.
      h. Cables rated 600 volts and higher.
      i. Transfer switches, manual and automatic.
      j. Transient voltage surge suppression systems.
      k. Grounding and bonding system.
      l. Lighting fixtures and associated controls.
      m. Other systems as listed under Part 3 of this Specification.

C. Related Documents:
   1. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and other Division 1, General Requirements, Specification Sections, apply to the Work of this section.
   2. All work performed under this Section of the Work is subject to all requirements contained under Section 16000, General Electrical Requirements".

3. All Division 16, Electrical, Specifications for electrical equipment provided for this Project that requires electrical acceptance testing.

1.2 REFERENCES

A. NETA ATS, Acceptance Testing Specifications, 2003 edition.

B. NFPA 70, National Electrical Code, 2008 edition.

C. Incorporated by reference all Codes, Standards, and Specifications referred to in the "Applicable References" section of NETA ATS-2003.

1.3 DEFINITIONS

A. NETA, InterNational Electrical Testing Association Inc.

B. NEC, National Electrical Code.

1.4 SYSTEM DESCRIPTION

A. Conditions:
   1. Provide all items, articles, materials, operations, or methods listed, mentioned, or scheduled on Drawings and/or herein including all labor, materials, equipment, and incidentals necessary and required for Electrical Acceptance Testing.
   2. Following established procedures, equipment shall be energized after certification by the testing organization that the installation is satisfactory.
   3. Correct or replace any current-carrying circuit, electrical equipment, or system which is defective or grounded and correct all other troubles encountered by these tests. All defects, whether through faulty workmanship or materials furnished, shall be corrected under this Section at the CONTRACTOR'S expense.

1.5 SUBMITTALS

A. Test Report Forms:
   1. All test reports shall be submitted using NETA or approved similar format and, where appropriate, test forms. Reports shall be legible using permanent ink. Pencil is not acceptable.
   2. Provide for ENGINEER'S review and approval a copy of each test form to be used on the Project. No testing shall be started prior to approval of all test forms.
   3. All test reports shall include the following information:
      a. Summary/description of the Project.
      b. Description of equipment tested.
      c. Description of the tests.

d. Test data and analysis of the data indicating whether the equipment passed or failed the test.

4. All test data records shall include the following minimum requirements:
   a. Equipment identification, including tag numbers.
   b. Humidity, temperature, and other conditions that may affect the results of the tests and/or calibrations.
   c. Date of inspections, tests, maintenance, and/or calibrations.
   d. Identification of the testing technician and their employer.
   e. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
   f. Indication of expected results when calibrations are to be performed.
   g. Indication of "as-found" and "as-left" results, as applicable.
   h. Sufficient spaces to allow all results and comments to be indicated.

B. Closeout Submittals:
   1. Provide one copy each to ENGINEER and OWNER of all testing reports organized as follows:
      a. Bind report in 3-ring binder(s).
      b. Identify Project name, description, testing organizations name, and submittal date on front face and back cover of binder.
      c. Provide all test reports, organized by equipment tag number.
      d. Separate different equipment numbers with colored or numbered tabs.
      e. Provide an index/table of contents.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Any materials provided as part of the testing shall be new, unused, and in manufacturer's original packing.

2.2 TEST INSTRUMENT CALIBRATION

A. Contractor performing the testing shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy for each test instrument calibrated.

B. Contractor performing the testing shall maintain up-to-date instrument calibration instructions and procedures for each test instrument calibrated.

C. It is preferred that instrument calibration accuracy be directly traceable to the national Institute of Standards and Technology (NIST).

D. Instruments shall be calibrated in accordance with the following frequency schedule:

1. Field Instruments: Analog, six months maximum. Digital, 12 months maximum
2. Laboratory Instruments: 12 months maximum
3. Leased Specialty Equipment: 12 months maximum.

E. Dated calibration labels shall be visible on all test equipment.

F. Records, which show date and results of instruments calibrated or tested, must be kept up to date.

G. Calibrating standard shall be better accuracy than that of the instrument tested.

PART 3 - EXECUTION

3.1 QUALIFICATIONS

A. The testing organization shall be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated. When such testing organization is used, it must meet the following requirements:
   1. The testing organization shall be regularly engaged in the testing of electrical equipment, devices, installations, and systems.
   2. The testing organization shall use technicians who are regularly employed for testing purposes.
   3. The testing organization shall be a member of NETA or be able to prove qualifications equal to or better than required for membership in NETA.
   4. Submit appropriate documentation demonstrating that the testing organization meets the requirements listed above.
   5. Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make a judgment on the serviceability of the specific equipment.
   6. Technicians shall be certified in accordance with ANSI/NETA ETT-2000, “Standard for Certification of Electrical Testing Personnel”. Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.

B. CONTRACTOR may perform the electrical acceptance testing under the following conditions:
   1. CONTRACTOR'S personnel performing the testing and their testing equipment meets all other requirements of this Specification.
   2. Written approval is received from ENGINEER after review of testing personnel qualifications. At a minimum, CONTRACTOR'S testing personnel

must have specific instruction on the testing instruments, accessories, and tests being performed and must be able to evaluate the test results.

3.2 NOTIFICATION

A. Notify ENGINEER and Construction Manager at least two days prior to testing so that they may be present during testing.

3.3 SAFETY AND PRECAUTIONS

A. Safety practices shall include, but are not limited to, the following requirements:
   1. Occupational Safety and Health Act OSHA.
   2. Accident Prevention Manual for Industrial Operations, National Safety Council, Chapter 4.
   3. Applicable State and local safety operating procedures.
   4. NETA Safety/Accident Prevention Program.
   5. National Fire Protection Association - NFPA 70E.
   6. ANSI Z244.1 American National Standards for Personnel Protection.

B. All tests shall be performed with apparatus de-energized, except where otherwise specifically specified.

C. The testing firm shall have a designated safety representative on the Project to supervise operations with respect to safety.

3.4 EQUIPMENT TESTING REQUIREMENTS

A. The intent of this Specification is not to duplicate testing performed at the point of manufacture or to impose additional burden on the CONTRACTOR which does not benefit the Project. The intent is to verify that electrical equipment has been securely fastened down, supported, and installed in accordance with the manufacturer's requirements. The intent is also to verify that all electrical connections are correctly torqued, properly aligned, properly insulated, and properly supported and that equipment is clean and ready for operation.

B. Except as noted below or as approved by engineer, test the following equipment and assemblies in full accordance with NETA-ATS 2003.

C. Switchgear and switchboard assemblies.

D. Transformers, dry type, air-cooled, low-voltage, small.

E. Transformers, dry type, air-cooled, large.

F. Transformers, liquid-filled.

G. Cables, low-voltage, 600 volt maximum.

1. Perform tests only on cables Size #4 AWG and larger.

H. Cables, medium-voltage and high-voltage.

I. Metal-enclosed busways.

J. Switches, air, low-voltage:
   1. Perform tests only on switches rated 100 amps or higher.

K. Switches, air, medium-voltage, metal-enclosed.

L. Switches, oil, medium-voltage.

M. Switches, vacuum, medium-voltage.

N. Switches, Cutouts:
   1. Perform tests only on equipment rated 100 amps or higher.

O. Circuit Breakers, Air, Insulated-Case, Molded-Case:
   1. Perform visual and mechanical inspections in accordance with NETA for all circuit breakers.
   2. Perform electrical tests only on circuit breakers rated 100 amps or higher provided in power distribution and lighting/receptacle panelboards.
   3. No testing is required for circuit breakers provided as part of any of the following:
      a. A UL listed control panel.
      b. UL listed factory supplied motor control centers.
      c. Stand-alone combination motor starters.

P. Circuit breakers, air, medium voltage.

Q. Circuit breakers, oil, medium voltage and high voltage.

R. Circuit breakers, vacuum, medium voltage.

S. Circuit switchers.

T. Network protectors, 600 volt class.

U. Protective relays.

V. Metering devices.

W. Regulating apparatus, voltage, step and induction voltage regulators.

X. Regulating apparatus, load tap-changers.

Y. Grounding systems.

Z. Ground-fault protection systems, low-voltage.

AA. Rotating Machinery, AC Motors, and Generators:
1. Motors provided as part of valve actuators do not require testing.
2. Perform visual and mechanical inspections on all motors.
3. Perform rotation tests on all motors.
4. Perform electrical tests only on motors 50 horsepower and larger.

BB. Motor control, motor starters, low-voltage.

CC. Motor control, motor starters, medium-voltage.

DD. Adjustable speed drive systems.

EE. Direct-current systems, batteries, flooded and valve-regulated lead-acid.

FF. Direct-current systems, chargers.

GG. Surge arresters, low-voltage surge protection devices.

HH. Surge arresters, medium and high-voltage surge protection devices.

II. Capacitors and reactors - all types.

JJ. Outdoor bus structure.

KK. Emergency and standby power systems, engine generator.

LL. Emergency and standby power systems, UPS.

MM. Emergency and standby power systems, automatic transfer switches.

NN. Fiber-optic cables.

3.5 CONSTRUCTION

A. Interface with Other Work:
1. Coordinate all testing activities with other disciplines. Retest any equipment disturbed or damaged in any manner after initial testing.

3.6 CLOSEOUT REPORT

A. Provide comprehensive bound test report in accordance with Part 1 of this Specification.

END OF SECTION

SECTION 16951

SHORT CIRCUIT, COORDINATION, AND ARC-FLASH HAZARD REPORT

PART 1 - GENERAL

1.1 DESCRIPTION

A. General:
   1. Prepare a short circuit analysis, protective device coordination study, and an arc flash hazard analysis for the project electrical power source and distribution system.
   2. The short circuit, coordination study, and arc flash hazard report shall provide an evaluation of the electrical power system with the model numbers and settings of the protective devices.

B. Scope:
   1. Perform and provide a complete short circuit analysis with equipment interrupting or withstand rating evaluation and a protective device coordination study for the electrical power distribution system serving the facility.
   2. Include all portions of the electrical power distribution system from the utility primary service drop through and including motor loads 50 hp and greater, loads 50 KVA and larger, and protective devices 100 amperes and larger.
   3. Electrical equipment bus impedance shall be assumed to be zero. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at each project power source or power distribution equipment including switchgear, switchboard, motor control center, and branch circuit panelboards.
   4. A protective device coordination study shall be performed to determine proper selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated voltage and current transformers, and circuit breaker trip characteristics and settings.
   5. The coordination study shall include all voltage classes of equipment from the utility's closest upstream protective device to existing and new equipment including switchgear, switchboards, motor control centers, and 120 volt panelboards main circuit protection.
   6. Panelboard branch circuit devices need not be considered. The phase overcurrent and ground-fault protection shall be included, settings for the adjustable protective devices, and electrical metering and monitoring devices.
   7. Provide an arc flash hazard analysis to warn personnel of the dangers of live exposed electrical equipment. Provide appropriate labeling for electrical equipment per NFPA 70E that indicates the flash hazard boundaries, incident energy available, and the required PPE (Personal Protective Equipment) level.

8. An equipment evaluation study shall be performed to determine the adequacy of existing or proposed electrical equipment by tabulating and comparing the short circuit ratings with the available fault currents.
9. Problem areas or inadequacies in the proposed equipment shall be identified in the report.

1.2 REFERENCES

A. This Section contains references to the following documents and they are part of this section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this section shall prevail.
   1. IEEE 141, Recommended Practice for Electrical Power Distribution for Industrial Plants.
   2. IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
   3. IEEE 1584, IEEE Guide for Performing Arc Flash Hazard Calculations.
   4. NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

1.3 SUBMITTAL SCHEDULE

A. The report shall be submitted with the major electrical distribution equipment and switchgear detailed product submittal.

B. The ENGINEER reviewed report shall be corrected, revised, and resubmitted as required. The report will be reviewed along with the electrical distribution and switchgear product submittal.

C. The CONTRACTOR shall distribute the ENGINEER accepted report to the major electrical distribution equipment and switchgear manufacturers before the electrical distribution equipment and switchgear is manufactured.

D. Provide an electronic copy, on CD-Rom, of the protective device coordination study results as generated by the study software.

E. The report specified herein shall be provided in accordance with Contract Documents.

F. Provide arc flash hazard warning labels for all electrical distribution equipment.

PART 2 - PRODUCTS

2.1 REPORT

A. The report shall be sealed and signed by the responsible electrical engineer, summarize the short circuit analysis, protective device coordination study, arc flash hazard analysis, potential problem issues, conclusions, and recommendations that may affect the integrity of the project power distribution system. As a minimum, the report shall include the following.
   1. The equipment manufacturer's information used to prepare the study.
   2. Assumptions made during the study.
   3. Short circuit calculations listing short circuit levels at each bus.
   4. Simplified single line diagrams generated by the study software.
   5. Coordination study time-current curves including the instrument transformer ratios, model numbers of the protective relays, relay settings, and trip unit settings associated with each breaker.
   6. Arc flash hazard analysis calculations.
   7. Comparison of short circuit duties of each bus to the withstand and interrupting capacity of the equipment protecting that bus.
   8. Data used as input to the report including cable impedance, source impedance, equipment ratings, equipment time-current curves etc.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide the short circuit analysis, coordination study, and arc flash hazard analysis for the electrical power distribution system using SKM System Analysis, Inc. Power Tools, or equal.

B. The studies shall be performed in accordance with IEEE Standards 141, 242, 1584, and NFPA 70E and shall utilize the ANSI; method of short circuit analysis in accordance with ANSI C37.010.

C. The studies shall be performed using actual equipment data for the new equipment. The analysis and study shall use the equipment and protective device data provided by the electrical distribution equipment manufacturer for the Project.

3.2 SHORT CIRCUIT ANALYSIS

A. The Short Circuit Analysis and Report shall include the following.
   1. One-Line Diagram:
      a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
      b. Type designation, current rating, range or adjustment, manufacturer's style and catalog number for all protective devices.
      c. Power, voltage ratings, impedance, primary and secondary connections of all transformers.

d. Type, manufacturer, and ratio of all instrument transformers energizing each relay.
e. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.

2. Impedance Diagram:
   a. Available MVA or impedance from the power utility company.
   b. Local generated capacity impedance.
   c. Bus impedance.
   d. Transformer and/or reactor impedance.
   e. Cable impedance.
   f. Equipment impedance.
   g. System voltages.
   h. Grounding scheme (resistance grounding, solid grounding, or no grounding).
3. Calculations:
   a. Determine the paths and situations where short circuit currents are the greatest.
   b. Assume bolted faults and calculate the 3-phase and line-to-ground short circuits of each case.
   c. Calculate the maximum and minimum fault currents.

3.3 PROTECTIVE DEVICE COORDINATION STUDY

A. The time-current characteristics of the specified and indicated protective devices shall be plotted on 5-cycle, log-log graph paper with a maximum of eight protective devices per plot. The coordination study time-current plots shall, at a minimum, include the following:
   1. Time-current for each protective relay or fuse showing graphically that the settings will provide protection and selectivity within industry standards. Each curve shall be identified, and the tap and time settings shall be specified.
   2. Time-current curves for each device shall be positioned to provide for maximum selectivity to minimize system disturbances during fault clearing. Reasonable coordination intervals and separation of characteristic curves shall be maintained.
   3. Where selectivity cannot be achieved, the report shall indicate the cause and recommend alternative solutions. Time-current curves and points for cable and equipment damage and symmetrical and asymmetrical fault currents.
   4. Circuit interrupting device operating and interrupting times.
   5. Indicate maximum fault values on the graph.
   6. Sketch of bus and breaker arrangement.

3.4 ARC FLASH HAZARD ANALYSIS

A. Calculated arc flash boundaries, incident energies, and PPE requirements shall be published in the study report as well as displayed on the report one-line diagrams.

B. Provide a direct printout of warning signs and labels using the study software.

3.5 STUDY FIRM

A. The report for the short circuit analysis and protective device coordination study indicating results shall be performed, stamped, and signed by an Electrical Engineer registered in the State where the Project is located.

B. The CONTRACTOR shall provide the ENGINEER with submittal information for the electrical products used for the Project.

C. The ENGINEER performing the study must visit the Project site after equipment is installed and modify the study as required, and resubmit the study.

END OF SECTION

SECTION 17000

INSTRUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Provide complete instrumentation and control systems as indicated on the Drawings, in the Specifications, and as required by other Contract Documents. These documents include descriptions of functional operation and performance, as well as standards, but do not necessarily enumerate detailed specifications for all components and devices which are necessary. However, all components and devices shall be furnished and installed as required to provide complete and operable systems for accomplishing the functions and meeting the performance requirements.
   2. Scope of Work includes:
      a. Provide all instruments.
      b. Provide all control panels.
      c. Provide all communication equipment required to make the control system fully operational including, but not limited to, autodialers, radios, antennas, switches, routers, hubs, protocol converters, communication cables, and communication racks and power supplies.
      d. Provide all conduit, conductors, enclosures, materials, and labor to fully interconnect and make operational all control system components.
      e. Provide power at proper voltage and amperage to all system components.
      f. Provide start-up and commissioning assistance.
      g. Train OWNER'S personnel on proper use and maintenance of the control systems.
      h. Other equipment, materials, and work as necessary to achieve a fully tested and operational control system.

B. Products Supplied But Not Installed Under This Section:
   1. None.

C. Products Installed But Not Supplied Under This Section:
   1. Instruments and controls provided loose for field installation by packaged equipment or skid-mounted equipment vendors.

D. Related Sections:
   1. All Division 16 Specifications provided for this Project.
   2. All Division 17 Specifications provided for this Project.
   3. Other division Specifications provided for this project as they relate to

Submittals, concrete, structural, piping/plumbing, mechanical, and HVAC systems.

E. Allowances:
   1. Not applicable this Section.

F. Unit Prices:
   1. Not applicable this Section.

G. Measurement Procedures:
   1. Not applicable this Section.

H. Special Payment Procedures:
   1. Not applicable this Section.

I. Alternates/Alternatives:
   1. All alternates, alternatives, or proposed substitutions of materials or equipment must be approved by ENGINEER.

1.2 REFERENCES

1.3 DEFINITIONS

A. The word "provide" means "furnish and install".

B. PLC means Programmable Logic Controller.

C. SCADA means Supervisory Control and Data Acquisition System.

1.4 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Using sound engineering principals and current best design practices, provide engineering Drawings, and design documents specifying system components and detailing their interconnection and installation.

B. Performance Requirements:
   1. The instrumentation and control systems shall be furnished and installed complete and ready to operate, including all necessary interconnections and connections to sources of electrical power, air, water, drains and vents, with all required valves, switches and accessories as specified or as recommended for best operation by the manufacturer of the equipment furnished.

1.5 SUBMITTALS

A. General:

1. Submittals for the equipment shall be provide in accordance with Section 16000, General Electrical Requirements, and as required elsewhere in the Contract Documents.

B. Product Data:
   1. Detailed catalog information for all system components in sufficient detail so that ENGINEER has sufficient information to determine if the equipment is acceptable for the intended purpose. Minimum information shall be:
      a. Instrument or equipment tag number.
      b. Manufacturer.
      c. Model number.
      d. Materials of construction.
      e. Materials in contact with process fluids.
      f. Dimensional information.
      g. Weight.
      h. Power consumption with required voltage and ampacity.
      i. Heat dissipation if greater than 200 watts.
      j. Process connection information detailing connection size, and type (threaded, flanged, socket weld, etc.).
      k. Recommended mounting details.
      l. Recommended spare parts for one year of operation.
   2. Instrument Data Sheets in ISA S20 format for all instruments.

C. Shop Drawings:
   1. For complex control systems consisting of mechanical, electrical, and control components, provide the following:
      a. A piping and instrument diagram in ISA format.
      b. Electrical load calculations with conduit and conductor sizing.
   2. For integrated control panels or control assemblies, provide the following:
      a. Dimensioned layout of the control enclosure and mounted equipment and instruments.
      b. Full bill of material for all components with detailed catalog information on all components.
      c. 11-inch by 17-inch fully developed schematic diagram(s) showing power and control wiring, terminal block assignments, and identifying field and enclosure wiring. Provide a drawing index and symbols and legend sheet with all schematics. Show all Input/Output (I/O) card details including rack, slot, channel numbers, field termination points, and control power wiring. Label all conductors and identify conductor size and color. Identify all field devices by tag number and by description. Provide over current protection in accordance with NEC requirements.
      d. 11-inch by 17-inch instrument loop drawings in ISA format for all analog control loops. Alternatively, multiple loops may be combined on a single analog input or analog output I/O card schematic diagram.
      e. Nameplate legend.

f. Paint color and type for painted assemblies.

3. Any special installation details.

D. Samples:
   1. Not applicable for this Section.

E. Quality Assurance/Control Submittals:
   1. Design Data, Test Reports:
      a. Submit calibration sheets for all field instruments containing the following information:
         1) Instrument tag number.
         2) Instrument manufacturer and model number.
         3) Person who performed the calibration.
         4) Manufacturer, model, and serial number of the calibrating device.
         5) Date that calibrating device was last calibrated.
         6) For analog instruments, process range and associated analog signal in at least five increments (For example: 4 mA DC/0 psig, 8 mA DC/25 psig, 12 mA DC/50 psig, 16 mA DC/75 psig, 20 mA DC/100 psig).
         7) For switches, process values at which the switch changes state and at which the switch resets.
         8) For instruments calibrated by manufacturer, manufacturer's calibration report is acceptable as proof of calibration.
      b. Factory acceptance test reports on all fabricated control panels or assemblies containing the following information:
         1) Date of test.
         2) Test participants.
         3) Visual inspection of components.
         4) Successful application of power.
         5) Validation of all internal wiring.
         6) Validation of correct control operation.
         7) Validation of screen graphics or alarm operation (if applicable)
         8) Validation of program installation into PLC's and that I/O is functioning properly (if applicable).
   2. Certificates, Manufacturer's:
      a. UL 508 certification for all assembled control panels and assemblies.
   3. Instructions, Manufacturer's Field:
      a. Furnish a complete Operations and Maintenance Manual for all assembled control panels and assemblies.
   4. Reports:
      a. Not applicable to this Section.

F. Closeout Submittals:
   1. Furnish Operations and Maintenance Manuals in 3-ring binders complete with the following:
      a. On front and spine of binders provide the project name, OWNER'S

name and Project number.
   b. Within the binder, identify the CONTRACTOR and provide contact information.
   c. Inside binders, provide a volume index and table of contents for each binder. Each instrument or control component tag number must be cross-referenced to a specific binder tab.
   d. Furnish manufacturers complete operations and maintenance manuals for all discrete instruments and controls.
   e. Furnish custom operations and maintenance Section for each custom control system, control panel, or fabricated assembly.
   f. Furnish "As-Built" loop and wiring diagrams.
   g. Furnish the written warranty.
2. Turn over all spare parts to OWNER with documentation showing which instrument or control system the spare parts are for.

G. Schedule:
1. Submit a detailed Work schedule showing start/finish dates, task duration, task sequencing, critical path, and available float. Identify task predecessors and identify coordination activities with other trades.

H. Start-up and Commissioning Plan:
1. Submit a detailed start-up and commissioning plan for review by OWNER and ENGINEER. Plan should include the following information:
   a. The order in which the various plant systems will be started up
   b. What work must be performed prior to the start-up
   c. What documentation will be maintained by the CONTRACTOR and provided to the OWNER validating that the start-up was performed in a safe and efficient manner.

1.6 QUALITY ASSURANCE

A. Qualifications:
1. CONTRACTOR performing the Work shall have a minimum five years experience performing similar work in similar industries. All CONTRACTOR'S personnel shall be trained and experienced in best current construction practices.

B. Regulatory Requirements:
1. Perform all Work in accordance with all applicable national and local codes.

C. Certifications:
1. Not applicable this Section.

D. Field Samples:
1. Not applicable this Section.

E. Mock-Ups:
   1. Not applicable this Section:

F. Pre-Installation Meetings:
   1. Not applicable this Section.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Perform these activities in a manner which assures instruments and equipment will arrive undamaged and in proper working order. Replace any instrument or equipment damaged upon arrival at no additional cost to OWNER.

B. Acceptance at Site:
   1. Maintain a comprehensive log by instrument or equipment tag number of all received instruments or equipment.

C. Storage and Protection:
   1. Store all instruments and equipment as recommended by manufacturer. Protect from physical damage, moisture, dirt/dust, or extremes of temperature.

1.8 PROJECT/SITE COORDINATIONS

A. Environmental Requirements
   1. Follow any and all environmental requirements pertaining to the site.
   Maintain a safe and clean job site.
   Dispose of all trash and construction debris in an approved manner.

B. Existing Conditions:
   1. CONTRACTOR is to examine the site and be thoroughly familiar with any site requirements which may affect the Work or storage of instruments or equipment.

1.9 SEQUENCING

A. Coordinate all Work with other trades.

1.10 SCHEDULING

A. Provide and maintain a detailed schedule for performance of the Work identifying start/finish dates, durations, required preceding activities, and coordination with other trades. Organize procurement, deliveries, and staff labor to meet the overall construction schedule and to assure that other trades are not delayed.

1.11 WARRANTY

A. Instrumentation:
   1. One year from system acceptance by OWNER for all discrete instrumentation, control devices, or equipment. During this period, replace any defective or malfunctioning device with 15 working days after notification by OWNER.
   2. One year from system acceptance by OWNER for the performance of the overall control system. Correct the defect within 15 working days after notification by OWNER. Warranty repair work includes but is not limited to the following:
      a. Improper sequencing or interlocking of equipment control systems.
      b. Wiring errors or omissions.
      c. Improper calibration of field instruments.
      d. Improper operation of programmable logic controllers or operator interface terminals.
      e. Improper operation of communications systems installed as part of the overall control system.
      f. Unsafe operations or maintenance conditions.
      g. Other system malfunctions which prevent or impair the plant from operating at design capacity, requires excessive operator intervention, or results in unsafe operating conditions.

1.12 SYSTEM START-UP/COMMISSIONING

A. General:
   1. Provide labor, tools, and equipment to start up the facility in a safe and efficient manner.
   2. Plant shall be started up by system. A system is defined as a collection of mechanical, electrical, and controls equipment configured to perform a specific function or purpose. Examples may be a UV disinfection system, a dissolved oxygen blower system, a grit removal system, etc. The order in which the systems will be started shall be submitted by CONTRACTOR in the start-up Plan and approved by OWNER and ENGINEER. Any variance in this schedule must be approved by OWNER and ENGINEER.
   3. Unless approved otherwise by OWNER and ENGINEER, CONTRACTOR is to follow the start-up sequence detailed below. The following Work must be complete prior to beginning the start-up:
      a. All mechanical equipment installed and tested in accordance with manufacturer's recommendations.
      b. All motors must have been rotation checked.
      c. Electrical power is available and wired to all mechanical equipment.
      d. All instruments must have been calibrated and installed in accordance with the manufacturer's recommendations.
      e. Control system communication systems are installed and fully operational. This includes DH+ networks, Modbus+ networks, Ethernet networks, radio telemetry systems, telephone systems, etc.

f. All power and control wiring must be installed, rung out, and validated to be in accordance with approved Construction Drawings.
g. If applicable, programmable logic controllers, SCADA computers, and Operator Interface Terminals all are installed, have their programs installed, and these devices are fully operational and functioning in their design configuration.

B. System Start-up Sequence:
1. By manipulation of the instrument or direct signal injection at the instrument, verify that the control signal (discrete or analog) is received at the programmable logic controller or by the hard wired control circuit.
2. For motorized equipment, disconnect the power leads at the starter, VFD, or solid state motor controller.
3. Completely exercise the control circuit in Manual, Remote, and Automatic modes and verify that all interlocks and permissives are functioning correctly.
4. Verify that run status, signal levels, and alarms display properly on the control panel.
5. Reconnect the motor power leads.
6. Configure the mechanical system for normal operation and leave system ready for normal operation.
7. Utilize colored tagging scheme to identify start-up condition. Red is not ready for start-up, yellow is mechanically and electrically ready but not yet tested or started up, and green is fully tested and ready for normal operation. Place these tags on all mechanical, electrical, instrumentation, and control components of each system.
8. As plant systems are started up, coordinate and remedy any coordination or interface issues between systems.

C. Remedies for Damages:
1. CONTRACTOR is liable for any and all damage done to mechanical or electrical equipment due to improper start-up procedures and shall repair or replace any damaged equipment at OWNER'S discretion without additional cost to OWNER.
2. CONTRACTOR is forbidden to jumper around any process or safety interlock either with wiring or within a PLC program without the express written permission of both the OWNER and ENGINEER. All jumpers, hardwired and programmed, must be maintained in a log book. Entries shall include:
a. Name of person placing the jumper.
b. Date of installation.
c. Reason for installation.
d. Approval of OWNER and ENGINEER.
e. Date of removal.
f. Name of person removing the jumper.

1.13 OWNER'S INSTRUCTIONS

A. Not applicable this Section.

1.14 MAINTENANCE

A. Extra Materials:
   1. Not required this Section.

B. Maintenance Service:
   1. Not required this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved manufacturers are listed in the other electrical and instrument Specification Sections.

2.2 EXISTING PRODUCTS

A. Not applicable this Section.

2.3 MATERIALS

A. All materials are to be new and the manufacturer's most current model.

2.4 MANUFACTURED UNITS

A. Manufactured units are to be fully assembled and tested at the point of manufacture and delivered to the job site ready for installation and start-up.

B. Regulated DC power supplies for instrument loops shall be designed and arranged so that loss of one supply does not affect more than one instrument loop or system. Power supplies shall be suitable for an input voltage variation of ±10%, and the supply output shall be fused or short circuit protected. Output voltage regulation shall be as required by the instrumentation equipment being supplied. Multi-loop, or multi-system power supplies, will be acceptable if backup power supply units are provided which will automatically supply the load upon failure of the primary supply. The backup supply systems shall be designed so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the instrument system operation.

C. The power distribution from multi-loop supplies shall be selectively fused such that a fault in one instrument loop will be isolated from the other loops being fed

from the same supply. Fuses shall be clearly labeled and located for easy access. Multi-loop supply systems shall be oversized for an additional 10% future load. Failure of a multi-loop supply shall be indicated on the respective instrument panel or enclosure.

2.5 EQUIPMENT

A. All equipment is to be new and the manufacturers most current model. All instruments and control devices and assemblies shall be standard devices constructed of corrosion-resistant materials enclosed in a water and dust proof case and mounted as specified in the individual application. Enclosures shall be manufacturer's standard color unless specified otherwise.

2.6 COMPONENTS

A. Not applicable this Section.

2.7 ACCESSORIES

A. Not applicable this Section.

2.8 MIXES

A. Not applicable this Section.

2.9 FABRICATION

A. Shop Assembly:
   1. Fabricate assemblies in accordance with approved Drawings. Notify ENGINEER and OWNER at least five working days prior to start of testing so that they may witness the testing if they choose to do so.

2.10 FINISHES

A. General:
   1. Finishes for all components, equipment, and fabricated assemblies must take into account the environment in which they will be installed. NEMA ratings must be appropriate for the environment. Ratings for corrosive areas must be NEMA 4X, for outdoor areas NEMA 4 or 3R, indoor dusty areas may be NEMA 12.

B. Shop Finishing:
   1. Where called for in other sections, sandblast, prime, and paint assemblies.

2.11 SOURCE QUALITY CONTROL

A. Fabrication/Tolerances:
   1. In accordance with generally accepted manufacturing standards.

B. Tests, Inspections:
   1. In accordance with generally accepted manufacturing standards.

C. Verification of Performance:
   1. Not applicable this Section.

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. CONTRACTORS having a minimum five years experience in the design, procurement, and construction of industrial water/wastewater instrumentation and control systems.

3.2 EXAMINATION

A. Site Verification of Conditions:
   1. Visit job site and ascertain any environmental or physical conditions which may affect the performance of the Work or the equipment requirements.

3.3 PREPARATION

A. Protection:
   1. Not applicable this Section.

B. Surface Preparation:
   1. Not applicable this Section.

3.4 ERECTION

A. Provide 4-inch tall reinforced concrete housekeeping pads for all control panels and floor-mounted fabricated control assemblies and consoles. Dowel into concrete base and extend a minimum of 2-inches past edges of equipment.

B. Provide Unistrut or fabricated structural supports for heavy equipment or assemblies. Prime and paint supports so that they are unaffected by the environment in which they are installed.

C. Securely fasten all panels and assemblies to their housekeeping pads or structural supports.

D. All interconnecting wiring shall be run in conduit in accordance with the Division 16 Electrical, Sections requirements.

3.5 INSTALLATION

A. Install all instruments and controls in accordance with manufacturer's recommendations and all applicable electrical codes and standards. Connect all required utilities including electrical power, air, hydraulics, etc.

B. Provide stainless steel tags for each instrument engraved with instrument tag number. Attach to instrument with stainless steel wire.

C. Provide engraved nameplates for all panel-mounted instruments. Attach to panel with stainless steel screws.

3.6 APPLICATION

A. Not applicable this Section.

3.7 CONSTRUCTION

A. Special Techniques:
In accordance with manufacturers recommended installation procedure.

B. Interface with Other Work:
Coordinate with all other trades.

C. Sequences of Operation:
Not applicable this Section.

D. Site Tolerances:
Not applicable this Section.

3.9 REPAIR/RESTORATION

A. Repair any damages caused by the installation or erection to original condition.

3.10 INSTALLATION

A. Not applicable this Section.

3.11 FIELD QUALITY CONTROL

A. Site Tests:
   1. Test and calibrate instrumentation in accordance with other parts of this Section.

B. Inspection
   1. Not required this Section.

C. Manufacturer's Field Services:
   1. If recommended by manufacturer, have equipment/control systems inspected, tested, and started up by manufacturer's representative.

3.12 ADJUSTING

A. Not required this Section.

3.13 CLEANING

A. Remove and dispose of construction debris daily. Wipe down and vacuum out all enclosures.

3.14 DEMONSTRATION/TRAINING

A. In accordance with the Start-up part of this Section.

B. Provide training of personnel in the operation and maintenance of the furnished control systems.

C. Training shall be provided as required elsewhere in the Contract Documents, but shall consist of at least eight hours, in a single, or multiple sessions, to accommodate the personnel schedules.

D. Coordinate with the ENGINEER, and the OWNER, to schedule the training sessions at least five workings days in advance.

3.15 PROTECTION

A. Protect instrumentation and control equipment from environmental damage and from damage by other trades.

3.16 SCHEDULES

A. Not applicable this Section.

END OF SECTION

SECTION 17119

PRESSURE GAUGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Permanently installed field pressure indicators with integral instrumentation devices.

1.2 SUBMITTALS

A. Product Data.

B. Manufacturer's Installation Instructions: Include mounting details.

C. Field Calibration Data Sheets: Include for instruments and devices requiring set-up and calibration.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGE

A. Bourdon Tube Pressure Element Type, Liquid Filled Gage (for pressure ranges of 15 psi and greater and vacuum ranges to 30-inches Hg):
   1. Performance Requirements:
      a. Accuracy: ±0.5 percent of span (ANSI B40.1 Grade 2A).
   2. Construction Features:
      a. Case:
         1) Solid front design constructed of glass filled polyester.
         2) Color: Black.
      b. Ring: Threaded, glass filled polyester.
      c. Full blowout back.
      d. Window: Glass.
      e. Dial: White with black marking; 270-degree scale.
      f. Material: All wetted parts to be metal selected from table in Article 1.6, above, based on process fluid being measured.
      g. Movement: Cam and roller movement, 300 Series stainless steel.
      h. Size: 4-1/2-inch.
      i. Connection: 1/4-inch male NPT back or bottom, as required.
      j. Mounting: Stem, flush panel or wall mounting, as required.
      k. Adjustable pointer.

l. Externally accessible zero adjustment.
m. Built-in overload and underload movement stops.
n. Pressure Snubber: Sintered Type 316 stainless steel snubber threaded into gage socket or in external stainless steel housing with 1/4-inch NPT male and female connections.

3. Assembly: Where specified equipment is shown to be mounted to annular or diaphragm seals, equipment and seal shall be factory assembled, calibrated and furnished as a single unit.
4. Gauge Filling Liquid: Silicone Oil.

B. Product and Manufacturer: Provide one of the following:
1. Wika.
2. Ashcroft.
3. Or Approved Equal.

C. Diaphragm seals shall be manufactured by Ashcroft.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this Section shall be installed and connected as specified and shown on the drawings. CONTRACTOR shall coordinate with Mechanical Engineer and Piping Engineer to insure proper connection to piping and/or other mechanical equipment.

3.2 ACCEPTANCE

A. As a condition precedent to Final Acceptance of the Work, the CONTRACTOR shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these Specifications. This requirement is in addition to the manufacturer's guarantee.

END OF SECTION

SECTION 17221

ELECTRONIC 4-20 mA INDICATORS

PART 1 - GENERAL

1.1 SCOPE

A. This Section covers digital panel meters, and other types of 4 mA to 20 mA DC analog indicators indicated on the Drawings.

B. Related Work specified elsewhere includes, but is not limited to Section 16000, General Electrical Requirements. Also refer to requirements of General Conditions for testing, adjusting, and balancing of systems.

1.2 QUALITY ASSURANCE

A. Equipment to be furnished under this Section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the CONTRACTOR from responsibility for the proper installation and functioning of the equipment.

B. Reference Standards: Standards shall be the latest edition, including addenda, supplements, and revision. Applicable reference publications include the following:
   1. NEC.
   2. NEMA.

1.3 SUBMITTALS

A. Submit product information cut sheets containing manufacturer's specifications, operations and maintenance data, instrument enclosure type, installation location, and process pressure range to be supplied. Indicate product part number in full.

B. Provide Submittals in accordance with Section 16000, General Electrical Requirements, and elsewhere in the Contract Documents.

PART 2 - PRODUCTS

2.1 ELECTRONIC 4-20 mA INDICATORS

A. Digital indicators shall be designed for semi-flush mounting in a panel. The display shall be a 3-1/2 digit LCD type with digit height of not less than 0.35 inches. The display shall be easily read from a distance of 10 feet, in varying lighting environments. Operating temperature range shall be 0° C to 50° C.

B. The indicator shall have a differential type ungrounded input screw terminal connector. Accuracy shall be ±0.5%. The indicators shall include user selectable scale and offset factors, which allow operators to scale and offset displayed measurement for conversion to desired units of measurement. The display shall be scaled in engineering units with the units shown on the display face, or engraved on the associated nameplate. The display shall have a movable decimal point, and shall provide over-range indication.

C. Indicator shall be calibrated from the front panel, using zero and span potentiometers. Decimal place position shall be set from DIP switches. Indicators shall be Action Instruments, Red Lion, Newport, or equal, and shall be powered by 120 VAC, or 24 VDC, as shown on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this Section shall be installed, connected, and tested in accordance with the manufacturers Specifications, and as indicated on the Drawings.

3.2 ACCEPTANCE

A. Prior to Final Acceptance, the CONTRACTOR shall certify the equipment and installation included under this Section to be free of defects, and suitable for trouble-free operation.

END OF SECTION

SECTION 17222

SIGNAL CONDITIONERS

PART 1 - GENERAL

1.1 SCOPE

A. This Section contains Specifications for analog (4 mA to 20 mA DC) signal conditions, used for loop isolation, protection, and switching. Refer to the Drawings and provide the devices as indicated.

B. Related Work specified elsewhere includes, but is not limited to Section 16000, General Electrical Requirements. Also refer to requirements of General Conditions for testing, adjusting, and balancing of systems.

1.2 QUALITY ASSURANCE

A. Equipment to be furnished under this Section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the CONTRACTOR from responsibility for the proper installation and functioning of the Work.

1.3 SUBMITTALS

A. The following material shall be submitted to the ENGINEER prior to installation, in accordance with Section 16000, General Electrical Requirements, and as required elsewhere in the Contract Documents:
   1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
   2. Prior to Final Acceptance of the Work, the CONTRACTOR shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

1.4 MANUFACTURERS

A. Moore Industries.

B. Phoenix Contact.

C. Measurement Technologies Ltd.

D. Action Instruments, Inc.

E. Approved equal.

PART 2 - PRODUCTS

2.1 CURRENT-TO-CURRENT CONVERTER

A. Current-to-current converters shall provide electrical isolation between the input and output. Current-to-current converters shall be supplied where indicated on the Drawings, and wherever the circuit impedance exceeds the capability of a transmitter.

B. The converter shall receive a 4 mA to 20 mA DC analog current input signal and produce an identical 4 mA to 20 mA DC output signal into a 0 to 1,000 ohm load. Accuracy shall be ±0.1% of span. The converter shall be provided with an enclosure suitable for back of panel mounting.

C. Power requirements shall be 120 VAC, or 24 VDC, as indicated on the Drawings.

2.2 DUAL CHANNEL CURRENT ISOLATOR

A. Dual channel current isolators shall provide electrical isolation between the input and output. The instruments shall receive a 4 mA to 20 mA DC analog current input signal and produce two identical 4 mA to 20 mA DC output signals.

B. Each channel shall be fully isolated, and capable of driving a 0 to 650 ohm load. Accuracy shall be ±0.1% of span. The isolators shall be provided with an enclosure suitable for back of panel mounting.

C. Power requirements shall be 120 VAC, or 24 VDC, as indicated on the Drawings.

2.3 SET POINT RELAY

A. The set point relays shall be solid state devices, and shall provide dual output relay contact closures from a 4 mA to 20 mA DC input. Each relay shall be controlled by an adjustable set point from a 10-turn potentiometer.

B. The dual deadbands shall be adjustable from 0 to 100 percent. The output relay shall be DPDT with contacts rated 10 amps at 120 VAC. Accuracy and repeatability shall be within 0.1% of span.

C. The instruments shall be immune to humidity and line voltage regulation problems. Power requirements shall be 120 VAC, or 24 VDC. The unit shall be

housed in a general purpose type housing suitable for subpanel mounting in a control panel enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this Section shall be installed and connected as specified, and as shown on the Drawings.

3.2 ACCEPTANCE

A. Prior to Final Acceptance of the Work, the CONTRACTOR shall certify the equipment and installation included under this Section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these Specifications.

3.3 WARRANTY

A. The equipment listed in this Section shall have a seven year warranty from the manufacturer.

END OF SECTION

SECTION 17410

AUTOMATIC DIALER

PART 1 - GENERAL

1.1 SCOPE

A. This section covers the automatic dialer to voice annunciate alarm conditions over the telephone lines.

B. Related work specified elsewhere includes, but is not limited to Section 16000, Electrical. Also, refer to requirements of general conditions for testing and adjusting system.

1.2 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

B. Reference standards. Standards shall be the latest edition, including addenda, supplements, and revision. Applicable reference publications include the following:
   1. NEC.
   2. NEMA.

1.3 SUBMITTALS

A. Products shall be submitted to the Engineer for review in accordance with Section 16000 of the Specifications, and as required elsewhere in the Contract Documents.
   1. Manufacturer's complete model and part number, product specifications, and installation details.
   2. Detail electrical wiring diagrams showing component designation, and rating.
   3. Operations and maintenance manuals shall be provided for review, prior to Final Acceptance.

PART 2 - PRODUCTS

2.1 AUTOMATIC DIALER

A. Furnish the number of output channels as required on the drawings and in Specification 17454, Control Description. Each channel shall monitor a normally closed input contact.

Upon alarm, the automatic dialer shall dial, over a cellular network dial-up telephone line, the telephone number of designated personnel. When the phone call is answered, the automatic dialer shall identify which alarm condition has occurred, and its location. If the phone call is unanswered, the automatic dialer shall cycle indefinitely through the programmed telephone numbers, until the alarm condition is acknowledged.

B. The 16 telephone numbers shall be programmable using an integrally mounted keypad. The dialer shall be capable of dialing 24 digits.

C. The dialer shall have provision to accept incoming. The dialer shall, during an incoming call, report the status of its monitored points to the caller.

D. The dialer shall be powered by 115 volts, 60 hertz, and dialer shall contain its own integrally mounted and wired battery backup. The battery shall be able to operate the dialer for 24 hours during power failure.

E. The cellular communication module shall be powered by 115 volts, 60 hertz, and shall contain its own integrally mounted and wired battery backup. The battery shall be able to operate the cellular module for 24 hours during power failure.

F. The cellular communication module shall operate on the cellular network protocol of the Owner's choice—GSM or CDMA.

G. The messages transmitted by the dialer shall be electronically recorded, or voice synthesized.

H. The dialer and cellular communication module shall be tested and guaranteed for performance in ambient temperatures 0 to 50 degrees C.

I. The dialer shall be equipped with alarm channels as indicated on the P&ID Drawings, the schematic diagrams, and Specification 17454, Control Description. The dialer shall have 8 alarm channels.

J. Unless specifically indicated otherwise on the Drawings, the automatic dialer shall be enclosed in a NEMA 12 enclosure (if installed indoors) and NEMA 4X enclosure (if installed outdoors or in a corrosive area).

K. The automatic dialer shall be a Verbatim model with Cellularm telephone option, by Raco Manufacturing Company, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed and connected as specified herein, indicated on the Drawings, and per manufacturer's recommendations.

B. The Contractor shall program the automatic dialer with the messages and phone numbers provided by the Owner.

C. The Contractor shall test and verify all alarms with the Owner.

3.2 ACCEPTANCE

A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

END OF SECTION

SECTION 17454

CONTROL DESCRIPTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Definition of data and control points and instrumentation and control systems operations and strategies.

1.2 DEFINITIONS

A. Control Strategy: A procedure or procedures implemented within local or remote controllers to satisfy the control requirements shown on the Drawings or described in these Specifications, or both.

B. Data and Control Point: Inputs and outputs to and from control equipment to and from field devices that are shown on the Drawings or described in these Specifications, or both.

C. PID Control: Proportional, integral, and derivative three-mode control as defined by ISA. Provide tuning parameters as described below.

1.3 REQUIREMENTS

A. Data and Control Points:
   1. Establish the source of the signal at field instrumentation.
   2. Terminate the field signal at panel-mounted instrumentation or other instrumentation as shown on the Drawings or described in these Specifications, or both.
   3. Connect the point to the respective controller or device as shown on the Drawings or described in these Specifications, or both.
   4. P&ID circles shown on the Instrument Drawings are used to describe the function of a data and control point.
   5. Provide displaying and controlling functions at all operator interfacing equipment as shown on the Drawings or described in these Specifications, or both.
   6. Provide secure transmission of signals between control and instrumentation equipment.

B. Control Strategies and Descriptions:
   1. Furnish and install all hardware required to fully implement the control and instrumentation strategies and descriptions shown on the Drawings, specified herein.
   2. Simulate each control strategy and provide report of operation prior to installing.

3. Modify, correct, and re-simulate as required so that the control strategy functions as shown on the Drawings or described in these Specifications, or both.

C. Instruments:
   1. Provide instruments shown on the Drawings. Notify where conflicts exist between the Specifications and the Drawings.

D. PID Control:
   1. Provide 0% to 400% proportional band with 1% resolution, or equivalent gain adjustment.
   2. Provide 0 to 10 repeats per minute integral adjustment with 0.1 repeat per minute resolution, or equivalent.
   3. Provide 0 to 4 minutes derivative adjustment with 0.1 minute resolution, or equivalent.

1.4 DATA AND CONTROL POINTS

A. Provide interconnecting input/output as required to provide functions indicated on the Drawings.

B. Terminations are shown schematically on the P&ID Drawings.

C. Lines shown connecting P&ID circles do not imply the actual number of wires that are needed to interconnect the functions represented. These lines show a functional connection between hardware or software devices. Furnish and install all interconnecting wiring and cabling required to render all functions shown on the Drawings or described in these Specifications, or both, fully operational.

D. Process the data and control points at the control panels to obtain the functions as required by the Drawings and the Specifications. Display the points along with associated parameters or calculated functions on the operator interface (OI), as required by the Contract Documents.

1.5 PLC AND SCADA REQUIREMENTS

A. No PLC system and the Site will not communicate to any off site SCADA system.

1.6 REFERENCES

A. Process and Instrumentation Diagram (P&IDs):
   1. Equipment Specifications.

1.7 PROCESS DESCRIPTION

A. Wet Well:
   1. Overview: Two submersible pumps will be used, one pump will be the lead pump and the other one will be the lag pump. The lead pump shall start at high

water level indication and stop once the low water level indication is reached. The lead and lag pumps will alternate operation after every start to equalize run time. Float switches will be utilized for pump level control. Control instrument shall be located at lift station control panel, PCP-120. The control panel will communicate with the auto dialer, via hardwire points, to automatically dial and send messages to preprogram numbers during pump failure alarms, power failure, and when High-High LEVEL at wet well is detected.

2. Pump Manual Control (At Equipment):
   a. Pumps will be manually controlled, start/stop, by the operator when Hand/Off/Auto switch is set in the Hand position at the control panel. The pump shall run when the start button is pushed and the pump shall shutdown when the stop button is pushed.
   b. All of the Pump Control Panel alarms shall reset once the reset button is pushed.
3. Pump Automatic Control:
   a. Pumps will be automatically controlled, start/stop, when the Hand/Off/Auto switch is set to the Auto position at the control panel. When water level rises to the HIGH LEVEL float at the wet well the lead pump shall start (only one pump shall operate at any one time, the lag pump shall only start once the primary pump fails). The pumps shall start based upon the HIGH LEVEL float and stop based on the LOW LEVEL float. If the lead pump fails to start after a 30 second time delay, the lag pump shall start.
   b. If the HIGH LEVEL float switch fails and water level reaches the HIGH HIGH LEVEL float, BOTH pumps will start and run until LOW LEVEL is reached, the HIGH HIGH LEVEL alarm shall be activated and the auto dialer will send HIGH HIGH LEVEL messages to the preprogram numbers.
   c. All pump station alarms shall reset once the pump controller reset command is initiated.
4. The following status and alarms shall send messages out via auto dialer.
   a. Pump fail alarm
   b. High High Level.
   c. Lag Pump Running.
   d. Power Failure.
5. The following status shall be displayed on the control panel:
   a. Wet well HIGH HIGH LEVEL alarm.
   b. Pumps RUNNING status.
   c. Wet well LOW LOW LEVEL status.
   d. Lift pump HIGH TEMPERATURE alarm.
   e. Lift pump LEAK/MOISTURE alarm.
   f. Wet Well Level Indication

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION