

**CONTRACT DOCUMENTS  
AND  
SPECIFICATIONS  
FOR  
PROJECT NO. ES 2022-10  
CITYWIDE LIFT STATION IMPROVEMENTS -  
TURLEY NORTH**

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**ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY**

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**WATER AND SEWER**  
Engineering Design

ERIC LEE, DIRECTOR

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**TECHNICAL SPECIFICATIONS  
Vol. II**

**TECHNICAL SPECIFICATIONS  
FOR  
CITYWIDE LIFT STATION IMPROVEMENTS  
TURLEY NORTH  
PROJECT NO. ES 2022-10**

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**Tulsa Metropolitan Utility Authority  
Tulsa, OK**

**Citywide Lift Station Improvements  
Turley North  
Project No. ES 2022-10**

**Specification Certification Sheet**


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Holloway, Updike and Bellen, Inc.  
C.A. No. 219  
Expires June 30, 2025

**Tulsa Metropolitan Utility Authority  
Tulsa, OK**

**Citywide Lift Station Improvements  
Turley North  
Project No. ES 2022-10**

**Specification Certification Sheet**

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23000	Mechanical	

Bruce Brown, P.E.  
OK 20995

Brown Engineers of Arkansas, LLC.  
C.A. No. 4933  
Expires June 30, 2026

1.1 PROJECT TITLE:

Citywide Lift Station Improvements – Turley North

1.2 PROJECT IDENTIFICATION:

Project No. ES 2022-10

1.3 OWNER:

Tulsa Metropolitan Utility Authority

1.4 PLANS AND SPECIFICATIONS PREPARED BY:

Dale Seaton, P.E.  
Holloway, Updike & Bellen, Inc.  
2001 N Willow Avenue  
Broken Arrow OK 74012  
(918) 251-0717

1.5 MEASUREMENT AND PAYMENT:

It is the intent of the Proposal and these Special Conditions that the total bid, as submitted, shall cover all work shown on the contract drawings and required by the Specifications and other Contract Documents. All costs in connection with the work, including furnishing of all materials, equipment, supplies and appurtenances; providing all construction equipment and tools, and performing all necessary labor to fully complete the work, shall be included in the unit and lump sum prices named in the Proposal. No item of work that is required by the Contract Documents for the proper and successful completion of that contract will be paid for outside of or in addition to the prices submitted in the Proposal. All work not specially set forth in the Proposal as a pay item shall be considered a subsidiary obligation of the Contractor and all costs in connection therewith shall be included in the Lump Sum Prices named in the Proposal.

Payment cannot exceed 90% on any schedule of value item until items 1.13 Operation and Maintenance Manuals, item 1.15 Manufacturer's Startup/certification/Training Requirements and item 1.16 Miscellaneous Project Documentation with completed project's equipment warrantee log have been completed and provided to the City as applicable. These last components as described in these sections of the contract's work constitutes the last 10% of the cost of each item of the schedule of values as applicable.

1.6 ALLOWANCE:

An allowance has been provided in the contract for various mechanical, electrical, and plumbing (MEP) work.

- A. The allowance shall be used for the cost of materials, labor, installation, and overhead and profit, in accordance with GC-26, for additional MEP work that is not identified in the Construction Documents / Plans, and not included in the base bid lump sum.
- B. The allowance shall be used only at the discretion of the Authority.
- C. The Contractor shall provide, to the Authority Representative, a written request for the use of the allowance, with a schedule of values, and associated backup information.
- D. Contractor shall proceed with work included in the allowance only after receiving a written order, from the Authority Representative, authorizing such work. Proceeding with work in the allowance without a written order from the Authority Representative will be at the Contractor's cost.

#### 1.7 SCHEDULE OF VALUES:

The Contractor shall prepare a Schedule of Values for the work covered by the Agreement.

- A. Generally, the Schedule of Values should reflect the format of the Proposal and include specified allowances, alternates and any alternate equipment selected by the Owner as applicable.
- B. For Lump Sum items in the Schedule of Values should include breakdowns for major portions of the work including the following breakdown or as additionally required by the Engineer to facilitate the pay application process.
- C. An unbalanced or front-end loaded schedule will not be acceptable.
- D. Summation of the Complete Schedule of Values representing all Work shall equal the Contract Price.
- E. The Schedule of Values shall be submitted to the Engineer for approval prior to pay application processes and should be submitted during the week of the pre-construction meeting.

#### 1.8 TRADE NAMES AND MATERIALS:

Where materials or equipment are specified by a trade or brand name, it is not the intention of the Owner to discriminate against an equal product of another manufacturer, but rather to set a definite standard of quality of performance, and to establish equal basis for the evaluation of bids. Where the words "Equivalent", "proper", or "equal to" are used, they shall be understood to mean that the thing referred to shall be proper, the

equivalent of, or equal to some other thing, in the opinion or judgment of the Engineer. Unless otherwise specified, all materials shall be the best of their respective kinds and shall be in all cases fully equal to approved samples. Notwithstanding that the words "or equal to" or other such expressions may be used in the Specification in connection with a material, manufactured article or process, the material, article or process, specifically designated shall be used, unless a substitute shall have been approved in writing by the Engineer and the Engineer shall have the right to require the use of such specifically designed material, article or process.

No material which has been used by the Contractor for any temporary purpose whatsoever is to be incorporated in the permanent structure without written consent of the Engineer.

1.9 COORDINATION:

- A. Continuous operation of Owner's facilities is of critical importance. Schedule and conduct activities to enable existing facilities to operate continuously, unless otherwise specified, and to minimize the number of shutdowns.
- B. Perform Work continuously during critical connections and changeovers, as required, to prevent interruption of Owner's operations.
- C. Conduct Work outside regular working hours only with prior written consent of Owner.
- D. Be responsible for planning, designing, and providing various temporary services, utilities, connections, temporary piping, bypass facilities and temporary connections, and similar items to maintain continuous operations of Owner's facility. Sequences other than those specified will be considered upon written request to Owner and Engineer, provided they afford equivalent continuity of operations.
- E. Do not close lines, open or close valves, or take other action which would affect the operations of existing systems, except as specifically required by the Contract Documents and after authorization by Owner and Engineer. Such authorization will be considered within 48 hours after receipt of Contractor's written request.
- F. Any tanks or pipelines requiring drainage prior to construction will be drained by the Owner's staff to the maximum extent possible utilizing existing piping and drains where they exist. The contractor shall provide temporary pumping and effort to complete drainage of tank or pipeline as required. Provide minimum 7 days notice to Engineer and Owner of need to drain a facility, unless otherwise specified.
- G. Power outages will be considered upon 48 hours written request to Owner and Engineer. Describe the reason, anticipated length of time, and areas affected by



the outage in the written request. Provide temporary provisions for continuous power supply to critical existing facility components, is requested by Owner.

- H. Coordinate proposed work with Engineer and Owner before implementing shutdowns. Under no circumstances shall Work end if such actions may inadvertently cause a cessation of any facility operation. In such cases, remain onsite until necessary repairs are complete and facility is brought back online.

1.10 STANDARD SPECIFICATIONS:

The City of Tulsa Public Works Department Standard Specifications and Standard Details latest edition are hereby adopted as part of these Specifications where reference is made. Said Specifications will be referred to as the "Standard Specifications".

The Oklahoma State Highway Commission "Standard Specifications for Highway Construction" latest edition are hereby adopted as part of these Specifications where reference is made. However, no portion of the Standard Specifications referring to Basis of Payment will be adopted as part of these Specifications.

1.11 CONTRACTOR'S FIELD OFFICE:

Not required. At Contractors option.

1.12 ENGINEER'S FIELD OFFICE:

Not required.

1.13 OPERATIONS AND MAINTENANCE MANUALS:

Three (3) hard copies and Two (2) digital copies, unless otherwise stated, of manuals containing specifications, drawings and descriptions of each individual item of the equipment, equipment summary sheet, installation instructions, operating and maintenance instructions, inspection startup reports, initial set points if applicable, certifications and parts lists shall be provided. The manual shall be a single manual covering complete operating installation, separate sheets or brochures for the equipment not manufactured by the major supplier shall all be included. A cover pages and index shall also be included (sample form layout will be provided). These manuals shall be in addition to any instructions packed with the equipment and shall be submitted not later than the date of shipment of the equipment.

Preliminary O&Ms shall be submitted for review by the City and Engineer prior to equipment installation.

Final O&Ms shall be provided in 3-ring binder(s), 3" maximum, with clear view cover and spine, clearly identifying the project name/number and include index tabs if applicable, start up reports, certification, initial set points if applicable, City of Tulsa

equipment summary sheet and Manufacture's equipment O&M included. No spiral bound volumes permitted; spine must be suitable for affixing a self-adhesive label. All material content shall be clearly legible; material obscured or rendered partially illegible resolution as a result of photo-electronic reproduction will be considered unacceptable.

Digital copy shall be provided on USB Drive of the complete final O&M. All files shall be formatted in current searchable Adobe PDF format.

O&Ms shall include a completed equipment summary data sheet (attached) for each equipment item that has been named/tagged/numbered on the drawings.

Final O&Ms shall include a "screen shot" PDF of each HMI screen updated and/or added by this contract into related equipment's Final O&M. Contractor shall also transmit a complete package of PDF screen shots of each HMI screen updated and/or added by this contract as a summer booklet of HMI information and part of contract close out documentation.

Minimum key project O&Ms shall be provided for:

- a. Pump(s)
- b. Grinder(s)
- c. Crane/hoist
- d. Valve(s)
- e. Gate(s)
- f. Major electrical equipment.

Other appropriate equipment part of the project or requested by the Engineer. See other specification sections for additional requirements.

#### 1.14 PROGRESS MEETINGS:

Monthly progress meetings shall be scheduled on a weekday mutually agreeable to the Authority, Engineer and the Contractor. A reoccurring date shall be agenda item in the pre-construction meeting (pre-work). The Contractor shall run the Monthly Meetings for the duration of the project and provide a meeting agenda including work completed, work planned, project updates, submittal/RFI logs, monthly updated project schedule, monthly updated warrantee log and other pertinent project status information.

The contractor shall submit a work progress and planned completion schedule for each bid item at the monthly progress meeting. The pre-construction (pre-work) conference will constitute the first monthly progress meeting, however the City will run the meeting. The Contractor, at the contractor's option may include Subcontractor's in the Monthly Progress Meeting as appropriate and helpful for coordination during construction.

#### 1.15 MANUFACTURER'S START-UP, CERTIFICATIONS & TRAINING REQUIREMENTS:

Manufacture's certification that the equipment is suitable and will perform within

specification and manufacturer's design operating parameters for the locations and conditions herein specified. Manufacture's services shall also include site visits by the Manufacture's *Technical Representative's* prior to construction, during installation and for start-up, as necessary for an inspection, detailed start up report and Manufacture's certification of proper installation. Submit the Manufactures start-up report(s) and certification(s) of proper installation when they become available to the Engineer and during the week the equipment being put into service. Included final copies of the Manufacture's Start-up Certificates in the final O&Ms. Start-up report/Manufacture's Certification should include pertinent start up details, equipment description, location, project information, complete initial set points, initial operational readings, equipment numbers and date and other pertinent system information for future operations and maintenance.

Training shall also be provided for the equipment and systems installed. Submit a draft training agenda, draft handouts, power point/video and a Manufacture's Technical Representative's resume for acceptance prior to scheduling the start-up and training. Provide two separate training days, as coordinated with the Plant to accommodate both day and night shifts. The Contractor may be required to provide additional training beyond specific equipment training where the equipment is part of a system. Multiple training events may be required for both the equipment components, control/integration and for the "system". The duration of the training should be a minimum of 4 hours per training day of classroom and field training or more, if recommended by the Manufacturer. A professional video services shall also be provided to cover both complete class room and field training sessions. Deliverables are to Include; the full training video on DVD with the final O&Ms to the City. Provide additional standard Manufacturer's videos if available on the same DVD in the final O&M.

#### 1.16 MISCELLANEOUS PROJECT DOCUMENTATION:

Warranty Equipment Log: Submit within 90 calendar days from the issuing of the Notice to Proceed, a draft Warranty Equipment Log spreadsheet complete with project equipment information and equipment numbers for review. From that point on, the log will be updated each month by the Contractor and be a handout in the Monthly Meetings. A live spread sheet version shall be provided by the Contractor upon request by the Authority. Upon project completion, the spread sheet shall be completed with all required information from the Contractor such as equipment numbers, start-up dates, training dates, O&M dates and other relevant information and transmitted to the Owner for their future use in maintaining the equipment. A sample spread sheet is available upon request from the Engineer. *The warranty log will be used as the project tool to establish and agree on equipment warranty period start date(s). Equipment start up, City staff training completed and submission of draft O&Ms are the minimum requirements for a warrantee start date.*

See Specification section 1.4 Submittals for additional project submittals, record drawing and additional requirements.

1.17 EXPLOSIVES:

The use of explosives will not be allowed.

1.18 INSPECTION:

The Contractor will provide access to the work site and facilities for representatives of the Environmental Protection Agency and Oklahoma Department of Environmental Quality and other agencies, as well as, Owner and Engineer, as required whenever the work is in progress.

1.19 SATURDAY, SUNDAY, HOLIDAY AND NIGHT WORK:

No work shall be done between the hours of 7:00 p.m. and 7:00 a.m., nor on Saturday, Sunday or legal holidays without the written approval or permission of the Owner, in each case, except such work as may be necessary for the proper care, maintenance and protection of work already done, or of equipment, or in the case of an emergency.

1.20 PROTECTION OF PROPERTY:

- A. The protection of Local, State, and Government monuments, street signs and other Owner's property is of prime importance, and if the same be damaged, destroyed or removed, they shall be repaired, replaced or paid for by the Contractor. Disturbance to this property must first be approved by the agency which controls it.
- B. No valves or other control on any utility main or building service line shall be operated for any purpose by the Contractor. Coordinate with Plant Operations for valve and other control on any utility main or building service line.
- C. At places where the Contractor's operations are adjacent to the plant of railway, telegraph, telephone, electric and gas companies, or water, sanitary sewers and storm sewers, damage to which might result in expense, loss or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been completed.
- D. The contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner and that services rendered by those parties will not be unnecessarily interrupted. The revision and crossings of the various types of lines shall be made as follows:
  - (1) Storm sewers and culverts may be removed at the time of crossing or may be adequately braced and held in position while the pipe is placed beneath them. If the storm sewer or culvert is removed, it shall be replaced with pipe of the same type and size as that removed and it shall be re-joined to

the undisturbed line with a joint satisfactory to the Engineer. Backfill over the main up to and around the storm sewer shall be thoroughly compacted in order that no settlement will occur. The revision and crossing of said lines shall be at the expense of the Contractor.

- (2) All overhead and buried telephone and electrical conduits, to be revised or crossed by the construction of this project shall be protected in accordance with the directions of the utility company owning the conduits and/or mains. The Contractor shall notify the companies and obtain their permission before making any crossing or revisions. The revision and crossing of said lines shall be at the expense of the Contractor. Any overhead cables or buried cables or conduits damaged by the Contractor shall be repaired at his expense to the satisfaction of the Engineer and of the Owner.
- (3) The Contractor shall not remove any water or sanitary sewer lines except as directed by the Owner or as required by the Drawings and Specifications, and shall adequately brace and protect them from any damage during construction. Any existing water main or sewer main damage caused by the Contractor's operations will be repaired by the Contractor. The repairs will be made at the Contractor's expense.

- E. The location of utility service lines serving individual properties are generally not shown on the Drawings, but the CONTRACTOR shall assume that such service lines exist whether or not they are shown on the Drawings, and it shall be the responsibility of the CONTRACTOR to contact the necessary utilities and have all utilities located. It shall be the responsibility of the CONTRACTOR to make any necessary changes in the line and/or grade of such services or to secure the necessary changes therein to be made by the particular utility company involved or other owner thereof, or by an agent or individual CONTRACTOR approved by such utility company or other owner. CONTRACTOR shall pay the cost of all such revisions whether performed by CONTRACTOR, the utility company or other owner, or an approved CONTRACTOR. In the event of interruption of a utility service as a result of accidental breakage, CONTRACTOR shall promptly notify the ENGINEER and the owner of the utility, and shall repair or cause the same to be repaired, in the same manner as necessary changes above are provided for, the CONTRACTOR shall do all things necessary to see that the restoration of services are done as promptly as may be reasonably done.
- F. In the event the Contractor in any way fails to comply with the requirements of protecting, repairing and restoring of any utility or utility service, the Owner may, upon forty-eight (48) hours written notice proceed to protect, repair, rebuild or otherwise restore such utility service as may be deemed necessary, and the cost thereof will be deducted from any money due or which may become due the Contractor pursuant to the terms of his contract.

**1.21 ASSISTANCE BY ENGINEER:**

It is understood and agreed that such assistance as the Engineer may render to the Contractor in connection with the interpretation of drawings and Specifications shall not relieve the Contractor from any responsibility for the work. Any work which proves faulty shall be corrected by the Contractor without delay. The failure of the Engineer, or Resident Project Representative to call the Contractor's attention to faulty work or work performed which is not in accordance with Drawings and Specifications shall not imply acceptance or exempt the Contractor for correcting the improper work.

**1.22 INCIDENTAL WORK:**

Work called for on the Drawings and/or Specifications and are not set forth in the Bid Schedule as pay items, shall be considered as incidental work and will not be paid for directly, but shall be included in the price bid for the various pay items.

**1.23 SUBSTANTIAL AND FINAL COMPLETION:**

When the work is substantially complete, Contractor shall notify the Owner and Engineer in writing that the entire work is substantially complete (operational or beneficial occupancy) and request that Engineer issues a certificate of substantial completion. Work which may remain uncompleted at substantial completion shall include only minor surface work relative to right-of-way restoration, sodding, seeding, pavement replacement, etc.

Upon written notice from Contractor to the Engineer and Owner that the entire work is complete within the time called out on the Bid the Engineer will make a final inspection with Owner and Contractor and will notify Contractor in writing all particulars of the project which are incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such work prior to final payment.

**1.24 EXCAVATION:**

No additional payment shall be made for encountering materials such as limestone, groundwater, or other natural formations.

Prior to any excavation work, Contractor shall contact OKIE (1-800-CALL-OKIE) as well as all utility Owners within the work site.

**1.25 DETERMINATION AND EXTENSION OF CONTRACT TIME:**

The contract time consists of the number of calendar days stated in the Contract for the completion of the work beginning on the effective date of the work order or the date the CONTRACTOR begins work, whichever is earlier, including all Sundays, holidays and non-work days. All calendar days elapsing between effective dates of any orders of the Engineer to suspend work and to resume work for suspensions, not the fault of the

CONTRACTOR shall be excluded.

The occurrence of unusually severe weather during the life of the contract will be considered a basis for extending contract time when work is not already suspended for other reasons. Unusually severe weather shall mean weather which at the time of year it occurs is unusual for the place in which it occurs.

Extension of time for unusually severe weather will be determined on a monthly basis and will include only those actual adverse weather days in excess of the normal adverse weather days included in the contract time. Normal adverse weather shall mean adverse weather which, regardless of its severity, is to be reasonably expected for that particular place at that particular time of year. The normal adverse weather days included in the contract time as shown in Table A are based on historical records of temperature and precipitation.

Actual adverse weather days are those days meeting one or more of the criteria in "a", "b", "c" and "d" below. Time extensions for days meeting more than one criterion will take into consideration only that criterion having the greatest impact. Those actual adverse weather days covered by criterion "a", "b", or "c" that are in excess of the days in Table A will be allowed without regard to when they occur (except prior to mobilization or during suspension for other reasons) or their impact on contract completion. However, those days covered by criterion "d" will be subject to the limitations as noted:

- "a" Days with Maximum temperature of 32° F or less - one full day allowed.
- "b" Days with Minimum temperature of 32° F or less, but whose Maximum temperature is over 32° F - one-half day allowed.
- "c" Days when 1/2" or more precipitation (rain or snow equivalent) occurs - one full day allowed.
- "d" Days when weather related conditions exist which prohibit proper performance of work as specified - one full day allowed. Allowance of such days will be subject to the work which is being delayed, being critical to timely contract completion and the CONTRACTOR making every reasonable effort to minimize the adverse impact of the conditions.

**TABLE A**  
**NORMAL ADVERSE WEATHER DAYS**

(The days the Contractor should anticipate within the contract duration that should be anticipated by the month and during the contractual workdays per work week noted above.)

<u>MONTH</u>	<u>NORMAL ADVERSE WEATHER DAYS</u>
January	9
February	7
March	6
April	3
May	3
June	3
July	2
August	2
September	3
October	3
November	5
December	7

END OF SECTION



## PRODUCT STORAGE AND HANDLING REQUIREMENTS

1.2 - 1

- 1.1 **SCOPE.** This section covers delivery, storage, and handling of materials and equipment.
- 1.2 **DELIVERY.** Contractor shall bear the responsibility for delivery of equipment, spare parts, special tools, and materials to the site and shall comply with the requirements specified herein and shall provide required information concerning the shipment and delivery of the materials specified in this Contract. These requirements also apply to any sub-contractor suppliers making direct shipments to the Site.

Contractor shall, either directly or through contractual arrangements with others, accept responsibility for the safe handling and protection of the equipment and materials furnished under this Contract before and after receipt at the port of entry. Acceptance of the equipment shall be made after it is installed, tested, placed in operation and found to comply with all the specified requirements.

All items shall be checked against packing lists immediately on delivery to the site for damage and for shortages. Damage and shortages shall be remedied with the minimum of delay.

Delivery of portions of the equipment in several individual shipments shall be subject to review of Engineer before shipment. When permitted, all such partial shipments shall be plainly marked to identify, to permit easy accumulation, and to facilitate eventual installation.

- 1.3 **STORAGE.** Upon delivery, all equipment and materials shall immediately be stored and protected until installed in the Work.

Stacked items shall be suitably protected from damage by spacers or load distributing supports that are safely arranged. No metalwork (miscellaneous steel shapes and reinforcing steel) shall be stored directly on the ground. Masonry products shall be handled and stored in a manner to hold breakage, chipping, cracking, and spalling to a minimum. Cement, lime, and similar products shall be stored off the ground on pallets and shall be covered and kept completely dry at all times. Pipe, fittings, and valves may be stored out of doors, but must be placed on wooden blocking. PVC pipe, geomembranes, plastic liner, and other plastic materials shall be stored off the ground on pallets and protected from direct sunlight.

Pumps, motors, electrical equipment, and all equipment with antifriction or sleeve bearings shall be stored in weathertight structures maintained at a temperature above 60°F. Electrical equipment, controls, and insulation shall be protected against moisture and water damage. All space heaters furnished in equipment shall be connected and operated continuously.

## PRODUCT STORAGE AND HANDLING REQUIREMENTS

1.2 - 2

Equipment having moving parts, such as gears, bearings, and seals, shall be stored fully lubricated with oil, grease, etc., unless otherwise instructed by the manufacturer. Manufacturer's storage instructions shall be carefully followed by Contractor.

When required by the equipment manufacturer, moving parts shall be rotated a minimum of twice a month to ensure proper lubrication and to avoid metal to metal "welding". Upon installation of the equipment, Contractor shall, at the discretion of Engineer, start the equipment at one-half load for an adequate period of time to ensure that the equipment does not deteriorate from lack of use.

When required by the equipment manufacturer, lubricants shall be changed upon completion of installation and as frequently as required thereafter during the period between installation and acceptance. New lubricants shall be put into the equipment by Contractor at the time of acceptance.

Equipment and materials shall not show any pitting, rust, decay, or other deleterious effects of storage when installed in the Work.

In addition to the protection specified for prolonged storage, the packaging of spare units and spare parts shall be for export packing and shall be suitable for long-term storage in a damp location. Each spare item shall be packed separately and shall be completely identified on the outside of the container.

- 1.4 HANDLING. Stored items shall be laid out to facilitate their retrieval for use in the Work. Care shall be taken when removing the equipment for use to ensure the precise piece of equipment is removed and that it is handled in a manner that does not damage the equipment.

END OF SECTION

## PART 1 – GENERAL

- 1.1 SCOPE. This section covers the furnishing and installation of nameplates and tags for identification of equipment, valves, gates, panels, and instruments.
- 1.2 GENERAL. Except as otherwise specified in equipment, valve, and instrumentation sections, nameplates and tags shall be as specified herein. Nameplates or tags shall be provided for all equipment, valves, operator interfaces, control and electrical panels, cabinets, instruments, and instrument racks that have been named and/or tagged on the Drawings.
- 1.3 SUBMITTALS. Drawings and data shall be submitted in accordance with the requirements of the Submittals Procedures section for each type of tag provided including materials, colors, sizes, letter sizes, and installation instructions.

## PART 2 - PRODUCTS

- 2.1 EQUIPMENT NUMBER PLATES. All Equipment tagged on the drawings, except for submerged equipment shall be provided with number plates bearing the equipment tag number and general description of item identified on the Drawings. The number plate and the description plate shall be two plates with number mounted one above the other as coordinated with the Engineer. Number plates shall be bevelled, 1/8th inch thick laminated blue phenolic plastic engraving stock with white core. Lettering on number plates shall be capitalized block letters  $\frac{3}{4}$  inch high. Number plate height shall be twice the letter height. Number plate length shall be as needed, with suitable margins all around. Lettering shall be placed in one row where practicable; however, where necessary due to excessive length, lettering shall be placed on more than one row and centered.

Number plates shall be attached with stainless steel panhead screws, stainless steel rivets, or stainless steel drive screws.

When a number plate cannot be installed due to the physical size, space, other limitations or mounting surface geometry of the equipment, the Contractor shall provide a 12 gauge stainless steel tag with engraved or imprinted equipment tag number. Lettering on tags shall be  $\frac{1}{4}$  inch high. Tags shall be rectangular with smooth edges, and shall be fastened to the equipment with stainless steel mechanical fasteners or with a stainless steel chain.

Additional tags showing the primary Equipment Number (ID number) and a secondary equipment description tag shall be provided for ancillary equipment that does not have an individual Equipment Number assigned. Ancillary equipment includes electrical control panels, power panels, transformers, disconnects, seal water stations, valves and other miscellaneous equipment as determined by the Owner.

## 2.2 VALVE AND GATE TAGS.

- A. Temporary Tags. Each valve and gate with an identifying number indicated on the Drawings or listed in the valve or gate schedule, shall be tagged or marked in the factory with the identifying number.
- B. Permanent Tags. All valves and gates, except buried or submerged valves, that have been assigned an equipment number on the Drawings or in the valve or gate schedule, shall be provided with a permanent number plate. Equipment Number Plates shall be round 1.5” and 1/16” thick laminated blue phenolic plastic engraving stock that is U/V stable. Lettering shall be in 3 sections, centered, and white capitalized block letters 3/16” high and engraved to a depth of 0.08mm.

Example: 1<sup>st</sup> line XXXX -  
2<sup>nd</sup> line XXXX -  
3<sup>rd</sup> line XXXX -

Equipment Number Plates must follow the equipment numbering scheme.

Equipment Number Plates shall be attached with permanent ties.

All buried valves shall be tagged with a 304 stainless steel 1/32” plate with embed anchoring cast into a concrete collar pad at grade around valve box (See plans for detail). The numbers and service description shall be engraved in the plate with lettering and numerals at least 1 inch [25 mm] high.

Valve and gate tags shall at a minimum contain the following information:  
“Descriptive System or Equipment Name”, as applicable  
“Equipment Number”  
“Plan ID (if different from Equipment Number)”

## 2.3 EQUIPMENT, PANELS, INSTRUMENTS.

- A. Temporary Tags. Each equipment, panel or instrument with an identifying number indicated on the Drawings or listed in plan sheet schedule as applicable, shall be tagged or marked in the factory, by the factory with the identifying number and description tag.
- B. Permanent Tags. All equipment tagged on the drawings, except for buried submerged equipment shall be provided with an Equipment Number Plate bearing the equipment tag number identified on the drawings. Equipment Number Plates shall be rectangular 3.5”x .75” and 1/16” thick laminated blue phenolic plastic engraving stock that is U/V stable. Lettering shall be

## EQUIPMENT AND VALVE IDENTIFICATION

1.3 - 3

1 line of text, centered, and white capitalized block letters .25" high and engraved to a depth of 0.08mm.

Example: 1<sup>st</sup> line XXXX -  
2<sup>nd</sup> line XXXX -  
3<sup>rd</sup> line XXXX -

Equipment Number Plates must follow the equipment numbering scheme.

Equipment Number Plates shall be attached with permanent adhesive.

Tags shall at a minimum contain the following information:

“Descriptive System or Equipment Name”, as applicable

“Equipment Number”

“Plan ID (if different from Equipment Number)”

### PART 3 – EXECUTION

Not used. See City of Tulsa standards and other specification sections as applicable.

END OF SECTION



## 1. SHOP DRAWINGS, SAMPLES AND PRODUCT DATA

- 1.1 GENERAL - Submittals on component parts forming a system, or that are interrelated, shall be submitted at one time as a single submittal in order to demonstrate that the items have been properly coordinated and will function as a unit.
- 1.2 Shop Drawings - Identify details by reference to sheet and detail numbers shown on Contract Drawings. Use same symbols wherever practicable. Reproductions of Contract Drawings are acceptable as shop drawings only when specifically authorized in writing by the Engineer.
- 1.3 Samples - Includes all required physical examples to illustrate materials, equipment or workmanship, which establish standards by which completed work is urged. Must be of sufficient size and clarity, and in sufficient quantity to clearly illustrate functional characteristics and full range of colors, patterns, textures or other properties which will be actually produced.
- 1.4 Product Data - Includes manufacturer's schematic drawings, catalog sheets, brochures, diagrams, schedules, performance charts, illustrations, test reports, certificates of compliance, and other descriptive data not included on shop drawings. Modify standard descriptive data to delete information which is not applicable, and clearly identify pertinent data.
- 1.5 SUBMISSION REQUIREMENTS - Submittals shall be made with a letter of transmittal to the Engineer by the Contractor, and not by sub-contractors, suppliers or manufacturers.
- 1.6 Submit samples in number specified, or if not so specified, in triplicate.
- 1.7 Submit Project Data in sufficient quantity for required distribution and record, allowing two copies to be retained by Engineer.
- 1.8 Identify all submittals with the following information, as applicable:
  - Project title and Engineer's project number.
  - Name of Contractor, Engineer, originating sub-contractor or supplier.
  - Submittal date, and all revision dates.
  - Identify each product or material submittal by reference to Specification section and page no., drawing no., or any other contract document reference applicable thereto.
  - Applicable conformance standards.

Include certification of Contractor review and conformity to contract requirements per General Conditions, Paragraph 6.25. Identify any deviations from Contract Documents. Provide 3" x 3" minimum space for Engineer's review stamp.

## 2. PROJECT RECORD DOCUMENTS

- 2.1 MAINTENANCE OF DOCUMENTS - Maintain at jobsite one record copy of Contract Drawings, Specifications, Addenda, approved Shop Drawings, Change Orders, other modifications to the Contract, field test records and other approved documents submitted by Contractor in compliance with Specification requirements.
- 2.2 Maintain documents at the project apart from documents used for construction. Do not use record documents for construction purposes. Maintain documents in clean, legible condition. Make documents available at all times for inspection of the Engineer and Owner.
- 2.3 RECORDING - Label each document "PROJECT RECORD COPY" in 2" high printed letters. Keep record documents current. Do not permanently conceal any work until required information has been recorded.
- 2.4 CONTRACT DRAWINGS - Legible mark most appropriate drawing to record, where applicable:
  - Depths of various elements of foundation in relation to first floor level.
  - Horizontal and vertical location of underground utilities and appurtenances referenced to permanent surface improvements. Any elevation(s) and location(s) which were provide in the contract plan and documents with elevations and coordinates must be updated in the submitted project record documents.
  - Location of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of structure.
  - Provide elevations and survey coordinates locations for all buried fitting(s), valves, solid sleeves, couplings, repairs, change in material piping and on crown of piping every 100 LF feet on center from bends and valves. Elevations should be top of item and not top of ground or surface.
  - Field changes of dimension and detail made during construction process.
  - Changes made by Change Order or Field Order.
  - Details not on original Contract Drawings.
  - Any change in location of facilities. Use City Survey Control System.
  - Payment shall be made by through the pay application process.
  - **Reference and provide for current City of Tulsa standard, section 334.**
  - Submit the Contractor's record drawings by electronic PDF to the Engineer.



- 2.5 SPECIFICATIONS AND ADDENDA - Legibly mark up each Section to record:
- Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.
  - Changes made by Change Order or Field Order.
  - Other matters not originally specified.
- 2.6 SHOP DRAWINGS - Maintain as record drawings. Legibly annotate shop drawings to record changes made after review. Use red felt tip marking pen for all recording.
- 2.7 SUBMITTALS- At completion of project, deliver record documents to the Engineer. Accompany submittal with transmittal letter, in duplicate, containing:
- Date, project title and number.
  - Contractor's name and address.
  - Title and number of each record document.
  - Certification that each document as submitted is complete and accurate.
  - Signature of Contractor or his authorized representative.
  - Create all final O&M cover sheets to be the same "touch and feel" to the project.
  - See sample cover sheet and equipment summary for O&Ms after the end of the section.

3. PROJECT SUBMITTAL LOG

- 3.1 Contractor shall provide draft submittal log prior to the first monthly meeting identifying and listing by specification number, description and other submittal information for use on the project. Contractor will incorporate comments provided by the Owners Representative. Log shall separately list the preliminary O&Ms also. Contractor shall maintain and provide a copy of the submittal log at each Monthly Progress Meeting.

END OF SECTION

*{MANUFACTURER INFORMATION (Logo, etc.)}*

## OPERATION AND MAINTENANCE MANUAL

**{Description of item}**

**To:**

Project Contractor Name

Address

City, State Zip

Phone Number

**Project Name**

**Project Location**

**PO#: (if applicable)**

**Manufacture Project Number (if applicable)**

**Submittal for fulfillment of specification section:**

**{Specification Section and Short Description}**

**Equipment List (if applicable)**

<b>Application</b>	<b>Type</b>	<b>Number</b>	<b>Equipment Tag #</b>

**Represented Locally By:**

Supplier Name

Address

City, State Zip

Phone Number

**Prepared By:**

Manufacturer

Address

City, State Zip

Phone Number

**Date**

## I. GENERAL

- A. Mobilization Bid Item – A mobilization bid item is included to help cover initial costs of bonds, insurance, permits, submittal preparation and other incidental costs. Include demobilization costs in other items of work.
- B. Payment shall be made for a Mobilization Bid Item which is intended to cover the costs of bonds, insurance, permits, submittal preparation and other incidental costs. Payment of the Mobilization Bid Item may be requested in full on the first payment application. The Mobilization Bid Item shall not exceed five percent (5%) of the **sum of all Base Bid Items excluding the Mobilization Bid Item**. Add Alternate Items are not part of the Base Bid Items.

END OF SECTION

I. GENERAL

- A. Mechanical, Electrical, Plumbing, and Unforeseen Circumstances Allowance – The allowance amount is shown on the bid proposal for various mechanical, electrical, plumbing, or unforeseen circumstances work not shown on the Construction Drawings or specified in the Contract Documents.
- B. The allowance shall be used for cost of materials, labor, installation, and overhead and profit for additional MEP/Unforeseen Circumstances work that is not shown on the Construction Drawings or specified in the Contract Documents.
- C. The allowance shall be used only at the discretion of the City of Tulsa. Any allowance balance remaining at the completion of the contract will be credited back to the City of Tulsa on the final Application for Payment submitted by the contractor.
- D. The contractor shall provide to the City of Tulsa representative a written request for the use of any of the allowance with a schedule of values and all associated backup information.
- E. The contractor shall proceed with work included in the allowance only after receiving a written order from the City of Tulsa representative authorizing such work. Proceeding with work expected to be covered in the allowance without a written order from the City of Tulsa representative will be at the contractor's risk. Contractor may not be paid for unapproved work/materials at the discretion of the City of Tulsa representative.
- F. Any additional costs for bonds and insurance shall not be included in any MEP allowance because this cost is already included in the contract.

END OF SECTION

## PART 1- GENERAL

### 1.1 CLEARING AND GRUBBING

- A. This item shall consist of the clearing and/or grubbing, including the disposal of materials for all areas within the construction limits of work reflected on the plans and any other areas designated on the plans.
- B. Clearing shall consist of the removal of all trees, brush, stumps, logs, or other objects in the designated area(s).
- C. Grubbing shall consist of the removal of all stumps, roots, buried logs, brush, grass, and other unsatisfactory materials to a depth of at least 18 inches unless the object if left would be detrimental to the purpose of the site in which case the object shall be totally removed to at least a depth which would not be detrimental to the purpose of the site.
- D. Depressions left from the clearing and grubbing operations shall be filled using suitable fill material. The fill operation shall be done in six-inch (compacted thickness) lifts and compacted to 90% of maximum in future grass areas as determined by the Standard Proctor Test (ASTM D698) and to 95% of maximum in future pavement or structure areas as determined by the Standard Proctor Test (ASTM D698).

### 1.2 EXCAVATION AND EMBANKMENT

- A. This item shall consist of the excavation, placement, compaction, and disposal of earth materials within the project area to the lines and grades shown on the plans. The contractor shall remove and dispose of excess excavation off site or provide borrow material from off site, both at his expense.
- B. All excavation and embankment shall be unclassified with respect to pay purposes and shall be included in the lump sum contract price including any rock excavation.
- C. Before beginning excavation, grading and embankment operations in any area, the area shall be completely cleared and/or grubbed.
- D. The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All unsuitable material shall be suitably disposed of by the Contractor. Waste areas shall be graded to allow positive drainage of the area and adjacent areas.
- E. If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor

shall notify the Engineer, who shall arrange for their removal if necessary. The Contractor shall, at his/her own expense, satisfactorily repair or pay the cost of all damage to such facilities or structures which may result from any of the Contractor's operations during the period of the contract.

- F. The contractor shall provide drains, pumps, well points or other equipment as necessary to dewater the site as required to perform the sitework.
- G. All fill or embankment shall be placed in six-inch (compacted thickness) lifts and compacted, using suitable equipment to 95% of maximum as determined by the Standard Proctor Test (ASTM D698). Compliance with this requirement shall be evidenced by independent laboratory tests performed by and paid for by the Owner.
- H. Rock in size or quantities such that a well compacted embankment cannot be assured will not be permitted in the fill material.  
  
Stones or rocks in excess of four inches in their greatest dimension shall not be permitted in the top 24 inches of fill unless specifically required on the Construction Drawings. No rocks or debris larger than 6 inches in their greatest dimension shall be used as backfill.
- I. Blasting will not be permitted
- J. When an embankment is to be constructed on existing grade, all sod and vegetation shall first be removed and the cleared surface scarified to a depth of six inches and compacted to the same density as the fill to be placed.
- K. The Contractor shall provide all necessary water and equipment to meet compaction requirements of fill material.

### 1.3 TOPSOIL

- A. This item shall consist of the furnishing and placement of topsoil on embankments, excavations or areas directly or indirectly disturbed by the project work. If sufficient topsoil is not available on site the contractor shall obtain topsoil from offsite at no additional cost to the owner.
- B. Topsoil shall be the surface layer of soil not less than 4" or if greater what is observed onsite with no admixture of refuse or material toxic or inhibitive to plant growth and shall be reasonably free of sub-soil, brush, roots, rocks, clay lumps, or similar objects.

The topsoil used from on site or otherwise furnished shall have a pH range of 5.5 to 7.6 when tested in accordance with the "Methods of Testing" of the Association of Official Agricultural Chemists. The organic content shall be not less than 3% nor more than 20% as determined by the Wet Combustion Method (chronic acid

reduction). There shall be not less than 20% nor more than 80% of the material passing the 200 mesh sieve as determined by the Wash Test in accordance with AASHTO T11.

- C. Immediately prior to dumping and spreading topsoil, the surface shall be loosened by disc to a minimum depth of two inches. Prior to placing topsoil, the area shall be cleared of rocks in excess of 1½ inches in one dimension and any other debris or trash.
- D. Topsoil shall be spread evenly on the prepared areas to a uniform depth of three inches after compaction.

Spreading shall not be done when ground conditions are too wet or otherwise in a condition detrimental to the work.

After spreading clods shall be broken up and rocks in excess of two inches, and any debris shall be removed.

After spreading and debris removal is complete, the topsoil shall be compacted by rolling with a multi-packer.

#### 1.4 SODDING

##### A. General:

This item shall consist of sodding preparation, furnishing and placing sod in those areas top soiled per section 1.3 these specifications and areas disturbed during construction activities. The use of seeding or vegetative mulch are not part of this project unless for the Contractors own temporary use(s).

##### B. Materials and Construction Methods:

1. Sod shall be place in accordance with City of Tulsa Standard Specifications, Division III, Part 325 sodding and seeding March 2022.
2. Contractor shall coordinate and schedule final site fine grading and placement to promote grass growth. Full “carpet” grass growth of more than three inches shall be established during growing seasons.
3. Spray for weeds and undesirables after grass is established.
4. Sodding activity shall be shown on the Contractor project schedule.
5. Fertilizer - Fertilizer shall be applied in liquid form at a concentration to provide the equivalent of a 10-20-10 commercial fertilizer applied at the rate of two hundred (200) pounds per acre, unless recommended otherwise by the Sod Supplier.

END OF SECTION

## PART 1 - GENERAL

### 1.1 SCOPE

This section covers the demolition of existing piping, equipment and sitework and the salvage of existing material and equipment as indicated on the drawings.

### 1.2 GENERAL - Contractor shall be responsible for all work under this section.

All structures and facilities of the existing lift station which are not to be removed must remain in continuous operation during the proposed work. Demolition and salvage work shall create minimum interference with Owner's operations and minimum inconvenience to Owner.

Blasting will not be permitted.

## PART 2 - PRODUCTS

Not Used

## PART 3 - EXECUTION

### 3.1 DEMOLITION

#### A. Project Demolition

1. Refer to Construction Drawings for site demolition. Contractor is to protect the existing onsite structures, electrical, water and other services during demolition and the construction work. Refer to the Demolition Plan for demolition notes.
2. All miscellaneous metals shall be removed from structures and disposed of off site by the Contractor. This includes, grating, pipe supports, handrail, ladders, doors, door frames, window frames and other related items.
3. All surface and buried items associated the proposed structure and service shall be removed. This also includes sequenced demolition during construction and coordination for the removal of the gravity sanitary sewer piping at the new screening structure. Refer to the Demolition Plan and the Proposed Structural Plans for additional information.
4. All anchor bolts shall be demolished per "rebar and embedded item concrete repair detail" unless specifically noted otherwise. All wall, ceiling, floor and surface areas of new work, including



demolition shall be surface repaired and painted to match unless specifically noted otherwise. See additional requirements noted in the plan set general notes section.

- B. Piping and Equipment Demolition – The following piping and equipment shall be removed and shall become the property of Contractor. All such items shall be promptly removed from the jobsite.
1. Existing valves and pump equipment not salvaged by the City and other related process and electrical equipment as shown on the Construction Drawings.
  2. Excluding items identified in Demolition section 3.2 Salvage or shown on the Construction Drawings, demolition shall include pumps, piping, wire-conduits to extent possible, electrical cabinets, valves, equipment, related process items, electrical equipment and appurtenances being demolished.
  3. Other underground piping as required to accomplish the proposed grading and proposed screening facilities as shown in the Construction Drawings.
- C. Sitework Demolition shall include the following as indicated on the drawings:
1. Removal of concrete sidewalks, electrical duct, curbs, fencing, cable guards, trees-shrubs and other miscellaneous structures within the limits of the proposed grading as shown on the Construction Drawings.

### 3.2 SALVAGE

- A. Items To Be Salvaged by Owner – Contractor shall coordinate with the Owners Representative to identify any Owner salvage items, if any. Contractor will be remove, packaged and delivered to Plant Maintenance Department. Larger items, like valves, fittings should be palletized and delivered to Plant Maintenance Department.

Items identified to be salvaged include at Owner option during construction:

- a. XXX
- b. XXX
- c. XXX

- B. Items To Be Salvaged by Contractor - Removed and salvaged equipment or facilities shall include removal and salvage of all accessories, piping,

wiring, supports, associated electrical starters and devices, baseplates and frames, and all other appurtenances, unless otherwise directed.

1. Existing Materials and equipment removed, and not reused as a part of the work, shall become Contractor's property unless otherwise specified, and shall be removed from the jobsite.
2. Contractor may, at his option, furnish and install new items instead of those specified or indicated to be salvaged and reused, in which case such removed items will become Contractor's property.

END OF SECTION

A DESCRIPTION OF WORK

This Section includes the following:

Preparation of subgrade for building slabs, foundations and structures.

Grading, excavation and fill for the site and structures shall be performed by the contractor to the grades indicated on drawings. The site plan shows approximate existing and proposed finish grades and elevations.

Undercut areas of subgrade that are spongy and yielding as designated by the engineer.

B DEFINITIONS

1. Excavation consists of removal of material encountered to subgrade elevations indicated and subsequent disposal of materials removed.
2. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer shall be at Contractor's expense.
3. Additional Excavation: When excavation has reached required subgrade elevations, notify Engineer, who will make an inspection of conditions. If Engineer determines that bearing materials at required subgrade elevations are unsuitable, continue excavation until suitable bearing materials are encountered and replace excavated material as directed by Engineer.
4. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular subbase, granular base, or topsoil materials.
5. Structure: Buildings, foundations, slabs, tanks, curbs, or other man-made stationary features occurring above or below ground surface.

C SUBMITTALS

1. Product data for the following:  
  
Each type of plastic warning tape.  
  
Vapor barrier.

EXCAVATION & BACKFILL FOR BUILDINGS,  
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2. Samples of the following:

Coordinate, provide access to and provide equipment for selected samples(s) and/or deliver samples to City's Independent Testing lab as required for new work. Submit Reports for products intended for backfill use.

3. Test reports: In addition to test reports required under field quality control, submit the following:

Laboratory analysis of each soil and base course material proposed for fill and backfill from on-site and borrow sources.

One optimum moisture-maximum density curve for each soil material.

Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.

D QUALITY ASSURANCE

1. Codes and Standards: Perform excavation work in compliance with applicable requirements of authorities having jurisdiction.
2. Retesting of work: When initial testing indicates unacceptable work or materials, retesting will be paid for by the Contractor until acceptable results are achieved.
3. Codes and Regulations: All operations shall conform to applicable local and state codes and regulations including OSHA requirements.

E PROJECT CONDITIONS

1. Site Information: No geotechnical investigation has been performed.
2. Existing Utilities: It is the Contractor's responsibility to locate existing underground utilities in areas of excavation work prior to beginning the excavation. If utilities are indicated to remain in place, provide adequate means of support and protection during earthwork operations. The Contractor shall notify the appropriate utility for field location of all utilities.
3. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

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4. Do not interrupt existing utilities serving facilities occupied by Owner or others, during occupied hours, except when permitted in writing by Engineer and then only after acceptable temporary utility services have been provided.
5. Provide minimum of 48-hour notice to Engineer, and receive written notice to proceed before interrupting any utility.
6. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shutoff of services if lines are active.
8. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.
9. Operate warning lights as recommended by authorities having jurisdiction. Construction within street right-of-way may require an approved barricade and maintenance of traffic plan.
10. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
11. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.

F SOIL MATERIALS

1. It is acceptable to utilize the on-site soil materials for subgrade construction not indicated to be "backfill or fill" if the material can be successfully proof-rolled with a 20,000 pound pneumatic tired roller or loaded dump truck without excessive rutting or "pumping".
2. Granular Base Course: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100% passing a 3/4" sieve and not more than 5% passing a No. 4 sieve. Acceptable material will include coarse aggregate for concrete. Washed Concrete sand may also be used.
3. Backfill and Fill Materials: Soil materials having a liquid limit less than 45, a Plasticity Index (PI) between 8 and 20, free of rock or gravel larger than 2 inches in any dimension, debris, waste, frozen materials, vegetation, organics and other deleterious matter is designated "satisfactory" as determined by the Engineer and may be used for backfill and fill material.

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4. Subbase Material: Soil material designated "satisfactory".
5. Vapor Barrier: Vapor Barrier required under all interior concrete slabs on grade and where noted in Drawings shall be polyethylene sheet, 6 mil thickness conforming to ASTM E-154.

G EXCAVATION

1. Excavation is unclassified and includes excavation to subgrade elevations indicated, regardless of character of materials and obstructions encountered.
2. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Engineer.
3. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by Engineer. If unsuitable bearing materials are encountered at required elevations, carry excavation deeper and replace excavated material as directed by Engineer.
4. Additional Excavation: When excavation has reached required subgrade elevations, notify Engineer who will make an inspection of conditions.
5. Stability of Excavations:
  - a. Slope sides of excavations to comply with local codes, ordinances, and requirements of agencies having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.
  - b. Shoring and Bracing: Establish requirements for trench shoring and bracing to conform with local codes and authorities having jurisdiction. Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses.
6. Trench and Excavation Safety Systems
  - a. Description: This section covers trench and excavation safety system required for constructing improvements that necessitate open excavations on the project. All work under this item shall be in accordance with the

EXCAVATION & BACKFILL FOR BUILDINGS,  
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current edition of the "Occupational Safety and Health Administration Standard for Excavation and Trenches Safety System", 29 CFR 1926, Subpart P.

- b. Notifications Required: The Contractor, prior to beginning any excavation, shall notify the State Department of Labor (Safety Division) that work is commencing on a project with excavations greater than five feet.
- c. The Contractor shall notify all Utility Companies and Owners in accordance with OSHA Administration 29 CFR 1926.651(b) (2) for the purpose of locating utilities and underground installations.
- d. Existing Structures and Utilities: Where the trench or excavation endangers the stability of a building, wall, street, highway, utilities or other installation, the Contractor shall provide support systems such as shoring, bracing, or underpinning to ensure the stability of such structure or utility. The Contractor may elect to remove and replace or relocate such structures or utilities with the written approval of the Owner of the structure of utility and the Project Owner.

**H     DEWATERING**

- 1. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area. No fill shall be placed in water or upon saturated soils.
- 2. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
- 3. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or runoff areas. Do not use trench excavations as temporary drainage ditches.
- 4. The Contractor is responsible for all surface runoff, ground water, rain or snow and system piping dewatering as necessary of the contract work.

**I     STORAGE OF EXCAVATED MATERIALS**

- 1. Stockpile excavated materials satisfactory for backfill and fill where directed. Place, grade, and shape stockpiles for proper drainage.

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2. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.
3. Dispose of excess excavated soil material and materials not satisfactory for use as backfill or fill.

J EXCAVATION FOR STRUCTURES

1. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, and other construction and for inspection.
2. Excavations for footings and foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive other work.

K TRENCH EXCAVATION FOR PIPES AND CONDUIT

1. Excavate trenches to uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches of clearance on both sides of pipe or conduit.
2. Excavate trenches and conduit to depth indicated or required to establish indicated slope and invert elevations and to support bottom of pipe or conduit on undisturbed soil. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
3. Where rock is encountered, carry excavation 6 inches below required elevation and backfill with a 6-inch layer of crushed stone or gravel prior to installation of pipe.
4. For pipes or conduit less than 6 inches in nominal size, and for flat-bottomed, multiple-duct conduit units, do not excavate beyond indicated depths. Hand-excavate bottom cut to accurate elevations and support pipe or conduit on undisturbed soil.
5. For pipes and equipment 6 inches or larger in nominal size, shape bottom of trench to fit bottom of pipe for 90 degrees (bottom 1/4 of the circumference). Fill depressions with tamped sand backfill. At each pipe joint, dig bell holes to relieve pipe bell of loads ensure continuous bearing of pipe barrel on bearing surface.

L BACKFILL AND FILL



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1. General: Place satisfactory soil material in layers to required subgrade elevations, for each area classification listed below, using materials specified herein.
2. Under building slabs, Provide satisfactory soils over an acceptable subbase material and provide a granular base immediately under slabs.
3. Under piping and conduit and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation. Shape excavation bottom to fit bottom 90 degrees of cylinder.
4. Backfill trenches with concrete where trench excavations pass within 18 inches of column or wall footings and that are carried below bottom of such footings or that pass under wall footings. Place concrete to level of bottom of adjacent footing.
5. Backfill trenches for utility and piping as required for the area adjacent to the trench.
6. Do not backfill trenches until tests and inspections have been made and accepted. Use care in backfilling to avoid damage or displacement of pipe systems.
7. Backfill excavations as promptly as work permits, but not until completion of the following:
  - a. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
  - b. Inspection, testing, approval, and recording locations of underground utilities have been performed and recorded.
  - c. Removal of concrete formwork.
  - d. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.
  - e. Removal of trash and debris from excavation.
  - f. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

M PLACEMENT AND COMPACTION

1. Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to

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placement of fills. Plow strip, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with existing surface.

2. Proof roll all existing soil areas under pavements, buildings and other structural site improvements with a 20,000 pound pneumatic tired roller or loaded dump truck. Areas which can be successfully proof rolled without excessive rutting or "pumping" are acceptable. Where proof rolling cannot be successfully accomplished, scarify and compact to stable condition. If stable condition cannot be achieved, notify Engineer.
3. 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.
4. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
5. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.
6. Control soil and fill compaction, providing minimum percentage of density specified for each area classification indicated below. Correct improperly compacted areas or lifts as directed by Engineer if soil density tests indicate inadequate compaction.
  - a. Under pavements, and exterior slabs, compact the upper portion of the natural subgrade soils and fill material to not less than 95 % of maximum Standard Proctor dry density (ASTM D-698). Compact select fill layer to not less than 95% of maximum modified Proctor dry density (ASTM D-1557).
  - b. Under structures and building areas, compact upper 8" of natural subgrade soils; fill and backfill materials (each layer) to 98 percent of maximum modified Proctor dry density (ASTM D-1557).
7. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer of soil material. Apply water in minimum quantity as necessary to prevent free water from appearing on surface during or subsequent to compaction operations.

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8. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

N GRADING

1. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated or between such points and existing grades.
2. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding.
3. Surface of fill under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grade within a tolerance of 1/2 inch when tested with a 10-foot straightedge.
4. Any excavation or grading under a building, structure or piping shall be backfilled with ODOT type A aggregate base rock and compacted to 98% standard proctor unless required contractually otherwise and is more stringent required. Rock backfill shall be extend at least two feet beyond structure “drip line” minimum.

O BUILDING SLAB BASE

1. General: Building slab base consists of placement of vapor barrier and granular base in layers of indicated thickness, over subgrade surface to support concrete building slabs.
2. Placing: Place granular base material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Compaction shall be by powered or hand tampers to 98% maximum density and then install vapor barrier.

P FIELD QUALITY CONTROL

1. Quality Control Testing During Construction: Allow testing service to inspect and approve each subgrade and fill layer before further backfill or construction work is performed.
2. If, in opinion of Engineer, based on testing service reports and inspection, subgrade or fills that have been placed are below specified density, additional compaction and testing shall be performed at the Contractor's expense until specified density is obtained.

Q EROSION CONTROL AND STORM WATER CONTROL

Provide erosion control and storm water runoff control methods in accordance with requirements of local and state authorities having jurisdiction.

R MAINTENANCE

1. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.
2. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.
3. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.
4. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn, or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

S DISPOSAL OF EXCESS AND WASTE MATERIALS

Remove trash, debris, and waste materials and dispose of it off Owner's property.

END OF SECTION

A. GENERAL

This work shall cover the composition, mixing, construction upon the prepared subgrade, and the protection of hot asphalt concrete pavement. The hot asphalt concrete pavement shall consist of an aggregate or asphalt base course and asphalt surface course constructed in conformity with the lines, grades, thickness, and cross sections as shown. Each course shall be constructed to the depth, section, or elevation required by the drawings and shall be rolled, finished, and approved before the placement of the next course.

1. Inspection of plant and equipment

The Engineer shall have access at all times to all parts of the material producing plants for checking the mixing operations and materials and the adequacy of the equipment in use.

2. Alignment and grade control

The contractor's land surveyor shall establish and control the pavement (aggregate or asphalt base course and asphalt surface course) alignments, grades, elevations, and cross sections as shown on the drawings.

3. Submittals

a. Data and Test Reports:

1. Aggregate Base Course: Sources, gradation, liquid limit, plasticity index, percentage of wear, and other tests required by State Highway Department.
2. Asphalt Base/Surface Course: Aggregate source, gradation, soundness loss, percentage of wear, and other tests required by State Highway Department.
3. Job-mix formula.

b. Certifications:

1. Asphalt prime and tack coat material certificate of conformance to State Highway Department requirements.
2. Asphalt cement certificate of conformance to Oklahoma State Highway Department requirements.

3. Job-mix certification - Submit plant mix certification that mix equals or exceeds the State Highway Specification.
- c. One copy of State Highway Department Specifications.
- d. Provide MSDS (Material Safety Data Sheets) for all chemicals used on ground.

**B. PRODUCTS**

1. Aggregate base and asphalt concrete materials shall conform to the requirements of the following and other appropriate sections of the latest version of the state highway material specifications, including amendments, addenda and errata. Where the term "engineer" is referenced in the state highway specifications, it shall mean the project engineer.
2. Aggregates
  - a. Provide aggregates consisting of crushed stone, gravel, sand, or other sound, durable mineral materials processed and blended, and naturally combined.
  - b. Subbase aggregate (where required) maximum size: (1-1/2").
  - c. Base aggregate maximum size:
    1. Base course over (6") thick: (1-1/2");
    2. Other base courses: (3/4").
  - d. Asphaltic base course:
    1. Maximum particle size not to exceed (1").
    2. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.
  - e. Aggregates for asphaltic concrete paving: Provide a mixture of sand, mineral aggregate, and liquid asphalt mixed in such proportions that the percentage by weight will be within:

<u>Sieve Sizes</u>	<u>Percentage Passing</u>
(3/4")	100
(3/8")	67 to 85
(1/4")	50 to 65
(No. 8 mesh)	37 to 50
(No. 30 mesh)	15 to 25
(No. 200 mesh)	3 to 8

plus 50/60 penetration liquid asphalt at 5 percent to 6-1/2 percent of the combined dry aggregates.

3. Asphalts

a. Comply with provisions of Asphalt Institute Specification SS2:

1. Asphalt cement: Penetration grade 50/60
2. Prime coat: Cut-back type, grade MC-250
3. Tack coat: Uniformly emulsified, grade SS-1H

4. Sealer

- a. Provide a sealer consisting of suitable fibrated chemical type asphalt base binders and fillers having a container consistency suitable for troweling after thorough stirring, and containing no clay or other deleterious substance.
- b. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.

C. EXECUTION

The Asphalt Concrete Paving equipment, weather limitations, job-mix formula, mixing, construction methods, compaction, finishing, tolerance, and protection shall conform to the requirements of the appropriate sections of the State Highway Specifications for the type of material specified.

1. Mixing Asphaltic Concrete Materials

- a. Provide hot plant-mixed asphaltic concrete paving materials.
  1. Temperature leaving the plant: 143 degrees C(290 degrees F) minimum, 160 degrees C(320 degrees F) maximum.

2. Temperature at time of placing: 138 degrees C(280 degrees F) minimum.

2. Subgrade

- a. Shape to line and grade and compact with self-propelled rollers.
- b. All depressions that develop under rolling shall be filled with acceptable material and the area re-rolled.
- c. Soft areas shall be removed and filled with acceptable materials and the area re-rolled.
- d. Should the subgrade become rutted or displaced prior to the placing of the subbase, it shall be reworked to bring to line and grade.
- e. Proof-roll the subgrade with maximum (50 ton) gross weight dump truck as directed by Engineer. If pumping, pushing, or other movement is observed, rework the area to provide a stable and compacted subgrade.

3. Base Courses

- a. Subbase (when required)
  1. Spread and compact to the thickness shown on the drawings.
  2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.
  3. After completion of the subbase rolling there shall be no hauling over the subbase other than the delivery of material for the top course.
- b. Base
  1. Spread and compact to the thickness shown on the drawings.
  2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.
  3. After completion of the base rolling there shall be no hauling over the base other than the delivery of material for the top course.
- c. Thickness tolerance: Provide the compacted thicknesses shown on the Drawings within a tolerance of minus (0.0") to plus (0.5").



- d. Smoothness tolerance: Provide the lines and grades shown on the Drawings within a tolerance of (3/16 inch in ten feet).
  - e. Moisture content: Use only the amount of moisture needed to achieve the specified compaction.
4. Placement Of Asphaltic Concrete Paving
- a. Remove all loose materials from the compacted base.
  - b. Apply the specified prime coat, and tack coat where required, and allow to dry in accordance with the manufacturer's recommendations as approved by the Engineer.
  - c. Receipt of asphaltic concrete materials:
    - 1. Do not accept material unless it is covered with a tarpaulin until unloaded, and unless the material has a temperature of not less than 130 degrees C(280 degrees F).
    - 2. Do not commence placement of asphaltic concrete materials when the atmospheric temperature is below 10 degrees C (50 degrees F), not during fog, rain, or other unsuitable conditions.
  - d. Spreading:
    - 1. Spread material in a manner that requires the least handling.
    - 2. Where thickness of finished paving will be (3") or less, spread in one layer.
  - e. Rolling:
    - 1. After the material has been spread to the proper depth, roll until the surface is hard, smooth, unyielding, and true to the thickness and elevations shown on the drawings.
    - 2. Roll in at least two directions until no roller marks are visible.
    - 3. Finished paving smoothness tolerance:
      - a. No depressions which will retain standing water.
      - b. No deviation greater than (1/8" in six feet).

5. Application Of Seal Coat

- a. Prepare the surfaces, mix the seal coat material, and apply in accordance with the manufacturer's recommendations as approved by the Engineer.
- b. Apply one coat of the specified sealer.
- c. Achieve a finished surface seal which, when dry and thoroughly set, is smooth, tough, resilient, of uniform black color, and free from coarse textured areas, lap marks, ridges, and other surface irregularities.

6. Protection

Protect the asphaltic concrete paved areas from traffic until the sealer is set and cured and does not pick up under foot or wheeled traffic.

7. Testing

The Owner shall engage an independent testing laboratory to conduct onsite tests. Contractor will be responsible for assisting in sampling for test at the field directed by the Owners Representative. The Contractor shall be responsible for the costs of work performed by the laboratory required for any retesting or rework resulting in materials placed determined to be unacceptable by the Owner. Additional requirements are defined by City standards as applicable.

At least one test shall be made per placement day (or fraction thereof) placed on any one day and in any event, not less than one test for each type of material utilized that day. One test per 50 tons of materials placed. Additional tests beyond requirements may be pulled at the sole discretion of the Owners Representative,

8. Final Clean-Up

Remove all debris, rubbish, and excess material from the work area.

END OF SECTION

## PART 1 - GENERAL

### 1.1 STANDARDS

- A. Concrete work shall conform to all requirements of ACI 301-89 "Specifications for Structural Concrete for Buildings", ACI 350 "Code Requirements for Environmental Engineering Concrete Structures", ACI 318-89 "Building Code Requirements for Reinforced Concrete" except as modified herein.
- B. All referenced standards shall be the latest editions.

### 1.2 SCOPE

- A. Work consists of furnishing all plant, labor, materials, equipment and appliances, and performing all operations in connection with installation of the concrete work, complete, in strict accordance with the Specifications and Drawings.

### 1.3 INSPECTION

- A. Embedded items must be inspected and tests for concrete and other materials shall have been completed and approved by the Engineer before concrete is placed.

### 1.4 SLAB ON EARTH

- A. Before proceeding to construct concrete slabs on earth, all pipes under concrete floor on earth shall have received the required tests. All backfill and fill material under slabs on grade shall be compacted in 6" layers to 95% maximum density as measured by AASHTO T99 test method. Unsuitable material encountered in subgrade shall be removed and replaced with material approved by the Engineer. Subgrade shall be brought to true, even plane and compacted to solid bearing. Gravel drainage fill shall be placed and compacted where shown on Drawings.

## PART 2 - MATERIALS

2.1 All concrete materials shall conform to the latest revised ASTM Designations listed below and shall be subject to the approval of the Engineer:

- A. Coarse Aggregate shall be crushed stone conforming to ASTM C-33 with a maximum size of 1".
- B. Fine Aggregate shall conform to ASTM C-33 and shall be washed river sand composed of clean, uncoated grains of strong materials.
- C. Cement shall be Portland cement conforming to ASTM Specification C-150, Type V. Only one brand of cement shall be used for exposed concrete.

- D. Water: Clean, fresh and free from oil, acids, alkali, vegetable, sewage, organic or other deleterious matter.
- E. Air-Entraining Admixtures shall conform to ASTM C-260.
- G. Premolded Expansion Joint Filler Strips shall be non-extruding type conforming to the current AASHTO Designation M213.
- H. Non-Shrink Grout shall be Pre-mixed "Embeco" as manufactured by Master Builder's, "Ferrolith G" as manufactured by Sonneborn-Contech, or approved equal. Type as recommended by the manufacturer for the particular applications.
- I. Liquid Curing Compound/Sealer shall be "MC 429" as manufactured by Master Builder's, "Kure-N-Seal" as manufactured by Sonneborn-Contech, "Thompson's Water Seal" as manufactured by E. A. Thompson, Inc. or approved equal.
- J. Granular Drainage Fill: Required under all interior building concrete slabs on grade and where noted on the drawings. It shall be either:
  - 1. Clean, washed gravel with particle sizes grading from maximum of 1" down to not more than 5% passing a No. 4 sieve.
  - 2. Clean, washed coarse sand with particular sizes ranging from pea gravel down to largest grains permitted in concrete sand.
- K. Joint Waterproofing for existing structures or as required on the plans shall be Ironite (Metallic) Waterproofing as manufactured by the Ironite Company of Chicago, Illinois or approved equal.
- L. Vapor Barrier required under all interior concrete slabs on grade and where noted in drawings shall be polyethylene sheet, 6 mil thickness conforming to ASTM E-154.
- M. Liquid Chemical Hardener shall be the magnesium fluosilicate and zinc fluosilicate type "Lapidolith" as manufactured by Sonneborn-Contech, Inc., "Symons Quad Cure" as manufactured by Symons Corp., "Hornolith" as manufactured by W. R. Grace & Co., or approved equal.
- N. Cementitious Waterproofing and Finish Compound shall be "ThoroSeal Plaster Mix" with "Acryl 60" as manufactured by Standard Dry Wall Products or equal.

## 2.2 QUALITY AND CONTROL

### A. Design

Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate and water. All concrete shall be designed by an independent testing laboratory, approved by the Engineer, in accordance with the A.C.I. Standard "Recommended Practice for Selecting Proportions for Concrete" (ACI 211) to produce the strength for each class of concrete specified, and with slumps and maximum sizes of coarse aggregate in accordance with the requirements outlined below. The concrete shall be so designed that the concrete materials will not segregate and excessive bleeding will not occur. Submit laboratory trial mix designs and test results for each class of concrete to be used to the Engineer for approval before any concrete is placed. Any costs of the testing laboratory for designing concrete mixes shall be borne by the Contractor. Concrete strengths shall be as follows:

Class A Concrete - 4000 psi minimum @ 28 days (Air entrained) - six (6) sacks cement minimum

Class B Concrete - 3000 psi @ 28 days - five (5) sacks cement minimum

Class C Concrete - 2000 psi @ 28 days

Class D Concrete - 3000 psi @ 28 days (3/8" Max. Aggregate Size "Pea Gravel")

### MAXIMUM SLUMPS FOR VARIOUS TYPES OF CONSTRUCTION

<u>Types of Construction</u>	<u>Hand Placed Maximum</u>	<u>High Frequency Vibrator Used - Maximum</u>
Reinforced Foundation, Footings and Base Slabs of Tanks	5"	3"
Slabs, Beams and Reinforced Walls	6"	5"
Building Columns	6"	5"
Pavements, curb and sidewalks	3"	3"

The slump shall not exceed the maximum specified above for the type of construction for which it is to be used. The 28 day compressive strength determined in accordance with current ASTM Specifications C-39 and C-31 and with specimens cured in accordance with C-31 shall not be less than that shown above for the specified class of concrete. No water will be added after the amount specified by the mix design.

B. Production of Concrete

All ready-mix concrete shall be batched, mixed and transported in accordance with "Specifications for Ready-Mixed Concrete (ASTM C-94)". Plant equipment and facilities shall conform to the "Check List for Certification of Ready-Mixed Concrete Production Facilities" of the National Ready-Mixed Concrete Association. Site mixed concrete shall conform to the requirements of "Specifications for Structural Concrete" (ACI 301). The Contractor may elect to use either ready-mixed or site mixed concrete for this project provided he informs the Engineer of his choice.

C. Laboratory Testing

The Owner shall engage an independent testing laboratory to conduct concrete tests. Contractor will be responsible for sampling concrete for test cylinders, recording, and delivering them to the laboratory, providing all materials required, and for making all slump tests in the field directed by the Engineer. All costs in connection with work performed by the laboratory will be paid by the Owner. The Contractor shall be responsible for the costs of work performed by the laboratory required for redesign of concrete proportions and additional testing of in place concrete when cylinders indicate low strength concrete has occurred.

At least one test shall be made on fresh concrete for each one hundred (100) cu. yds. of each class of concrete (or fraction thereof) placed on any one day and in any event, not less than one test for each class of concrete each day it is used. Testing shall be done in accordance with the following ASTM Specifications, latest edition:

C172- Standard Method of Sampling Fresh Concrete

C31 - Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field

C39 - Standard Method of Test of Compressive Strength of Molded Concrete Cylinders

C143- Standard Method of Slump Test for Consistency of Portland Cement Concrete

Before any concrete is poured, the Contractor shall construct a storage box in accordance with ASTM Specification C31. Each set of tests shall consist of one slump test and four compression test cylinders. All cylinders shall be kept in the storage box for the first 24 hours. The four cylinders shall be laboratory cured and tested for adequacy of the design for strength of the concrete in accordance with ASTM Specification C31. One cylinder shall be tested at 7 days and two at 28 days.

The fourth cylinder will be retained for subsequent testing if required by the Engineer.

- D. **Failure of Concrete to Meet Strength Requirements:** The concrete shall be considered acceptable if, for any one class of concrete, the average of all tests of any five consecutive sets is equal to or greater than the specified strength, provided that no more than one test in ten falls between 90% and 100% of the specified strength. The only cylinders to be used for determination of concrete acceptability will be those laboratory cured and tested at 28 days. When it appears the tests of laboratory-cured cylinders will fail to meet these requirements, the Engineer may require changes in the proportions of concrete for the remainder of the work in order to meet the strength requirements. In addition, the Engineer may also require additional curing on portions of the concrete already poured.

The Engineer may also require tests in accordance with Methods of Securing, Preparing and Testing Specimen from Hardened Concrete for Compressive and Flexural Strengths (ASTM Specifications C42) when the concrete cylinder tests fail to meet strength requirements. In the event there still is question as to the quality of the concrete in the structure, the Engineer may require load tests for that portion where the questionable concrete has been placed. Such load tests will be made as outlined in American Concrete Institute Building Code, (ACI 318), and shall be at the expense of the Contractor. In-place testing shall be at the expense of the Contractor.

- E. **Removal of Under Strength Concrete:** If the above tests indicate that a particular batch of previously placed concrete is under strength, the Engineer may direct that the under strength batch be removed and replaced. The removal of the under strength concrete shall also include the removal of concrete that has obtained the required strength if the Engineer deems this necessary to obtain structural or visible continuity when the concrete is replaced.

The removal, and replacement of any under strength concrete, shall be made at no additional cost to the Owner. This shall include any new formwork required or any reinforcing steel that may be required. The Owner shall not be charged any additional costs for any extra work that is required because of the failure of any concrete to meet the minimum test requirements.

- F. Concrete Strengths: The various strengths of concrete shall be installed as follows:
1. Class A, 4000 psi, Air-Entrained shall be used for all liquid containing and non-liquid containing structures, (footings, driveways, slabs, walls, columns and roofs.)
  2. Class B, 3000 psi shall be used for sidewalks, curbs and thrust blocking.
  3. Class C, 2000 psi shall be used for all non-structural fill concrete, mud slabs, over excavation concrete and other selective backfill conditions as approved by the Engineer.
  4. Class D, 3000 psi pea gravel concrete (maximum aggregate size of 3/8") shall be used for all masonry fill, masonry columns cells, and masonry bond beams.

## PART 3 - INSTALLATION

### 3.1 PREPARATION BEFORE PLACING

- A. Water shall be removed from excavations before concrete is deposited. Hardened concrete, wood chips, shavings, and other debris shall be removed from interior of forms and inner surfaces of mixing and conveying equipment. Wood forms shall be oiled or, except in freezing weather, wetted with water in advance of pouring. Reinforcement shall be secured in position, inspected and approved by the Engineer before starting pouring of concrete.

### 3.2 CONVEYING

- A. Concrete shall be conveyed from mixer to forms as rapidly as practicable and by methods, which will prevent segregation or loss of ingredients. It shall be deposited as nearly as practicable in its final position. Chutes used shall be such that concrete slides in them and does not flow. Chutes, if permitted, shall have a slope of less than 1 on 2. Where a vertical drop greater than five (5) feet is necessary, placement shall be through elephant trunks or similar devices to prevent segregation. Ready-mixed concrete shall be delivered with a load ticket showing mix proportions and the time mixing began for each load. The load ticket shall be furnished to the Engineer.

### 3.3 PLACING

- A. Concrete shall be placed before initial set has occurred and in no event after it has contained its water content for more than 30 minutes for site mixed concrete or 1 hour for ready-mixed concrete. Unless otherwise specified, all concrete shall be placed upon clean, damp surfaces free from running water, or upon properly



consolidated fills, but never upon soft mud or dry, porous earth. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section.

- B. If a section cannot be placed continuously, provide construction joints as herein specified. The concrete shall be compacted and worked in an approved manner into all corners and angles of the forms and around reinforcement and embedded fixtures as to prevent segregation of the coarse aggregate. Construction of forms for the lifts of vertical walls shall be such as to make all parts of the walls easily accessible for the placement, spading, and consolidation of the concrete as specified herein.
- C. No “finished water” shall be surface applied during finishing efforts.
- D. Curing methods shall be submitted to the Engineer and applied per manufacturer’s recommendations.

### 3.4 VIBRATION

- A. All concrete shall be placed with the aid of mechanical vibration equipment as approved by the Engineer. Vibration shall be transmitted directly to the concrete; in no case shall it be transmitted through forms. The duration of vibration at any location in the forms shall be held to the minimum necessary to produce thorough compaction. Vibrations shall be supplemented by forking or spading by hand, and adjacent to the forms on exposed faces in order to secure smooth, dense and even surfaces, with particular care being taken to prevent coarse aggregate from becoming set too near any surfaces that are to receive rubbed finish.

### 3.5 CONSTRUCTION JOINTS

- A. Construction joints shall be formed as indicated on the drawings or as approved or directed by the Engineer. Contractor shall submit a joint location plan for each structure to the Engineer for approval 28 days prior to commencing concrete operations on that structure. Where indicated or required, dowel rods shall be used. All concrete at the joints shall have been in place not less than 12 hours, and longer if so directed by the Engineer, before concrete resting thereon is placed. Before placing is resumed, or commenced, excess water and laitance shall be removed, and concrete shall be cut away, where necessary, to insure a strong dense concrete at the joint. In order to secure adequate bond, the surface of concrete already in place shall be cleaned, roughened, and then spread with a one-half (1/2) inch layer of mortar of the same cement-sand ratio as is used in the concrete, immediately before the new concrete is deposited. The unit of operation is not to exceed 40 feet in any horizontal direction, unless otherwise required by the Drawings. Construction joints, if required, shall be located near the mid-point spans for slabs, beams or girders. Joints in columns or piers shall be made at the

underside of the deepest beam or girder at least five (5) hours before any overhead work is placed thereon. Joints not shown or specified shall be so located as to least impair strength and appearance of work. Vertical joints in wall footings shall be reduced to a minimum. Placement of concrete shall be at such a rate that surfaces of concrete not carried to joint levels will not have attained initial set before additional concrete is placed thereon.

- B. Girders, beams and slabs shall be placed in one operation. To insure a level straight joint in exposed vertical surfaces, a strip of dressed lumber may be tacked to the inside of the forms at the construction joint. The concrete shall be poured to a point one (1) inch above the underside of the strip. The strip shall be removed one (1) hour after concrete has been placed and any irregularities in the joint line leveled off with a wood float and all laitance removed. Waterstops shall be installed in all construction joints below grade or in liquid containing structures as noted on the Plans. Install as per SECTION 3.3, CONSTRUCTION JOINTS, EXPANSION JOINTS, & WATERSTOPS.

### 3.6 PATCHING

- A. Any concrete which is not formed as shown on the Plans, or for any reason is out of alignment or level or shows a defective surface shall be considered as not conforming with the intent of these Specifications and shall be removed from job by Contractor at his expense, unless the Engineer grants permission to patch defective area, which shall be done in accordance with the following procedure. Permission to patch any such area shall not be considered a waiver of the Engineer's right to require complete removal of defective work if patching does not, in his opinion, satisfactorily restore quality and appearance of surface. Suitable non-shrink, latex or epoxy mortar shall be used for patching and repairing defective surface if permitted by the Engineer.
- B. After removing forms, all concrete surfaces shall be inspected and any poor joints, voids, stone pockets, all tie holes, or other defective areas shall be patched, if permitted by the Engineer. Where necessary, defective areas shall be chipped away to a depth of not less than one (1) inch with edges perpendicular to the surface. Area to be patched and a space at least six (6) inches wide entirely surrounding it shall be wetted to prevent absorption of water from the patching mortar. A grout of equal parts Portland cement and sand, with sufficient water to produce a brushing consistency, shall then be well brushed into the surface followed immediately by the patching mortar. The patch shall be made of the same material and of approximately the same proportions and shall not be richer than 1 part cement to 3 parts sand. White Portland cement shall be substituted for a part of the gray Portland cement to match color of the surrounding concrete. The proportion of white and gray cements shall be determined by making a trial patch. The amount of mixing water shall be as little as consistent with the requirements of handling and placing. The mortar shall be retempered without the addition of water by allowing it to stand for a period of one (1) hour during

which time it shall be mixed occasionally with a trowel to prevent setting.

- C. The mortar shall be thoroughly compacted into place and screened off so as to leave patch slightly higher than surrounding surface. It shall then be left undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished. The patch shall be finished in such a manner as to match the adjoining surface. On surfaces where unlined forms have been used, the final finish shall be obtained by striking off the surface with a straightedge spanning the patch and held parallel to the direction of the form marks.
- D. Tie holes left by withdrawal of rods or the holes left by removal of ends of ties shall be filled solid with non-shrink grout after first being thoroughly wetted within 7 days of placement and prior to any area backfill.

### 3.7 SLAB FINISHES

- A. Exterior Concrete Walks:

After thoroughly consolidating the concrete the top surface shall be struck off with a straight edge and tamped or vibrated sufficiently to bring mortar to the surface. Finish with a wood float to a smooth, even surface and lightly broomed to provide "slip resistant" surface. Edges shall be rounded with a 1/4" radius.

- B. Interior slabs to receive grout fill or mortar setting bed shall be finished by tamping concrete with special tools to force coarse aggregate below the surface, and screened with straightedges to bring surface to finish plane with a tolerance not exceeding 1/8" in 2 feet. Surface shall be left roughened sufficiently to produce good bond with topping material. Use stiff brushes, brooms or rakes as necessary to provide 1/8 inch deep grooves at maximum of 1/2 inch on center.
- C. Top and bottom slabs of all structures and water carrying conduits except as noted otherwise on the Plans shall be finished as follows: The top of the slab shall be screened to grade and cross section; lightly tamped as required to bring up a good bed of mortar for finishing and re-screened as necessary. The surface shall then be finished with a wood float and leveling darby. No further finish will be required on top slabs of structures or conduits, which are to be buried. In the case of all exposed top slabs of structures and conduits, they shall be given a final wood float and a lightly broomed, slip resistant finish to a uniform surface, which conforms with accuracy to required shape, slope and grade. Slabs shall be edged as appropriate. No liquid hardener is to be applied to these surfaces.
- D. Interior floor slabs that are not to receive any finish floor covering shall be "slip resistant finish" as follows: The top surface shall be steel troweled and have a final finish applied by brushing lightly with a soft bristle brush to form a slightly roughened surface.

- E. Liquid Hardener shall be applied to the floors where scheduled to be exposed concrete. Concrete surfaces to be treated must be thoroughly set and dry, clean and free of dust. Three applications of the liquid hardener are required, using one gallon per 100 square feet for the complete treatment. Apply hardener strictly according to the manufacturer's printed instructions. Liquid floor hardener is not required when a minimum of two (2) coats of Thompson's Waterseal or equal has been used as a curing and/or separating compound. Submit material and method to be used for Engineer's approval.

### 3.8 FINISH OTHER THAN SLABS

- A. All top surfaces, other than slabs, not covered by forms, and which are not to be covered by additional concrete or fill shall receive a wood float finish without additional mortar. Care shall be taken that no excess water is present when the finish is made. Other surfaces shall be brought to finished elevations and left true and regular. All exposed top surface interior concrete shall be grouted smooth and given a cement wash of one part light colored Portland cement and two parts fine aggregate mixed with water to consistency of thick paint. Grout shall be cork or wood floated to fill all pits, air bubbles, and surface holes. Excess grout shall be scraped off with a trowel and rubbed with burlap to remove any visible grout film. Surface shall be kept damp during setting period. The finish for any area shall be completed in the same day and the limits of a finished area shall be made at natural breaks in finished surface. Painting of exposed-to-view concrete surfaces is specified under SECTION 9.1 - PAINTING of these Specifications.

- B. Rubbed Finish:

Unless otherwise indicated, all faces (except top surfaces of slabs) exposed to view, such as walls, grade beams, columns, beams, walls of water carrying conduits to a point 1'-0" below normal water level, canopy soffits and fascias, etc. shall be finished as follows:

Forms shall be removed, as specified in SECTION - CONCRETE FORMWORK, and all fins removed, off-sets leveled, damaged places and depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in the proportion which has been employed for the particular class of concrete treated. The surface film of all such pointed places shall be carefully removed before setting occurs. After the point has set sufficiently to permit it, all exposed surfaces shall be dampened and rubbed with a No. 16 Carborundum stone, to a smooth even plane. Final rubbing shall be done with a No. 30 Carborundum stone, or an abrasive of equal quality, to obtain an entire surface of a smooth texture and uniformity in color. Mortar or grout worked up during rubbing shall be promptly removed by sacking with burlap or other suitable means so that no visible grout film or paste will remain. A cement wash or plaster coat shall not be used. All surfaces shall be finished uniformly smooth and washed clean. The rubbed finish for any area shall be completed in

the same day and the limits of a finished area shall be made at natural breaks in the finished surface. If the Contractor does not provide suitable surface finish using Carborundum stones specified above, the Engineer, without additional cost to the Owner, may require the use of a power operated grinding machine or other methods to produce the desired finish.

C. Cementitious Waterproofing and Finish:

As an option to the rubbed finish, as specified herein, all faces (except top surfaces of slab) exposed to view, such as walls, grade beams, columns, beams, canopy soffits and facias, etc., shall be finished using "Thoroseal" coating or approved equal as described in the following paragraphs.

1. General

Forms shall be removed, as specified in SECTION 3.4 - CONCRETE FORMWORK, and all fins removed, off-sets leveled, damaged places and depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in proportion which has been employed for the particular class of concrete treated. The surface film of all such pointed places shall be carefully removed before setting occurs. After the point has set sufficiently to permit it, all exposed surfaces shall receive the following treatment.

2. Mixing

Thoroseal plaster mix shall be prepared using a solution composed of not less than one part Acryl 60 (approximately two quarts Acryl 60 per bag) and three parts of clean, potable water (for ceilings, use 1 part Acryl 60 to 2-1/2 parts of the water). This solution shall then be added to the Thoroseal plaster mix slowly in sufficient quantity so that the mixture is the consistency of a heavy batter suitable for application by method specified. Color to be selected by the Owner.

3. Application

At Contractor's option, one of the following methods of application shall be selected:

- a. Sprayed-on finish should be applied with plaster-type spray gun, not high pressure paint type. Spray on evenly distributed coat of Thoroseal plaster mix. To spot-fill deep holes, float or brush first coat before starting second spray application.

Thoroseal plaster mix shall be applied on average surfaces in two coats at the rate of 5 to 6 lbs. per square yard for concrete walls, 6

to 9 lbs. per square yard for masonry walls; but sufficient material shall be applied to fill all holes and voids.

- b. Trowel and float finish - Apply light trowel coat of Thoroseal plaster mix over entire surface to be treated. The workman shall make sure the material is firmly pressed into all voids and leveled. Allow this coat to cure thoroughly before applying the regular trowel application. When surface is set so it will not roll or lift, float uniformly using a sponge float.

Thoroseal plaster mix shall be applied on average surfaces at the rate of 4 to 6 lbs. per square yard for concrete walls, 6 to 9 lbs. for masonry walls. If concrete is rough or untrue, 6 to 9 lbs. per square yard may be required, but sufficient material shall be applied to fill and seal all pores and voids. This application will be approximately 1/8" thick. Leveling uneven surfaces will require more material per square yard.

To prevent shadowing of struck or deep masonry joints, or areas of unequal absorption (like some form marks), after key coat has cured for 5 days, apply a light trowel coat of Thoroseal plaster mix with Acryl 60 in the mixing water over the entire surface to be treated. Allow this coat to set thoroughly before applying the regular trowel application as outlined above.

Do not apply when temperatures are 40°F or due to fall below 40°F within 24 hours or to frozen or frost-filled surfaces.

### 3.9 CURING

- A. General - Immediately following placing, all Class A and Class B concrete shall be protected from premature drying, hot and cold temperatures, rain, flowing water and mechanical injury. Maintain above 50°F and in moist condition for at least seven (7) days after placing for normal concrete and three (3) days for high early strength concrete. Comply with "Recommended Practice for Curing Concrete" ACI 308, unless otherwise indicated. Curing compound of satisfactory composition and characteristics may be used except on surfaces to which new concrete is to be bonded or surfaces scheduled to be painted or to receive other coating and provided such compound does not stain or discolor any surface which will be exposed. Cure formed concrete surfaces, including undersides of beams, supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.

B. Cold Weather Procedures - Protect concrete work from physical damage or reduced strength, which could be caused by frost, freezing actions, or low temperatures, in compliance with ACI 306, "Cold Weather Concreting", and as herein specified.

1. When air temperature has fallen to or is expected to fall below 40°F, uniformly heat water and aggregates before mixing as required to obtain a concrete mixture temperature of not less than 55°F, and not more than 80°F at point of placement.
2. Do not use frozen materials or materials containing ice, frost or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt and other materials containing antifreeze agents or chemical accelerators, unless otherwise accepted in mix designs.
4. Contractor shall obtain and keep on the Project site a copy of the current edition of ACI 306, "Recommended Practice for Cold Weather Concreting", for reference during all concrete operations in cold weather.

C. Hot Weather Procedures:

When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305, "Hot Weather Concreting", and as herein specified.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90°F. Mixing water may be chilled, or chopped ice may be used to control the concrete temperature provided the water equivalent of the ice is calculated to the total amount of mixing.
2. 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.
3. Wet forms thoroughly before placing concrete.
4. Do not use retarding admixtures unless otherwise accepted in mix designs.
5. Contractor shall obtain and keep on the project site a copy of ACI 305R, "Hot Weather Concreting" for reference during all concreting operations in hot weather.

D. Protection from the Sun:

All concrete shall be adequately protected from injurious action of sun in a manner satisfactory to the Engineer.

E. Temperature Control:

During and at the conclusion of the specified curing period, means shall be provided to ensure that the temperature of the air immediately adjacent to the concrete does not fall more than 3°F in any 1 hour nor more than 30°F in any 24 hours.

3.10 NON-SHRINKING GROUT

- A. Where non-shrinking grout is called for on the Plan, it shall be mixed in strict accordance with the manufacturer's directions. It shall be of a type as recommended by the manufacturer for the particular application.

END OF SECTION



## PART 1 – GENERAL

### 1.1 SCOPE

- A. The extent of concrete reinforcement is shown on the drawings and in schedules.
- B. The work includes fabrication and placement of reinforcement for cast-in-place concrete, including bars, welded wire fabric, ties and supports.

### 1.2 QUALITY ASSURANCE

- A. Codes and Standards:

Comply with requirements of the latest edition of the following codes and standards, except as herein modified:

American Welding Society (AWS), AWS D1.4 "Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction".

Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice". (Current Ed.)

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

American Concrete Institute (ACI), ACI 350 "Code Requirements for Environmental Engineering Concrete Structures"

- B. Submittals:

Mill Certificates; Concrete Reinforcement: Submit steel producer's certificates of mill analysis, tensile and bend tests for reinforcing steel.

Shop Drawings: Reinforcing number, sizes, spacing dimensions, configurations, locations, mark numbers, lap splice lengths, concrete cover and reinforcing supports. Sufficient reinforcing details to permit installation of reinforcing without reference to contract drawings.

### 1.3 DELIVERY, HANDLING AND STORAGE

- A. Deliver reinforcement to the project 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 materials at the site to prevent damage and accumulation of dirt or excessive rust.

#### 1.4 MATERIALS

- A. Steel reinforcement shall conform to the "Specification for Deformed Billet Steel Bars for Concrete Reinforcement," ASTM A615, Grade 60.
- B. Wire fabric reinforcement shall conform to the current "Specifications for Welded Steel Wire Fabric for Concrete Reinforcement," ASTM A-185, or "Specifications for Welded Deformed Steel Wire Fabric for Concrete Reinforcement," ASTM A-497.
- C. Supports for Reinforcement shall be bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcement in place. Use only wire bar type supports complying with CRSI recommendations, unless otherwise indicated. Do not use wood, brick, and other unacceptable materials.

#### 1.5 SPLICES

- A. No splices of bars, except when shown on the Plans, will be permitted without the approval of the Engineer. Minimum lap splice shall be 48 bar diameters unless specifically detailed or noted otherwise on drawings. Splices in adjacent bars shall be staggered a minimum distance equal to the lap splice length. Bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer. Welding may not be used except with the specific approval of the Engineer. Welding, when approved, shall conform to the AWS D1.4. Welded wire fabric shall be lap spliced a minimum of 2 inches plus the wire spacing at edge laps and end laps.

#### 1.6 DETAILING & FABRICATION

- A. Furnish Shop Detail and Field Placing Drawings for all reinforcing steel for approval of the Engineer. Shop Drawings shall include reinforcing, placing plans and details indicating size, location, arrangement, splice locations, bending diagrams, placing sequence, etc. Placing Drawings shall be in sufficient detail to allow field personnel to accurately place reinforcing. Shop and Placing Drawings shall be prepared in accordance with "Manual of Standard Practice for Detailing Reinforced Concrete Structures" ACI 315, current edition. Photographic copies of engineering drawings shall not be used as placing drawings.
- B. Reinforcement bars shall be bent cold to the shapes indicated on the Plans. Fabrication tolerances, fabrication, and detailing of steel reinforcement shall conform to the "Manual of Standard Practice for Detailing Reinforced Concrete Structures" (ACI-315).
- C. Steel reinforcement shall be of the type and size, cut to lengths and bent to shapes as indicated on the Plans. Unless otherwise indicated, hooks, lap splices, embedment lengths, and other details of reinforcement shall be provided as set

forth in the ACI Building Code (ACI 318) to develop the full tensile strength of the bar.

## 1.7 PLACING REINFORCEMENT

- A. All reinforcement at the time concrete is placed shall be free from mud, oil, paint, excessive rust and excessive mill scale or any other coating that would destroy or reduce its bond with the concrete.
- B. All reinforcement shall be secured in place true to lines and grades indicated by use of metal or concrete supports, spacers, or ties as approved by the Engineer. The bars and mesh shall be tightly secured against displacement by ties of annealed wire, or suitable clips at intersections. Wall reinforcement shall be supported and held securely against displacement in its proper position clear of the forms as indicated on the Plans. Placing tolerance shall conform to ACI 318.
- C. Nails shall not be driven into the wall forms to support reinforcement nor shall any other device used for this purpose come in contact with the form on the liquid side of any liquid containing structure. Metal devices used to provide the required clear distances from reinforcing steel to liquid side of concrete surfaces shall be galvanized, or shall be as approved by the Engineer.
- D. The main reinforcement of slabs in contact with the ground shall be supported in its proper position, as indicated on the Plans, by means of precast cement mortar blocks, of approved dimensions, resting on the slabs' subbase. Such precast blocks shall be made of mortar composed of 1 part cement to 2 parts sand and shall have a loop of No. 16 black annealed wire cast into each block. The length of the wire loop shall be sufficient to allow the block to be tied to the reinforcement. Blocks shall be spaced at the intervals required to maintain the reinforcement in its required position in the slab during the placing of the concrete. The slab reinforcement shall not be used to support planking or runways used in placing concrete.
- E. Bending of bars embedded in hardened concrete will not be permitted except when specifically approved by the Engineer for the field condition encountered. Field cutting of bars will only be permitted when specifically approved by the Engineer.
- F. In the case of exposed finish surfaces of floor slabs, galleries, deck slabs, and beams, metal chairs, spacers and other metal accessories necessary to provide the required clear distances and proper alignment and spacing between bars shall be galvanized or shall have plastic protective covering over portions in contact with forms.

## 1.8 CONCRETE PROTECTION FOR REINFORCEMENT

- A. Steel reinforcement shall be placed and held in position so that the concrete cover, as measured from the surface of the bar shall be the following, except as otherwise shown, on the drawings:
1. Slabs:
    - 1½ inches, in general, top and bottom.
    - 1½ inches at surfaces troweled as floor finish, walkway, or driveway.
    - 2 inches on bottom for slabs over water and where exposed to the weather.
  2. Footings:
    - 2 inches at top of footings.
    - 3 inches at bottom, sides, and end of footings.
  3. Walls:
    - 2 inches on surfaces against earth.
    - 1½ inches on interior surfaces.
    - 2 inches on interior surfaces contacting water.
  4. Beams and Girders in Contact with Water:
    - 2 inch minimum to stirrup steel.
    - 2½ inch minimum to main longitudinal steel.
  5. Columns:
    - 2 inches, in general, to main vertical reinforcement.
    - 2½ inches, to main reinforcement on surfaces in contact with water.
  6. Beams and Girders: General:
    - 1½ inch minimum to stirrup steel.
    - 2 inches minimum to longitudinal steel.

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## 1.9. ADDITIONAL REINFORCEMENT

- A. The Contractor shall provide on the job site additional reinforcement to be used at locations as directed by the Engineer at no additional cost to the Owner. The contract price shall include all labor and material charges for handling, field cutting and bending, bar supports, and placing of said reinforcement. Additional reinforcement shall be ASTM A615, Grade 60 and is beyond reinforcement indicated on the contract drawings. Field bending will be limited to right angle bends and standard 90 degree hooks on No. 3 & No. 4 Bar sizes. Additional steel shall be as follows:

No. 3 bars - 20 pieces 20'-0" long

No. 4 bars - 30 pieces 20'-0" long

No. 5 bars - 30 pieces 20'-0" long

No. 6 bars - 20 pieces 20'-0" long

END OF SECTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Construction joints, expansion joints, and the placing of waterstops where such are indicated on the plans.
- B. Construction joints shall be of the type indicated on the drawings and shall be located as shown on the plans unless otherwise approved by the Engineer. Contractor shall submit a joint location plan as specified in SECTION 3.1 - CAST-IN-PLACE CONCRETE.

1.2 WATERSTOPS

- A. Waterstops shall be installed in construction joints as required by the Plans. All waterstops shall be continuous throughout their length.
- B. The waterstops shall be heavy duty polyvinyl waterstop conforming to Corps of Engineers Specification CRD-C-572, latest edition, as manufactured by Serviced Products Division of W.R. Grace and Company: Vinylstops by Sonneborn-Contech; Sealtight Duo-PVC Waterstops by W. R. Meadows, Inc.; Vinylex Corporation; "labyrinth" waterstop, Type B-2 as manufactured by Water Seals, Inc.; or an approved equal of the same type and material and approximately equal in dimensions and weight but not necessarily of exactly the same shape. Waterstops shall be of the size and type designated on the Plans.
- C. "Rib Type" waterstops shall be of ribbed construction with a center bulb, 5" wide, capable of resisting a maximum pressure load of 65 feet of water.
- D. All waterstops shall be installed so that one-half its width will be embedded on one side of the joint and one-half on the other. The Contractor shall employ a method of holding the waterstop in position for the first pour that is satisfactory to the Engineer. The method selected must insure that the waterstop will be held securely in true vertical or horizontal position and in straight alignment in the joint.
- E. Care shall be exercised to ensure that the waterstop is completely encompassed in good mortar.

F. Preformed Plastic Waterstops:

Preformed Plastic Waterstop, when approved by the Engineer, shall meet or exceed all requirements of Federal Specifications SS-S-00210, "Sealing Compound, Preformed Plastic for Expansion Joints", Type I or Type II. Such plastic waterstop shall be equal to SYNKO-FLEX as manufactured by Synko-Flex Products Company, Houston, Texas, or "CenSeal GS-231" by Concrete Sealants, Inc., New Carlisle, Ohio and shall meet the following requirements:

The plastic waterstop shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler, and shall contain no solvents, irritating fumes or obnoxious odors. The plastic waterstop shall not depend on oxidizing, evaporating or chemical action for its adhesive or cohesive strength. It shall be supplied in extruded form of suitable cross-section and of a size to seal the joint areas of concrete sections. The plastic waterstop shall be protected by a suitable removable two-piece wrapper. The two-piece wrapper shall be so designed that one-half may be removed longitudinally without disturbing the other half, to facilitate application of the sealing compound.

### 1.3 JOINTS IN WATERSTOPS

- A. All waterstops shall be continuous and so joined at all points of contact in the same plane, or at intersections with waterstops in different planes, as to form a complete barrier to the passage of water through any construction or contraction joint.
- B. Joints in the waterstops, whether made for the purpose of continuity in a straight strip or for the purpose of securing a watertight junction between strips in different planes, shall be made by heat welding as hereinafter specified.
- C. Joints in PVC waterstops shall be made by heating the two surfaces to be jointed until the material has softened to the point where it is just short of being fluid and then bringing the two softened surfaces together with a slight rubbing motion followed by firmly pressing them together so that a solid and tight bond is made.
- D. The joints in strips of waterstop made in the above manner shall be such that the entire cross section of the joint shall be dense, homogeneous and free of all porosity. All finished joints shall have a tensile strength of not less than 75 percent of the material of the strip as extruded.
- E. The heating of the surfaces to be joined shall be done by means of an electric splicing iron designed for the specified purpose and controlled by means of a voltage regulator.
- F. In use, the heat of the hot plate shall be so regulated as to prevent too rapid melting and accompanying charring of the waterstop material.
- G. The use of makeshift hot plates will not be permitted nor will other means of heating the strips to be joined be allowed except in a case of emergency, as determined by the Engineer.
- H. The Contractor shall provide such jigs as will assist in making the joints in a proper and workmanlike manner and in holding the strips so that the alignment of jointed strips is correct and angles are true to those required.

- I. Prior to embedment all joints in the waterstop strips will be inspected by the Engineer and any found defective shall be remedied without delay.

#### 1.4 PROTECTION OF WATERSTOP BETWEEN POURS

- A. The Contractor shall take such steps as are necessary to protect exposed waterstops in the interim period between concrete pours. This would include damage from construction equipment, tools and concrete “slobbers”. In the event the waterstop receives small amounts of construction debris and/or concrete “slobbers” while concrete is “green”, the Contractor shall fully clean waterstop directly following the stripping of formwork and prior to the placement of future reinforcement.

#### 1.5 EXPANSION JOINTS

- A. Expansion joints of the size and type shown on the plans, or specified herein, shall be placed in concrete pavement or structure as shown on the plans.

1. Materials:

- a. Preformed Asphalt Fiber Joint Material

Asphalt fiber sheet filler shall consist of preformed strips of inert material impregnated with asphalt. It shall be of the thickness shown on the Plans or indicated in these Specifications.

The sheet filler shall conform to the requirements of AASHTO Specification M-213 with the following additional provisions.

The sheet filler shall be of such character that it will not be deformed by ordinary handling during hot weather nor become hard and brittle in cold weather. It shall be of a tough, resilient, durable material not affected by weathering.

- b. Hot Poured Rubberized Tar Joint Sealer

Hot poured rubberized mastic joint sealer shall consist of a mixture of durable, elastic rubber, coal tar pitch and other materials which will form a resilient and adhesive compound capable of effectively sealing concrete joint surfaces against repeated expansion and contraction. The material shall be installed in accordance with the manufacturer's directions. Hot poured tar sealer shall be used for pavement and sidewalk expansion joints.



B. Joint Surface Preparation:

1. Clean joint surfaces immediately before installation of sealant or caulking compound. Remove dirt, insecure coatings, moisture and other substances which would interfere with bond of sealant or caulking compound.
2. For all sealants, do not proceed with installation of sealant over joint surfaces which have been painted, lacquered, waterproofed or treated with water repellent or other treatment or coating unless a laboratory test for durability (adhesion), in compliance with Paragraph 4.3.9 of FS TT-S-00227, has successfully demonstrated that sealant bond is not impaired by coating or treatment. If laboratory test has not been performed, or shows bond interference, remove coating or treatment from joint surfaces before installing sealant.
3. Etch concrete and masonry joint surfaces to remove excess alkalinity, unless sealant manufacturer's printed instructions indicate that alkalinity does not interfere with sealant bond and performance. Etch with 5% solution of muriatic acid; neutralize with diluted ammonia solution, rinse thoroughly with water and allow to dry before sealant installation.

C. Installation:

1. Comply with sealant manufacturer's printed instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.
2. Prime or seal joint surfaces where shown or recommended by sealant manufacturer. Do not allow primer/sealer to spill or migrate onto adjoining surfaces.
3. Employ only proven installation techniques, which will insure that sealants will be deposited in uniform, continuous ribbons without gaps or air pockets, with complete "wetting" of joint bond surfaces equally on opposite sides. Except as otherwise indicated, fill sealant rabbet to a slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, fill joint to form a slight cove, so that joint will not trap moisture and dirt.
4. Install sealants to depths as shown or, if not shown, as recommended by sealant manufacturer but within the following general limitations, measured at center (thin) section of bead.
5. For sidewalks, pavements and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to a depth equal to 75% of joint width, and neither more than 5/8" deep nor less than 3/8" deep.

CONSTRUCTION JOINTS, EXPANSION JOINTS  
AND WATERSTOPS  
3.3 - 5

6. For normal moving joints sealed with elastomeric sealants, but not subject to traffic, fill joints to a depth equal to 50% of joint width, but neither more than ½" deep nor less than 1/4" deep.
7. Do not allow sealants or compounds to overflow or spill onto adjoining surfaces, or to migrate into voids of adjoining surfaces. Use masking tape or other precautionary devices to prevent staining of adjoining surfaces, by either primer/sealer or the sealant.
8. Remove excess and spillage of compounds promptly as the work progresses. Clean adjoining surfaces by whatever means may be necessary to eliminate evidence of spillage, without damage to adjoining surfaces or finishes.
9. Placement of expansion joint material shall fully cover joint area(s) between concrete placements. No gaps or joint material opens which permit fresh concrete to flow to existing concrete surface will be allowed.

D. Cure and Protection

1. Cure sealants in compliance with manufacturer's instructions and recommendations, to obtain high early bond strength, internal cohesive strength and surface durability. Do not cure in a manner which would significantly alter material's modules of elasticity or other characteristics.
2. Installer shall advise Contractor of procedures required for curing and protection of sealants during construction period, so that they will be without deterioration or damage (other than normal wear and weathering) at time of Owner's acceptance.

END OF SECTION

## PART 1 - GENERAL

### 1.1 SCOPE

- A. Work in this section includes all labor, plant and material necessary to furnish and install all concrete formwork required by the project. Concrete formwork shall conform to all requirements of current editions of ACI 301 "Specifications for Structural Concrete for Buildings" and ACI 318 "Building Code Requirements for Reinforced Concrete" and ACI 347 "Recommended Practice for Concrete Formwork" and ACI 350 "Code Requirements for Environmental Engineering Structures" except as modified herein.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. Forms shall be of wood, metal, highly water resistant plywood, or other material approved by the Engineer. Forms for sections greater than 18" thick shall be of wood. Form surfaces shall be smooth and free from irregularities, dents, sags, or holes when used for permanently exposed surfaces. Bolts and rods used for internal ties shall be so arranged that, when the forms are removed, all metal will not be less than two (2) inches from any concrete surface. Wire ties will not be permitted where concrete surface will be exposed to weathering, and discoloration would be objectionable. Exposed concrete shall have approved form liners of Masonite or plywood, or shall be constructed of smooth surfaced plywood.
- B. Corner forms forming 3/4 inch chamfers or as otherwise specified on plans, shall be used on all outside corners that are to be exposed in the finished structure. Chamfer forms shall be of molded plastic or polyvinyl chloride chamfer strips. Use one style of form throughout the project. The type to be used shall be submitted to the Engineer for approval.
- C. Rustication and Score Line Strips shall be a non-absorbent material such as extruded polyvinyl chloride, plastic, fiberglass or metal or they may be milled from a good quality lumber and well sealed to prevent moisture absorption, wood strips may not have protruding splinters which may become embedded in the concrete. Sealing wood shall be accomplished by emersion or brushing on two coats of form coating.
- D. Form Ties for concrete shall have an approved waterstop barrier to prevent seepage of moisture along the ties. The ends of the metal after breaking off shall be minimum of 2 inches from the finished wall face. Submit samples to the Engineer for review. All temporary tie components of tie system shall be removed from placement once placement is completed and prior to backfilling. Non-shrink grout shall be placed at all voids created by ties.

- E. Form Coatings: 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.
- F. Cylindrical Columns and Supports: 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.
- G. Inserts: Provide metal inserts, anchor bolts and other embedded items for anchorage of materials or equipment to concrete construction, not supplied by other trades and as required for the work.
- H. Provide sheet metal reglets formed of the same type and gauge as the flashing metal to be built into the reglets, unless otherwise indicated. Where resilient or elastomeric sheet flashing or bituminous membranes are terminated in reglets, provide reglets of not less than 26 gauge galvanized sheet steel. Fill reglet or cover face opening to prevent intrusion of concrete or debris.
- I. Side forms of footings may be omitted and concrete placed directly against excavation only when requested by Contractor and accepted by Engineer. When forms are omitted, provide additional concrete required beyond the minimum design profiles and dimensions of the footings as indicated to provide minimum concrete coverage for reinforcement. Contractor shall maintain the earth form to proper alignment with no sloughing of material into the minimum design profile shown on the drawings.
- J. Dovetail Anchor Slots at surfaces to receive masonry veneer to be Heckman #100 or equal.
- K. Formwork used for exposed finished concrete surface placements shall be in like new condition and designed to provide flat and true surfaces.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Design and engineering of formwork, shoring and reshoring as well as its construction is the responsibility of the contractor. Design formwork for loads, lateral pressures and allowable stresses outlined in ACI 347R and for design considerations, wind loads, allowable stresses and other applicable requirements of the controlling local Building Code. Where conflicts occur between these two standards, the more stringent requirements shall govern.
- B. Forms shall be built true to line and grade, and be mortartight and sufficiently

rigid to prevent displacement or sagging between supports. All formwork and shoring shall be designed for the construction loads to be placed on them, and the design and construction of said forms shall be in accordance with ACI Standard "Recommended Practice for Concrete Formwork" (ACI 347). The structural adequacy of the formwork shall rest with the Contractor. All forms shall be so constructed that they can be removed without hammering or prying against the concrete.

- C. Before concrete placement check the lines and levels of erected formwork. Make corrections and adjustments to ensure proper size and location of concrete members and stability of forming systems.
- D. During concrete placement check formwork and related supports to ensure that forms are not displaced and that completed work will be within specified tolerances.
- E. Provide temporary openings in wall forms, columns forms and at other locations necessary to permit inspection and clean-out.

### 3.2 EMBEDDED ITEMS

- A. Before placing concrete, care shall be taken to determine that any embedded metal or wood parts are firmly and securely fastened in their correct location as indicated. Use setting drawings, diagrams, instruction and directions provided by suppliers of items attached thereto. They shall be thoroughly clean and free from coating, rust, scale, oil, or any foreign matter. Embedding of wood in concrete shall be avoided whenever possible, metal being used instead. If wood is allowed, it shall be thoroughly wetted before concrete is placed.
- B. All aluminum embedded items shall be coated with epoxy paint where in contact with concrete.

### 3.3 FORM REMOVAL

- A. Forms shall not be removed without approval of the Engineer. Forms shall not be removed before the minimum times given below, or longer if job control tests indicate the concrete has not attained strength specified below, except when specifically authorized by the Engineer.

Beams and Slabs	14 days or proof of strength requirements met.
Walls up to 12" Thick and Vertical Surfaces	1 day if minimum daily temperature is above 50°F, 3 days otherwise
Columns	5 days or proof of strength requirements met.
Walls greater than 12" Thick	3 days if minimum daily temperature is

above 50°F with proof of strength requirements met, 7 days otherwise.

- B. In general, forms or shores for supported slabs and beams shall not be removed until the concrete, so supported, has acquired 70% of its design strength; except where loads other than the dead weight of the concrete are added, the shores shall not be removed until 24 hours after the concrete has obtained 90% of its design strength. Forms shall be removed immediately after expiration of the lapsed times specified above or sooner, if required by the Engineer, where concrete is to receive a rubbed finish.

END OF SECTION

A. SCOPE

This section covers the furnishing and installation of all miscellaneous metals, including stainless steel, cast iron, and aluminum items not covered in other sections of the Specifications. Work generally included but is not limited to ladders, gratings, handrails and railings, anchorage devices, metal fabrications, and metal stairs.

B. GENERAL

Furnish all miscellaneous items such as anchor bolts, tie down bolts, nuts and washers, supports, connections, expansion and toggle bolts, etc., required by the work. Supplementary parts necessary to complete each item, though such work is not definitely shown or specified, shall be included. Furnish to appropriate trades all anchors, sockets or fastenings required for securing metal work to other constructions and wood items to concrete. Details and specifications of items for which standard products are available are representative guides of requirements for such items. Standard products generally meeting such requirements, will be accepted. Welding shall be continuous along entire area of contact, except where tack welding is permitted. Tack welding will not be permitted on exposed surfaces. All exposed welds shall be ground smooth. Riveting, where exposed, shall be flush type.

C. QUALITY ASSURANCE

Take field measurements prior to preparation of shop drawings and fabrication, where possible. Do not delay job progress; allow for trimming and fitting wherever taking field measurements before fabrication might delay work.

Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

D. SUBMITTALS

Submit for Engineer's review, 4 sets of shop drawings for fabrication and erection of miscellaneous metal items. Include plans, elevations, and details of sections and connections. Show anchorage and accessory items. Provide templates for anchor and bolt installation by others. Submit duplicate samples of all prefinished or shop finished items for approval of finishes. See specification section 1.3 for additional requirements.

E. MATERIALS AND COMPONENTS

1. Metal Surface, General: For fabrication of miscellaneous metal work which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and

roughness.

2. Ferrous Metals: Except as otherwise specified herein or noted on the Plans, stainless steel and wrought metals shall meet the requirements of the following standards (current edition):

Gray Iron Castings: ASTM A 48, Class 30.

Malleable Iron Castings: ASTM A 47, grade as selected.

Stainless Steel Plates, Shapes, Bars, Tubes shall be AISI Type 304 (18-8) mill finish.

Stainless Steel Castings shall be AISI Type 304 conforming to ASTM A 296, Iron-Chromium-Nickel Alloy.

3. Non-Ferrous Metals:

Aluminum Bar Grating: ASTM B 221, Alloy 6061 or 6063-T6 for bearing bars; ASTM B 221 or B 210 for cross bars or bent connecting bars.

Aluminum Extrusions: ASTM B 221; alloy 6063-T5, except alloy 6005-T5 for pipe; unless otherwise indicated.

Clear anodized finish AA-M21C11A41, unless otherwise indicated.

Aluminum Sheet or Plate: ASTM B 209; alloy 6061-T4; unless otherwise indicated. Mill finish.

4. Fasteners:

General: Provide zinc-coated fasteners for exterior use or where built into exterior walls. Provide AISI Type 303, stainless steel fasteners where exposed to liquids of treatment process, for connecting aluminum or where noted to be stainless steel. Select fasteners for the type, grade and class required.

Bolts and Nuts: Regular hexagon head type, ASTM A 307, Grade A.

Machine Screws: Cadmium plated steel, FS FF-S-92.

Plain Washers: Round, carbon steel, FS FF-W-92.



Concrete & Masonry Anchorage Devices: Expansion shields, FS FF-S325, Galvanized or Stainless Steel. Wedge type expansion anchors take "Kwik-Bolt" by HILTI Tulsa, Oklahoma or equal, size as noted on the Drawings. Length shall provide minimum embedment in concrete as specified by manufacturer's literature.

Toggle Bolts: Tumble-wing type, FS FF-B-588, type, class, and style as required.

Lock Washers: Helical spring type carbon steel, FS FF-W-84.

F. FABRICATION, GENERAL

Use materials of size and thickness shown or, if not shown, of required size and thickness to produce strength and durability in finished product. Work to dimensions shown or accepted on shop drawings, using industry proven details of fabrication and support. Use type of materials shown or specified for various components of work.

Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1/32" unless otherwise shown. Form bent metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

Weld corners and seams continuously, complying with AWS recommendations. At exposed connections, grind exposed welds smooth and flush to match and blend with adjoining surfaces.

Form exposed connections with hairline joints, flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of type shown or, if not shown, use phillips flat-head (countersunk) screws or bolts.

Provide for anchorage of type shown, coordinated with supporting structure. Fabricate and space anchoring devices to provide adequate support for intended use.

Cut, reinforce, drill and tap miscellaneous metal work as indicated to receive finish hardware and similar items.

G. PAINTING/COATING

All aluminum surfaces that will be in contact with concrete, steel or other dissimilar material shall be coated with asphaltic paint or aluminum impregnated caulking compound or other approved permanent insulation to prevent electrolytic action.

Additionally, Contractor shall be familiar with dissimilar metals corrosive issues and provide isolation materials or coatings appropriate to the installed project equipment and components to minimize future corrosion issues.

H. CHECKERED PLATE

Shall be standard checkered aluminum plate complete with angle frames and fasteners of thickness shown and located where shown on the drawings.

I. LADDERS

All ladders unless otherwise indicated, shall have flat bar side rails with eased edges spaced 20" o.c. with 3/4" diameter bar rungs welded to siderails at 12" o.c. maximum vertical spacing. Ladders shall be securely attached to supporting construction and extend at least 42" above top rung except where prohibited by overhead or other construction. Where steel ladders are required by the drawings, provide galvanized anchor bolts or expansion anchors. Where aluminum ladders are required by the drawings provide stainless steel anchor bolts or expansion anchors. 316 stainless ladders with 316 stainless steel anchor bolts are required in all wet well, vaults, manhole, water or wastewater holding structures where a ladder is called for.

J. GRATING

1. General: Use materials of the size and thickness shown, or if not shown, of the size recommended by NAAMM tables. Work to the dimensions shown or accepted on shop drawings, using proven details of fabrication and support. Use the type of materials shown or specified for the various components of the work. Comply with NAAMM "Metal Bar Grating Manual" and as herein specified.

Except where noted otherwise, provide removable grating sections with end-banding bars for each panel, 4 saddle clip anchors designed to fit over 2 bearing bars, and 4 stud bolts with washers and nuts, unless otherwise indicated.

Notch gratings for penetrations as indicated. Layout units to allow grating removal without disturbing items penetrating grating. All grating to be removable unless otherwise noted.

Provide banding for openings in grating separated by more than 4 bearing bars, of same material and size as bearing bars, unless otherwise indicated.

Notching of bearing bars at supports to maintain elevations will not be permitted.

Weld stud bolts to receive saddle clip anchors to supporting metal members.

2. Aluminum Grating: All aluminum grating shall be "Rectangular Pressure locked", KPL-19-4 Series, type as manufactured by Klemp Corporation; or equal. Bearing bar shall be 1¼" deep x 1/8" thick minimum spaced at 1-3/16" centers unless noted otherwise on the drawings. Provide aluminum clip anchors and stud bolts where grate is supported by aluminum members and stainless steel slip anchors and stud bolts where grade is supported by steel members. Coat surfaces in contact with concrete or steel with asphaltic paint or aluminum impregnated caulking compound or other approved permanent insulation. Stair treads to have checkered plate or abrasive nosings.
3. Aluminum Grating Treads: All aluminum grating treads shall be pressure-locked rectangular bar "KPL-19-4" as manufactured by "Klemp Corp." or equal. Bearing bars shall be 1-1/2" x 3/16" minimum unless noted otherwise on drawings. Treads shall have cast aluminum abrasive nosings.
4. To be considered equal a grating or tread must have the same load capacity as the size grating noted on the drawings. One type of grating shall be used throughout the job. The depth may vary from that shown on the drawings, provided adequate provisions are made to make modifications to the bearing and anchorage details.

#### K. PIPE RAILINGS

1. General: Fabricate pipe railings to dimensions and details shown, with smooth rounded bends and welded joints ground smooth and flush.

Adjust railings prior to anchoring to ensure matching alignment at butting joints. Space posts not more than 6'-0" on centers, unless otherwise shown. Plumb posts in each direction. Secure posts and rail ends to supporting construction as follows:

Anchor posts and rail ends into concrete with epoxy grout as detailed.

Provide removable railing sections as indicated. Furnish slip-fit metal socket or sleeve for casting into concrete. Accurately locate sleeves to match post spacing.

Secure single rail handrails to walls with wall brackets and end fittings. Provide brackets with not less than 3" clearance from inside face of handrail to the finish wall surface. Drill wall plate portion of bracket to receive bolt, unless indicated for concealed anchorage. Locate brackets as indicated or, if not indicated, at not more than 6' - 0' o.c. Provide flush-type wall return fittings with same projection as that specified for wall brackets. Secure wall brackets and wall return fittings to supporting construction as follows:

For concrete and solid masonry anchorage, use bolt anchor expansion shields and

lag bolts.

For hollow masonry anchorage, use toggle bolts having square heads.

2. Aluminum Pipe Railings: Pipe handrails of aluminum shall be installed in the locations shown on the drawings.

Horizontal aluminum handrails shall be 1 ½" schedule 40 pipe of aluminum alloy 6005-T5. Vertical posts to be 1 ½" schedule 80 pipe 6005-T5. Fittings shall be attached to the posts by internal welding. The various pieces of the rail shall be joined together by welding. After fabrication finish shall be a 180 grit belt grind with an Alumilite No. 204 Anodizing.

Contractor may submit, for approval, 1 ½" square tube section handrail of the same strength as the 1 ½" pipe. Contractor shall be responsible for design of modifications to handrail anchor details to fit tube handrail. Submit modifications for approval of the Engineer.

#### L. STAIR NOSINGS

Provide cast aluminum abrasive nosings for all concrete stairs. All nosings are to be three (3) inches wide and have a one (1) inch lip. Nosings shall be the length of the tread less 3" at each end and have integral imbed anchors.

Abrasive is to be #20 aluminum oxide (AL203), integrally cast into the walking surface to a minimum depth of 1/32". Fastener screws shall not protrude above that tread surface. Cross-hatching and fluting shall be 1/16" deep minimum and shall be clean, sharp, well-defined and free from washes, scabs, buckles, blow holes, knots, cuts, cracks and pin-holes. Abrasive cast aluminum to have sand blasted finish. Abrasive cast iron to have one coat of shop black paint.

#### M. CONSTRUCTION CASTINGS

Provide cast iron manhole ladder rungs as detailed. See drawings for locations, sizes, types and details. Unless otherwise indicated, units shall be McKinley Iron Works, or Neenah Foundry Co, castings or equal. **Castings shall also meet current ODOT and City of Tulsa/Sewer Operations standard requirements.**

END OF SECTION

A. SCOPE

The work covered by this section includes the furnishing of all labor, materials and equipment for all caulking of doors, and for all joint sealants where required. All materials shall be brought on the job in labeled original containers and shall show quality, kind and manufacturer's name. Materials incorporated into the project shall be new and be installed within the Manufacture's "use by date".

B. SUBMITTALS

Within sixty (60) days after award of Contract, and before any material are delivered to the job site, submit to the Engineer a complete list of all materials proposed to be furnished and installed under this portion of the work, making the submittal in accordance with the provisions of the General Conditions of these Specifications.

C. MATERIALS

Caulking Compound shall be an elastic waterproof acrylic latex caulking compound. Caulking compound shall be "Sonolac" as manufactured by Sonneborn Building Products Division, Contech, Inc., Minneapolis, Minnesota; "AC-20 Acrylic Latex" by Pecora Corp., Harleysville, Pennsylvania, or approved equal.

Color shall match adjacent work. Deliver caulking compound in manufacturer's original sealed containers.

Sealant: Polysulfide base sealant based on liquid polysulfide polymer manufactured by Thiokol Chemical Corporation, bearing Thiokol Chemical Corporation's "Tested and Approved Seal". Sealant shall be delivered to the job site in sealed containers, each bearing a "Tested and Approved" seal, manufacturer's name, and product designation. Sealant shall be two (2) part polysulfide base sealant conforming to Thiokol's Building Trade Performance Specification as follows:

- Class A (self-leveling) for joints in horizontal surfaces.
- Class B (non-sag) for joints in vertical surfaces.

Type I (Hardness: 20 35 Shore A) for caulking, glazing and sealing vertical surfaces and non-traffic bearing horizontal surfaces.

Type II (Hardness: 35 45 Shore A) for caulking and sealing horizontal surfaces subject to foot and light vehicular traffic, or abrasion.

Thiokol shall be "Synthacaulk GC-5" by Pecora Corp., Harleysville, Pennsylvania; "Sonolastic Two Part" by Sonneborn Building Products Division, Contech, Inc., or approved equal. Color shall match the adjacent materials as closely as possible. Colors shall be selected by the Engineer. Where stock colors are not acceptable, special colors shall be prepared and furnished, as approved by the Engineer. Submit cured samples for Engineer's color selection.

Joint Filler: Back-up material for caulking and sealant shall be compressible in nature and shall have a proven record of compatibility with the sealant used. Glassyard, PVC, Butyl or neoprene rod is acceptable -- expanded polyethylene foam, polyurethane foam, and similar gas-expanded foams are not acceptable.

D. INSTALLATION

Location: Polysulfide sealant shall be used for caulking all exterior joints of any type and elsewhere as indicated. Elastic caulking may be used for interior joints not requiring polysulfid sealant. Set all exterior thresholds in caulking. Caulk all joints in masonry walls; between masonry and concrete intersections; around all windows, door frames, louvers, pipes and other penetrations through walls, floors, and ceilings; joints in metal panels, fascias, etc., and all other joints required for a weathertight and/or neat workmanlike installation.

Application: Thoroughly clean all surfaces to be caulked so they will be clean, free from loose dirt, grease, etc., and dry. Surfaces that are to be caulked with polysulfide sealant must first be cleaned with Methyl-Ethyl- Keytone in strict accordance with manufacturer's directions. Install joint filler back-up material to provide proper caulking depth to width ratio according to sealant manufacturer's recommendations. Apply caulking with a gun with proper size nozzle. Use sufficient pressure to fill all voids and joints solidly. Remove excess caulking and leave surfaces neat, even, smooth, and clean; free of sags, blisters and irregularities. Application shall be according to manufacturer's directions and at least three (3) weeks ahead of painting. Where and to extent possible, caulk joints shall be applied to joint being put together and to joint after components are installed. An example of this would be at an exterior door jamb would have caulk under the threshold jamb area and outside threshold jamb area after door installation is completed. Other areas might include flashing set in a bed of caulk or surface mounted frames where required.

E. CLEAN-UP

Upon completion of the work, all caulking and sealing compounds shall be removed from surrounding areas and all joints checked for water tightness and touched up as required. It shall be the Contractor's responsibility to provide a weathertight building.

END OF SECTION

SUPPLEMENTAL SPECIFICATION  
LIFT STATION CONSTRUCTION STANDARDS

S-1.1 - 1

This following supplemental specification (Current City of Tulsa Lift/Pump Station Construction Standards) establishes minimum standards governing construction of sanitary sewer lift stations for the Tulsa Metropolitan Utility Authority (TMUA). These requirements are intended to supplement but not necessarily duplicate information provided in the Technical Specifications and Construction Drawings; so that any work exhibited in one and not the other shall be executed just as if it had been set forth in both, in order that the work shall be completed according to the complete design as decided and determined by the Owner and Engineer. Where conflicts exist between requirements set forth in these standards and requirements of the Technical Specifications and Construction Drawings, these standards shall govern.

Names, manufacturers and models of equipment and materials listed in these standards are provided in order to establish a basis of design by providing an approved model, material or manufacturer. Alternate manufacturers and models may be acceptable and may be submitted to the Owner for approval. No alternate materials or equipment may be utilized without explicit, written approval from the Owner.

**PART 1 - GENERAL****1.1 SUMMARY**

- A. This section of the specification describes requirements for a submersible pumping system to be installed at the Turley North Lift Station including two (2) submersible pumps and control system. The equipment shall be installed as shown on the plans, as recommended by the supplier, and in compliance with all OSHA, local, state and federal codes and regulations.

**1.2 WARRANTY**

- A. Pump manufacturer shall furnish to the City a warranty written expressly from the manufacturer to the City of Tulsa, covering workmanship, material, and performance deficiency under normal use and service. The full warranty shall cover 100 percent of parts and labor for at least 24 months. After that, the equipment shall be covered by a pro-rated warranty with the following minimum provisions:
1. From 25 to 39 months after acceptance: 50 percent of all replacement parts and labor for defective materials, workmanship, and performance deficiency.
  2. From 40 to 60 months after acceptance: 25 percent of all replacement parts and labor for defective materials, workmanship, and performance deficiency.
- B. The warranty period shall commence on the day of start-up acceptance by the City. Warranty shall be in printed form and previously published as the manufacturer's standard warranty for similar manufactured units.

**PART 2 - PRODUCTS****2.1 SUBMERSIBLE PUMPS**

- A. Conditions of Operation:

Each pump shall be capable of providing the following hydraulic conditions when pumping domestic sewage:



Item	Pumps 1 & 2
Pump Type	Submersible, Solids Handling
Primary Design Point:	
Capacity	525 gpm
Total Dynamic Head	52 ft.
Minimum Pump Efficiency at Design	65%
Maximum Speed	1800 rpm
Shutoff Head	97 ft.
Minimum Solid Size	3 in.
Discharge Size	4.0 in.
Motor Hp, Maximum	15 hp
Voltage	460V, 3PH, 60HZ
Drive	Variable Speed

The pump(s) shall be manufactured by:

1. Fairbanks-Nijhuis, Inc., as provided by Haynes Equipment Company, Oklahoma City, Oklahoma
2. Grundfos, Inc., as provided by Haynes Equipment Company, Oklahoma City, Oklahoma
2. Flygt, Inc., as provided by Automatic Engineering., Tulsa, Oklahoma
3. Approved alternate equipment and suppliers listed by addendum.

Design: The pump(s) shall be automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from the top of the station to the discharge connection. There shall be no need for personnel to enter the wet-well. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal watertight contact. Sealing of the discharge interface with a diaphragm, O-ring or profile gasket will not be acceptable. No portion of the pump shall bear directly on the sump floor.

- B. Pump Construction: Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. The lifting handle shall be of stainless steel. All exposed nuts or bolts shall be AISI type 316 stainless steel construction. All metal surfaces coming into contact with the pumpage, other than stainless steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.

Sealing design shall incorporate metal-to-metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or optional Viton rubber O-rings. Fittings will be the result of controlled compression of rubber O-rings in

two planes and O-ring contact of four sides without the requirement of a specific torque limit.

Rectangular cross sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical O-rings, grease or other devices shall be used.

- C. **Cooling System:** Each unit shall be provided with an integral motor cooling system. A motor cooling jacket shall encircle the stator housing, providing for dissipation of motor heat regardless of the type of pump installation. An impeller, integral to the cooling system and driven by the pump shaft, shall provide the necessary circulation of the cooling liquid through the jacket. The cooling liquid shall pass about the stator housing in the closed loop system in turbulent flow providing for superior heat transfer. The cooling system shall have one fill port and one drain port integral to the cooling jacket. The cooling system shall provide for continuous pump operation in liquid or ambient temperatures of up to 104°F. (40°C.). Operational restrictions at temperatures below 104°F are not acceptable. Fans, blowers, or auxiliary cooling systems that are mounted external to the pump motor are not acceptable
- D. **Cable Entry Seal:** The cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomer grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable. The assembly shall provide ease of changing the cable when necessary using the same entry seal.
- E. **Motor:** The pump motor shall be a NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31. The stator shall be heat-shrink fitted into the cast iron stator housing. The motor shall be designed for continuous duty handling pumped media of 40°C (104°F) and capable of no less than 30 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of cast aluminum. The motor and the pump shall be produced by the same manufacturer.

The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15. The motor shall have a voltage tolerance of plus or minus 10%. The motor shall be designed for operation up to 40°C (104°F) ambient and with a temperature rise not to exceed 80°C. A performance chart shall be provided upon request showing curves for torque, current, power factor, input/output kW and efficiency. This chart shall also include data on starting and no-load characteristics.

The motor construction shall be of explosion proof, TENV-TEXP design and capable of being certified for use in Class 1, Groups C & D hazardous locations by either Factory Mutual (F.M.) or Underwriters Laboratories (U.L).

The power cable shall be sized according to the NEC and ICEA standards and shall be of sufficient length to reach the junction box without the need of any splices. The outer jacket of the cable shall be oil resistant chlorinated polyethylene rubber. The motor and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet or greater.

The motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shut-off through run-out.

- F. Bearings: The pump shaft shall rotate on two bearings. Motor bearings shall be permanently grease lubricated. The upper bearing shall be a single deep groove ball bearing. The lower bearing shall be a two row angular contact bearing to compensate for axial thrust and radial forces. Single row lower bearings are not acceptable. The minimum  $L_{10}$  bearing life shall be 50,000 hours at any usable portion of the pump curve.
- G. Mechanical Seal: Each pump shall be provided with a tandem mechanical shaft seal system consisting of two totally independent seal assemblies. The seals shall operate in a lubricant reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump and the lubricant chamber, shall contain one stationary and one positively driven rotating, corrosion and abrasion resistant tungsten-carbide ring. The upper, secondary seal unit, located between the lubricant chamber and the motor housing, shall contain one stationary and one positively driven rotating, corrosion and abrasion resistant tungsten-carbide seal ring.

Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotation for sealing. The position of both mechanical seals shall depend on the shaft. Mounting of the lower mechanical seal on the impeller hub will not be acceptable. For special applications, other seal face materials shall be available.

The following seal types shall not be considered acceptable or equal to the dual independent seal specified: shaft seals without positively driven rotating members, or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower

seal faces. No system requiring a pressure differential to offset pressure and to effect sealing shall be used.

Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and to provide lubricant expansion capacity. The drain and inspection plug, with positive anti-leak seal shall be easily accessible from the outside. The seal system shall not rely upon the pumped media for lubrication. The motor shall be able to operate dry without damage while pumping under load.

Where a seal cavity is present in the seal chamber, the area about the exterior of the lower mechanical seal in the cast iron housing shall have cast in an integral concentric spiral groove. This groove shall protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

Seal lubricant shall be FDA Approved, nontoxic.

- H. Pump Shaft: Pump and motor shaft shall be the same unit. The pump shaft is an extension of the motor shaft. Couplings shall not be acceptable. The pump shaft shall be stainless steel – ASTM A479 S43100-T.

If a shaft material of lower quality than stainless steel – ASTM A479 S43100-T is used, a shaft sleeve of stainless steel – ASTM A479 S43100-T is used to protect the shaft material. However, shaft sleeves only protect the shaft around the lower mechanical seal. No protection is provided in the oil housing and above. Therefore, the use of stainless steel sleeves will not be considered equal to stainless steel shafts.

- I. Impeller: The impeller and the cutter insert ring shall be wear resistant against sand and grit which is expected to enter the pump station with the sewage or the storm water. They shall be made of ASTM A-532 Alloy III A with 25% chrome (hard-iron). The impeller shall be capable of handling solids, fibrous materials, heavy sludge and other matter found in normal sewage applications. Fibers are caught by the cutter grooves and sheared between the hardened edges of the impeller and the hard iron cutter plate.

Impellers that have surface hardening or coating will not be allowed.

The fit between the impeller and the shaft shall be a sliding fit with a taper-lock bushing pressed by a screw which is threaded into the end of the shaft.

- J. Volute: Pump volute(s) shall be single-piece grey cast iron, Class 35B, non-concentric design with smooth passages large enough to pass any solids that may enter the impeller. Minimum inlet and discharge size shall be as specified.
- K. Protection: All stators shall incorporate thermal switches in series to monitor the temperature of each phase winding. At 125°C (260°F) the thermal switches shall open, stop the motor and activate an alarm.
- L. Moisture Detection

Moisture detection shall be provided conforming to either of the following descriptions based on pump manufacturer's standard:

1. Two moisture detection probes shall be installed so that they will detect moisture in either the seal or stator cavity measuring resistivity between the probes. They shall be wired internally to the control cable connection at the top of the motor. O-ring sealed inspection plugs shall be provided in the mechanical seal oil chamber for ease in inspection, draining, and filling of oil.
  2. A leakage sensor shall be provided to detect water in the stator chamber. The Float Leakage Sensor (FLS) is a small float switch used to detect the presence of water in the stator chamber. When activated, the FLS will stop the motor and send an alarm both local and/or remote. The thermal switches and FLS shall be connected to a Mini CAS (Control and Status) monitoring unit. The Mini CAS shall be designed to be mounted in any control panel.
- M. Cable Entry System: The power and control cable entry system shall be designed to provide a positive, leak-free seal to prevent liquid from entering the air filled motor housing. The design shall incorporate provisions which prevent moisture from wicking through the cable assembly even in the event that the cable jacket has been punctured. All cable shall be type SEOW-A and U.L. listed for the intended submersible service.

The power and control cable entry into the lead connection chamber shall be encapsulated for positive moisture sealing. A Buna-N cable grommet shall be provided in addition to the epoxy sealed leads. Compression type grommet fittings employed as the primary sealing system shall neither be considered equal or acceptable. Separate power and control cables shall be provided to prevent false sensor warnings.

- N. Guide Bracket & Rail System: The pump shall be provided with a 316 SS guide system to allow easy removal without entering the wet well. The main base fixture shall be bolted to the floor and shall include a 90 degree Cast Iron elbow and mounts for two 316 SS rails of standard schedule 40 pipe. The base fixture shall be designed to receive the connecting pump slide bracket without the need for bolts, nuts, or clamps. The pump discharge will connect to a Cast Iron slide bracket with bronze guide shoe for non-sparking design that seals against the base fixture by the weight of the pump.
- O. Pressure Gauge: A discharge pressure gauge shall be installed on the common discharge header for start-up and pump performance testing. Provide a 316SS, 3" minimum face size, liquid filled gauge in a scale appropriate for the pumping system. Gauges shall be Ashcroft or approved equal.

## 2.2 CONTROL SYSTEM

- A. Electrical power to be furnished to the site will be 3 phase, 60 Hertz, 480

volts.

- B. The control circuitry shall be designed to operate on 115 +/-10% volts, 60 Hertz, single phase current, and control two (2) pumps driven by 12 H.P. motors at 1765 RPM. The control assembly shall provide means to operate each pump manually or automatically. When operated in the automatic mode, the control assembly shall provide means to automatically alternate the position of the "lead" pump after each pumping cycle.
- C. PANEL ENCLOSURE
1. The complete control assembly shall be contained in one NEMA 4X stainless steel enclosure.
  2. All seams shall be free of burrs and free of open voids to prevent leakage. The enclosure shall be constructed in conformance with applicable sections of the National Electrical Manufacturer's Association (NEMA). Enclosure construction to be NEMA 3 per NEMA Standard ICS-1970, Paragraph ICS1-110.12.
  3. The enclosure shall be equipped with a removable inner swing panel fabricated of steel, mounted on lift off hinges. The inner swing panel shall be of adequate size to completely cover all wiring and components mounted on the back panel and shall make provision for the mounting of all basic and optional controls and instruments. The inner swing panel shall have a minimum horizontal swing of 90o and shall be held in the closed position with straight slot screws.
  4. The door shall be mounted on a continuous (piano-type), vertical, steel hinge, sealed around its entire perimeter and held in the closed position with a three pad-lockable draw pull latches. The door shall have a minimum horizontal swing of 165o.
  5. The enclosure shall be furnished with a removable back panel fabricated of steel, secured to the enclosure on collar studs. The back panel shall be of adequate size to accommodate all basic and optional components.
  6. There shall be no holes in the enclosure for mounting the enclosure or mounting within the enclosure.
  7. All control wiring shall conform to the National Electric Code. Wires connected to components mounted on the enclosure door shall be bundled and tied in accordance with good commercial practice. Bundles shall be made flexible at the hinged side of the enclosure. Adequate length and flex shall be provided to allow the door to swing to its full open position without undue stress or abrasion on the wire or insulation. Bundles shall be held in place on each side of the hinge by mechanical fastening devices.
  8. The motor control shall be completely wired at the factory, except for the power feeder lines, in accordance with applicable wiring standards set forth by the National Electric Code (NEC).

9. All components shall be electrically grounded to a common ground lug mounted on the control panel sub plate. Upon installation of lift station, and before connection of any power feeder lines, contractor shall extend grounding wire from lug to external ground in accordance with local electrical code.

#### D. COMPONENTS

1. All major components shall be securely fastened to the removable back panel with screws.
2. VFD sizing shall be based on 125% of actual motor full load rated amps, not solely based on a published horsepower (HP) rating.
3. A properly sized thermal-magnetic air circuit breaker shall be furnished for each submersible pump motor, and shall have a symmetrical rms interrupting rating of 14,000 amperes at 460 volts. All circuit breakers shall be sealed by the manufacturer after calibration to prevent tampering. A mechanical disconnect mechanism shall be installed on each circuit breaker to provide a means of disconnecting power to the pump motors. Operator handles for the disconnect mechanisms shall be located on the exterior of the inner swing panel with interlocks which permit the swing panel to be opened only when the circuit breakers are in the "OFF" position.
4. Pump motors shall be provided with variable frequency drives as outlined below:
  - a. This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA induction motor. Variable Frequency Drive shall be ABB, Square d Altivar or equal.
  - b. The VFD package as specified herein shall be UL listed as a complete assembly and enclosed in an integrated UL type 1 enclosure, assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.
  - c. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.

The keypad shall include Hand-Off Auto selections and manual speed control. The drive shall incorporate bumpless transfer of speed reference when switching between Hand and Auto modes.

- d. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

The overloading rating of the drive shall be 110% of its normal duty current rating for one (1) minute every ten (10) minutes, 130% overload for two (2) seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.

- e. The VFD shall have an integral 5% impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC buss) reactors, or 5% AC line reactors. VFDs with only one DC reactor shall add AC line reactors.
- f. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOVs (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.
- g. The VFD shall be capable of sensing a loss of load (broken belt/broken coupling) and signal the loss of load condition. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.
- h. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user.
- i. The VFD shall have programmable Sleep and Wake up functions to allow the drive to be started and stopped from the level of process feedback signal.
- j. All VFD to have the following adjustments:
  - 1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.



2. Two (2) PID Setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.
  3. Two (2) programmable analog inputs shall accept current or voltage signals.
  4. Two (2) programmable analog outputs (0-20mA or 4-20mA).
  5. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices.
  6. Three (3) programmable digital Form-C relay outputs.
  7. Seven (7) programmable preset speeds.
  8. Two (2) independently adjustable accel and decel ramps with 1 - 1800 seconds adjustable time ramps.
  9. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.
  10. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.
  11. The VFD shall include password protection against parameter changes.
- k. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values shall be capable of being displayed at all times.
1. All VFDs shall include EMI/RFI filters. The onboard filters shall allow the VFD assemble to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

5. A padlocking operating mechanism shall be installed on each motor circuit breaker. Operator handles for the mechanism shall be located on the exterior of the control compartment door, with interlocks which permit the door to be opened only when the circuit breakers are in the "off" position.
6. Overload relays shall be of block-type, utilizing melting alloy type spindles, and shall have visual trip indication with trip-free operation. Pressing of the overload reset lever shall not actuate the control contact until such time as the overload spindle has reset. Resetting of the overload reset lever will cause a snap-action control contact to reset, thus reestablishing a control circuit. Overload relays shall be manually reset only and not convertible to automatic reset. Trip setting shall be determined by heater element only and not by adjustable overload relays. An overload reset pushbutton shall be mounted through the door of the motor control center and permit resetting of the motor overload relays without opening the control panel door.
7. A switch shall be provided to permit the station operator to select automatic alternation of the pumps, to select pump number one to be the lead pump for each pumping cycle or to select pump number two to be the lead pump for each pumping cycle. Selector switch shall be standard duty, rated NEMA 4X, with contacts rated NEMA A600 minimum.
8. Pump mode selector switches shall be connected to permit manual start and manual stop for each pump individually, and to select automatic operation of each pump under control of the liquid level control system. Manual operation shall override the liquid level control system. Selector switch shall be standard duty, rated NEMA 4X, with contacts rated NEMA A600 minimum.
9. A pump alternation shall be provided by the use of a PLC, Allen-Bradley CompactLogix. Pump alternator shall operate after pump shutdown.
10. Control panel shall be equipped with one standard duty, rated NEMA 4X, pilot light for each pump motor. Light shall be wired in parallel with the related pump motor starter to indicate that the motor is on. Run lights shall be equipped with lamps providing a minimum of 15,000 hours.
11. The pump control panel shall be equipped to terminate pump operation due to high motor winding temperature or moisture in the motor housing and shall utilize the contacts in the pump motor. If either event should occur, the motor starter will drop out and a mechanical indicator, visible on the inner door, shall indicate the pump motor has been shutdown. The pump motor shall remain locked out until the condition has been corrected and manually reset. Control panel shall be equipped with one standard duty, NEMA 4X pilot light for each pump motor to indicate a pump fail

condition.

12. Six digit elapsed time indicators (non-reset type) shall be connected to each VFD to indicate the total running time of each pump in "hours" and "tenth of hours".
13. The motor control center shall be equipped with a duplex grounding receptacle located on the exterior of the enclosure in weatherproof box. The receptacle circuit shall be protected by a 15 ampere thermal magnetic circuit breaker.
14. Lift station manufacturer shall furnish 115 Volt, A.C. 40-watt, vapor-tight alarm light with red globe, guard and mounting hardware. The contractor shall mount, wire and run conduit to the light as shown on the plans. Wiring shall be connected to the appropriate terminal blocks in the motor control center as shown on the lift station wiring schematic.
15. The control panel shall be equipped to monitor the incoming power and shut down the pump when required to protect the motors from damage caused by phase reversal, phase loss, voltage unbalance greater than 5% or voltage less than 83% of nominal. A time delay shall be provided to minimize nuisance trips. The motors shall automatically restart when power conditions return to normal. Control panel shall be equipped with a standard duty, NEMA 4X pilot light to indicate power failure.
16. The control circuit shall contain a pump delay circuit to prevent both pumps from simultaneous starting following a power failure.
17. An alarm silence switch and relay shall be provided to permit maintenance personnel to de-energize the external alarm device while corrective actions are underway. After silencing the alarm device, manual reset of the signal relay shall provide automatic reset of the alarm silence relay.
18. An 12" Performance Conformally Coated, operator interface terminal shall be provided for local monitoring and control, Allen-Bradley PanelView, Model 2711P-T12W22D9PK, or approved equal.
19. The following parameters shall be outputs to telemetry:
  - Power fail
  - Control fail
  - Dry well high
  - Wet well high
  - Influent vault high (if applicable)
  - Security alarm
  - Pump fail for each pump:
  - Seal fail
  - High temp
  - Check valve fail to open
  - Generator exercise

- Generator running
- Generator fail
- Grinder fail

#### E. LEVEL CONTROL SYSTEM

1. The level control system shall start, adjust pump speed and stop the pump motors in response to changes in wet well levels, as set forth herein.
2. The primary level control sensor shall A multi-stage level sensing device (Level Sensing Probe) designed to detect liquid level at specified intervals in tanks or sumps and interface with an electronic controller for pump control and liquid level display. Rising and falling liquid level in the wet well causes capacitive switches within the probe to open and close, providing level signals for the level control components. Probes shall be manufactured by Flygt, FOGRod, or equal.
3. A secondary level control system shall be installed using a submerged liquid level pressure transducer manufactured by Flygt, Siemens, or approved equal.
4. The level control system shall allow for manual selection of the primary or secondary level sensors and should revert to the other in event of failure of either sensor.
5. The level control system use a PLC based PID controller to vary pump speed from the minimum speed to the maximum speed (as set in the VFD) across the operating range as show on the drawings as "Pump On" to "Pump Off". When the liquid is lowered to the "Pump Off", the system shall stop this pump. These actions shall constitute one pumping cycle. **Pumps shall be interlocked to not allow simultaneous operation in Automatic mode.** Should the wet well level rise above to the "Wet Well High" level an alarm shall be initiated. Should either the lead pump or both fail to start, a pump fail alarm shall be initiated and the control system shall alternate to the Lag pump.
6. The level control system shall utilize the pump alternator to select first one pump, then the second pump to run as lead pump for a pumping cycle. Alternation shall occur at the end of a pumping cycle.
7. Pump station manufacturer shall furnish separate float switch assemblies, signal relays, for high water alarm, dry well high and influent vault high (if applicable) functions. Should the levels rise to the alarm level, the float switch assembly and relay shall energize the signal relay. The signal relay shall complete a 115-volt AC circuit for an external alarm device. A standard duty, NEMA 4X pilot light mounted in the control panel shall indicate that a high level exists.

## G. ANCILLIARY EQUIPMENT:

The control system shall include, but not be limited to, the equipment listed below.

1. A green Square-D 30 mm L.E.D. run pilot indicator shall be mounted on the door.
2. An elapsed time meter (Crammer 635 E&S) shall be mounted on the dead front door. The meter shall operate on 120 vac, shall indicate in hours [6 digits] and tenths and shall be non-resettable.
3. A float back up circuit shall be provided utilizing a wide angle float and intrinsic relay with time delays and indication that circuit is active via a green Square-D 30 mm L.E.D. indicator.
4. A green Square-D 30 mm L.E.D. pump running indicator pilot light for each pump.

## H. MISCELLANEOUS

1. A final as built drawing encapsulated in mylar shall be attached to the inside of the front door. A list of all legends shall be included.
2. All component parts in the control panel shall be permanently marked and identified as they are indicated on the drawing. Marking shall be on the back plate adjacent to the component. All control conductors shall be identified with wire markers at each end as close as practical to the end of conductor with white heat shrink sleeves and black numbers
3. All panels shall be tested to the power requirements as shown on the plans to assure proper operation of all the components. Each control function shall be activated to check for proper indication.
4. All control equipment shall be guaranteed for a period of three [3] years minimum from date of shipment. The guarantee is effective against all defects in workmanship and /or defective component. The warranty is limited to replacement or repair of the defective equipment unless noted otherwise with additional requirements.
6. Control system components, Pump VFDs, motor starters and other major equipment shall be tested fully and all operational functionality confirmed before shipped to the project site. All field devices shall be simulated in this functional test before the control panel is delivered to the project site.

7. The control system supplier shall be required to be on site to commission the panel, make setting changes, make corrections and address problems found during commissioning of equipment.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

Equipment shall be installed in accordance with the supplier's installation instructions, and in compliance with all OSHA, local, state, and federal codes and regulations.

#### **3.2 MANUFACTURER'S SERVICES**

- A. The Contractor shall require the manufacturer to furnish the services of a qualified field engineer to perform the following functions in the designed periods of time. These services are to be performed at the jobsite. A minimum of two (2) visits to the job site shall be required. A one week notice to the Owner and Engineer shall be provided for activities defined in section 3.2 Manufacture's Services.
  1. Check-out of installation, start-up of equipment and initial operator instruction. This service shall take place after all mechanical equipment associated with the control system is installed and mechanically operable.
  2. After equipment is fully operational, and before Owner will assume responsibility for the operation of the equipment, the equipment manufacturer's representative shall instruct the Owner's operating personnel in the care, maintenance and proper operation of the equipment. Contractor shall submit Manufacture inspection and certification of proper installation including all data checked noting all initial details verified by Manufacture and initial set point established. Start up and certification of proper installation shall be included and submitted with the O&M
  3. Provide Operation and Maintenance training. Training time required shall be in addition to time required for start-up activities noted above. Training should include a minimum of two (2) hour of field training and class room training, as required to provide sufficient Manufacture's recommended training.
- B. Field Test

1. Prior to equipment startup, all equipment described herein shall be inspected for quiet operation, proper connections, and satisfactory performance by means of a functional test.
2. The pump and motor assembly shall be field tested to verify vibration is not in excess of the limits stated in the latest revision of Hydraulic Institute and NEMA MG 1.
3. The pump, motor, and controls shall be given an operational test in accordance with the standards of the Hydraulic Institute. Recordings of the test shall substantiate the correct performance of the equipment at the design head, capacity, speed and horsepower as specified herein. When a lift station effluent flow meter is not installed Contractor shall perform a wet well drawdown test to establish pump capacity.
4. Units apparently failing to meet the Specifications to the satisfaction of the Engineer must be more accurately tested in accordance with Hydraulic Institute Standards. If the pump fails the second test, the unit will be rejected, and the Contractor shall furnish a unit that will perform as specified.

C. Operation and Maintenance Materials

1. The pump manufacturer shall be responsible for supplying written instructions, which shall be sufficiently comprehensive to enable the operator to operate and maintain the pump and all equipment supplied by the manufacturer. Instructions shall assume that the operator is familiar with pumps, motors, piping, valves, and controls, but that he has not previously operated and/or maintained the exact equipment supplied.
2. The instructions shall be prepared as a system manual applicable solely to the pump and equipment supplied by the manufacturer to these specifications, and shall include those devices and equipment supplied by him.
3. Operation and maintenance instructions shall be specific to the equipment supplied in accordance with these specifications. Instruction manuals applicable to many different configurations and pumps, and which require the operator to selectively read portions of the instructions shall not be acceptable. To clarify these types of manuals mark through all information not applicable to equipment supplied.
4. Provide five (5) hard copies and 1 PDF version of the final O&Ms.

SUBMERSIBLE PUMP SYSTEM

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- D. All costs for the above manufacturer functions including travel, lodging, meals, and incidentals shall be considered to have been included in the Contractor's lump sum bid price.

END OF SECTION



## PART 1 GENERAL

### 1.1 SCOPE OF WORK

A. The Contractor shall procure the services of a single System Integrator to furnish all materials, equipment, labor and services, required to achieve a fully integrated and operational system as specified herein and in other Specification Sections listed below.

B. Auxiliary and accessory devices necessary for system operation or performance, such as transducers, relays, signal amplifiers, intrinsic safety barriers, and signal isolators, to interface with existing equipment or equipment provided by others under other Sections of these specifications, shall be included whether they are shown on the Drawings or not.

C. Substitutions on functions or type of equipment specified shall not be acceptable unless specifically noted. In order to confirm compatibility between all equipment, coordinate all interface requirements with mechanical and electrical systems and furnish any signal isolation devices that might be required.

D. Equipment shall be fabricated, assembled, installed and placed in operating condition in full conformity with the project Specifications, Drawings, engineering data, instructions, and recommendations of the equipment manufacturer as approved by the Engineer.

E. To facilitate the Owner's future operation and maintenance, similar products (e.g., differential pressure transmitters, SCADA I/O cards) shall be supplied from the same manufacturer.

F. All equipment and installations shall satisfy applicable Federal, State and local codes.

### 1.2 QUALITY ASSURANCE

A. The System Integrator shall be regularly engaged in the design and the installation of instrumentation systems and their associated subsystems as they are applied to the municipal water and wastewater industry.

### 1.3 NOMENCLATURE AND IDENTIFICATION

#### A. Field Instrument Tags

1. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as indicated in the Drawings, shall be provided on each piece of equipment supplied under this Section. Equipment shall be tagged before shipping to the site.

2. Provide 1/8-in by 3/8-in, Type 316 stainless steel button head machine screws.

3. All supplied field instrument transmitters and field instrument transmitter elements shall have a stainless steel identification tag attached to each transmitter

and element prior to shipment. Tag shall be attached via stainless steel chain or stainless steel wire (24 gauge min) to a non-removable part of the device. The tag size shall be a minimum of 1.5 square inches. Tag shall include the ISA alphanumeric instrument number as indicated in the P&ID, loop, and detail drawings. The alphanumeric instrument number shall be stamped into the tag and shall have a minimum of 3/16-in high alphanumeric characters.

#### 1.4 PROJECT/SITE REQUIREMENTS

##### A. Temperature:

1. Outdoor areas' equipment shall operate between -30 to 50 C degrees ambient.
2. Equipment located in indoor locations shall operate between 10 to 35 C degrees ambient minimum.
3. Storage temperatures shall range from 0 to 50 C degrees ambient minimum.
4. Additional cooling or heating shall be furnished if required by the equipment as specified herein.

B. Relative Humidity. Air conditioned area equipment shall operate between 20 to 95 percent relative, non-condensing humidity. All other equipment shall operate between 0 to 100 percent relative, condensing humidity.

#### PART 2 PRODUCTS

##### 2.1 PRODUCTS GENERAL

A. All instrumentation and electronic equipment shall be of the manufacturer's latest design, utilizing printed circuitry and epoxy or equal coating to prevent contamination by dust, moisture and fungus. The field mounted equipment and system components shall be designed for installation in dusty, humid and slightly corrosive service conditions.

B. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks unless otherwise noted. Fasteners for securing control panels and enclosures to walls and floors shall be either hot-dipped galvanized after fabrication or stainless steel.

C. All indicators shall be linear in process units, unless otherwise noted. All transmitters shall be provided with indicators in process units, accurate to two percent or better.

D. All equipment, cabinets and devices furnished shall be heavy-duty type, designed for continuous industrial service. The system shall contain similar products of a single manufacturer, and shall consist of equipment models, which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.

E. All electronic/digital equipment shall be provided with radio frequency interference protection.

##### F. Electrical

1. Equipment shall operate on a 60 Hertz alternating current power source at a nominal 120 volts, plus or minus 10 percent, except where specifically noted. Regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.
2. With the exception for field device network connected devices, all electronic instrumentation shall utilize linear transmission signals of isolated 4 to 20 mA DC (milliampere direct current) capable of driving a load up to 750 ohms, unless specified otherwise. However, signals between instruments within the same panel or cabinet may be 1-5 VDC (volts direct current).
3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero based signals will be allowed.
4. All switches shall have double-pole double-throw contacts rated at a minimum of 600 VA, unless noted otherwise.
5. Switches and/or signals indicating an alarm, failure or upset condition shall be wired to be closed in alarm.
6. Materials and equipment shall be UL approved. Where components are not available with UL approval, integrate the device with ground fault protective devices, isolation transformers, fuses, or other protective equipment necessary to achieve compliance with UL 508 requirements.
7. Equipment shall be constructed so that when a power interruption occurs, the equipment specified hereunder resumes normal operation without manual resetting when power is restored unless otherwise noted.
8. All transmitter output signals shall include signal and power source isolation.

## 2.2 LIGHTNING/SURGE PROTECTION

A. General - Lightning/Surge protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines from lightning, utility, or the internal plant electrical distribution system. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level. Protection shall be maintenance free and self-restoring. Ground wires for all instrumentation device surge protectors shall be connected to a good earth ground.

B. Field Instrumentation Protection - Provide individual device protection for the 4-20 mA signal and, if 4 wire field instrument, the power supply of each field instrument mounted outside of the building or facility housing the control panel. Instruments mounted within the structure as the associated control panel shall not require surge protection. Instruments shall be housed in a grounded metallic case. Device surge protectors shall be mounted within the instrument enclosure or a separate junction box coupled to the enclosure. Provide gas tube or metal oxide varistors (MOVs) surge protection devices as manufactured by Maxivolt (M.V.C. #ICP24).

- C. Control Panel Power Feed – Provide protection of all 120 VAC power feeds into the control panels. Source voltage to cabinets/panels regardless of location (indoor or outdoor), shall be protected by isolation transformers and surge suppressors. Provide gas tube surge suppressors or metal oxide varistors (MOVs) located at the point where the 120V source supply enters the enclosure. Install the surge device to in strict compliance with the manufacturer's recommendation for maximum allowable circuit length between protective device and incoming circuit. Provide signal surge suppression devices as manufactured by Maxivolt (M.V.C. #ICP-110-VSP).
- D. 4-20 mA Signal Lines and Non-Fiber Based Data Highway Circuits – Provide protection on all signal and data highway circuits that leave a building or are routed external to a building. Provide gas tube surge arrestors, and Zener diode protectors. Circuit protection shall be provided at both ends of the signal or data highway lines within the control panel at one end and as close to the instruments or termination device as possible. Provide signal surge suppression devices as manufactured by Maxivolt (MVC).
- E. Inductive Loads – At a minimum, provide coil surge suppression devices, such as varistors, or interposing relays on all process controller outputs or switches rated 120 VA or less that drive solenoid, coil, or motor loads.

## 2.3 SPARE PARTS

- A. Spare parts of the type and quantity as recommended by the manufacturer shall be furnished for all devices furnished under these sections.
- B. All spare parts shall be wrapped in bubble wrap, sealed in a polyethylene bag complete with dehumidifier, then packed in cartons and labeled with indelible markings. Complete ordering information including manufacturer's part number, part ordering information including manufacturer, part number, part name, and equipment name and number(s) for which the part is to be used shall be supplied with the required spare parts. The spare parts shall be delivered and stored in a location directed by the Engineer.
- C. As a minimum, furnish the following spare parts for control panels:
1. Timers - Five of each type installed.
  2. Relays - Five of each type installed.
  3. Fuses and circuit breakers - 10% (minimum of 10 fuses and 2 circuit breakers) of each type and size installed.
  4. Light bulbs - 10% (minimum of 10) of each type installed.
  5. Power supplies - one of each type installed.
  6. Manufacturer's cables - one of each type installed.
  7. Selector switches/pushbuttons - Two of each type installed including 5 contact blocks.
  8. Surge protection devices - One of each type installed.

9. Provide one quart of touch-up paint, for each type and color used for all RTU cabinets, panels, and consoles supplied.
10. Provide and install one fuse, small parts and O&M manual cabinet large enough to store all spare parts and one full set of O&M manuals in 3 ring binders.

D. PLC components

1. One spare CPU of each type supplied
2. Two spare I/O modules of each type supplied
3. One spare specialty interface module of each type supplied
4. One spare remote I/O communication module of each type supplied
5. One spare communications module of each type supplied.
6. One spare power supply of each type supplied
7. One spare type of each communication cable supplied

PART 3 EXECUTION

3.1 GENERAL INSTALLATION

A. Instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions. The locations of equipment, transmitters, alarms and similar devices indicated are approximate only. Exact locations of all devices shall be as approved by the Engineer during construction. Obtain in the field, all information relevant to the placing of process control equipment and in case of any interference with other work, proceed as directed by the Contractor and furnish all labor and materials necessary to complete the work in an approved manner at no additional cost to the Owner.

B. The Drawings indicate the intent and not the precise nature of the interconnection between the individual instruments. Where indicated on the Drawings as not requiring installation, provide the instruments suitably packaged for storage.

C. Unless specifically indicated, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, 5-valve manifolds for calibration, testing and blow down service shall also be provided. For chemical or corrosive fluids, diaphragm seals with flushing connections shall be provided.

D. All piping and tubing to and from field instrumentation shall be provided with necessary unions, calibrations and test tees, couplings, adaptors, and shut-off valves. Process tubing shall be installed to slope from the instrument toward process for gas measurement service and from the process toward the instrument for liquid measurement service. Provide drain/vent valves or fittings at any process tubing points where the required slopes cannot be maintained.

E. Brackets and hangers required for mounting of equipment shall be provided. They shall be installed as shown and not interfere with any other equipment.

F. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded at only one ground point for each shield.

END OF SECTION

## PART 1 GENERAL

## 1.01 SCOPE OF WORK

- A. Furnish all labor, materials and equipment required and install complete and make operational, electrical system as shown on the Drawings and as specified herein.
- B. The work shall include the following:
  - 1. Coordinate the electrical service requirements with the power company and provide the electrical service(s) from the Power Company at the locations indicated.
  - 2. Provide conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions.
  - 3. Provide conduit, wiring and terminations for variable frequency drives, reactors, harmonic filters, transformers and power factor correction capacitors furnished and mounted under other related Divisions.
- C. Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the existing buildings and structures in which work under this sub-bid is to be performed and inspect carefully the present installation. The submission of the proposal by this bidder shall be considered evidence that their representative has visited the buildings and structures and noted the locations and conditions under which the work will be performed and that he/she takes full responsibility for a complete knowledge of all factors governing his/her work.

## 1.02 SUBMITTALS

- A. As a minimum all equipment specified in each Section of Division 16 shall be submitted at one time. As an example all lighting fixtures shall be submitted together, all motor control centers shall be submitted together, etc. Submittals that do not comply will be returned disapproved.
- B. Mark submittals to clearly identify proposed equipment including accessories, options, and features and to exclude parts not applicable to the project. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submittal piece of literature and each submittal drawing shall clearly reference the Project Specification and/or Contract Drawing that the submittal is to cover. General catalogs will not be accepted as cut sheets to fulfill submittal requirements.
- C. Check shop drawings for accuracy prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to this Section and the Drawings. This statement shall also list all exceptions to this Section and the Drawings. Mark submittals to identify proposed equipment including accessories, options and features being proposed for approval and exclude parts not to be used. Shop drawings not so checked and noted shall be returned marked NOT APPROVED.

- D. The Engineer's check shall be for conformance with the design concept of the project and compliance with this Section and the Drawings. Errors and omissions on approved shop drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by this Section and the Drawings.
- E. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.
- F. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered or shop work started if shop drawings are marked "APPROVED AS NOTED - CONFIRM," "APPROVED AS NOTED - RESUBMIT" or "NOT APPROVED."
- G. Operation and Maintenance Data
  - 1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with Section 01730. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists including replacement part numbers, to instruct operating and maintenance personnel unfamiliar with such equipment.
  - 2. Manuals shall include the following as a minimum:
    - a. A complete "As-Built" set of approved shop drawings.
    - b. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data, model number, size, and quantity.
    - c. Detailed service, maintenance and operation instructions for each item supplied.
    - d. JPEG photos of equipment data tags.
    - e. JPEG photos of underground installations.
- H. Exceptions for Submittals
  - 1. Exceptions to the Specifications or Drawings shall be clearly defined by the Electrical Subcontractor in a separate section of each submittal package. The submittal shall contain the reason for the exception, the exact nature of the exception and the proposed substitution so that a proper evaluation may be made by the Engineer. The acceptability of any device or methodology submitted as an "or equal" or "exception" to the Specifications shall be at the sole discretion of the Engineer.
    - a. By noting the term "compliance", it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
    - b. By noting the term "deviation", it shall be understood that the manufacturer prefers to provide a different component in lieu of the one specified and in so doing, takes full responsibility for making the equipment work as specified and will provide any and all ancillary components to make the equipment work at no extra cost to the Owner.



- c. By noting the term “alternate”, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner and in so doing, takes full responsibility for making the equipment work as specified and will provide any and all ancillary components to make the equipment work at no extra cost to the Owner. The alternate method shall be fully described with schematic diagrams and one-line diagrams as applicable.

#### 1.03 REFERENCE STANDARDS

- A. Electric equipment, materials and installation shall comply with the National Electrical Code (NEC).
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

#### 1.04 PRIORITY OF THE CONTRACT DOCUMENTS

- A. If, during the performance of the work, the Contractor finds a conflict, error or discrepancy between or among one or more of the Sections or between or among one or more Sections and the Drawings, furnish the higher performance requirements. The higher performance requirement shall be considered the equipment, material, device or installation method which represents the most stringent option, the highest quality or the largest quantity.
- B. In all cases, figured dimensions shall govern over scaled dimensions, but work not dimensioned shall be as directed by the Engineer and work not particularly shown, identified, sized, or located shall be the same as similar work that is shown or specified.
- C. Detailed Drawings shall govern over general drawings, larger scale Drawings take precedence over smaller scale Drawings, Change Order Drawings shall govern over Contract Drawings and Contract Drawings shall govern over Shop Drawings.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Contractor, unless otherwise directed by the Engineer.
- E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times

#### 1.05 ENCLOSURE TYPES

- A. Unless otherwise required, electrical enclosures shall be NEMA Types as follows:
  1. NEMA 4 in outdoor locations, rooms below grade including basements and buried vaults and "WET" locations shown on the Drawings.

2. NEMA 4X in "CORROSIVE" locations shown on the Drawings.

#### 1.06 SERVICE AND METERING

- A. Service will be obtained at 480 Volts, 3 Phase, 4 Wire, 60 Hz.
- B. The Contractor shall be responsible for the following work:
  1. Obtain an estimate from the power company for the work described above and include the cost of the power company work in the Bid Price.
  2. Make all arrangements with the power company for obtaining electrical service, pay all power company charges.

#### 1.07 CODES, INSPECTION AND FEES

- A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.
- B. Obtain all necessary permits and pay all fees required for permits and inspections.

#### 1.08 INTERPRETATION OF DRAWINGS

- A. Unless specifically stated to the contrary, the Drawings do not show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.
- B. Install each 3 phase circuit in a separate conduit unless otherwise shown on the Drawings.
- C. Conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed. Unless otherwise indicated install branch circuit conduits exposed in process/ industrial type spaces and concealed in finished spaces.
- D. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation. Where home-runs indicate conduit is to be installed concealed or exposed the entire branch circuit shall be installed in the same manner.
- E. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
- F. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Exact locations shall be determined by the Contractor and approved by the Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

- G. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials to install and place in satisfactory operation all power, lighting and other electrical systems shown.
- H. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at his/her own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his/her own or others, caused by such redesign.
- I. Raceways and conductors for low voltage (120 Volts) thermostats controlling HVAC unit heaters, exhaust fans and similar equipment are not shown on the Drawings. Provide raceways and conductors between the thermostats, the HVAC equipment and the motor starters for a complete and operating system. Raceways shall be installed concealed in all finished space and may be installed exposed in process spaces. Refer to the HVAC drawings for the locations of the thermostats.

#### 1.09 SIZE OF EQUIPMENT

- A. Investigate each space in the structure through which electrical equipment furnished under Division 16 must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.
- B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

#### 1.10 RECORD DRAWINGS

- A. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called the "As Builts". Include digital photographs in JPEG format of all underground installations.

#### 1.11 MATERIALS AND EQUIPMENT

- A. Materials and equipment furnished under this contract shall be new.
- B. Material and equipment of the same type shall be the product of one manufacturer and shall be UL listed.

#### 1.12 EQUIPMENT IDENTIFICATION

- A. Identify equipment, disconnect switches, separately mounted motor starters, control stations, etc. furnished under Division 16 with the name of the equipment it serves. Motor control centers, control panels, panelboards, switchboards, switchgear, junction or terminal boxes, transfer switches, etc, shall have nameplate designations as shown on the Drawings.
- B. Nameplates shall be engraved, laminated plastic, not less than 1/16-in thick by 3/4-in by 2-1/2-in with 3/16-in high white letters on a black background.

- C. Nameplates shall be screw mounted to NEMA 1 enclosures. Nameplates shall be bonded to all other enclosure types using an epoxy or similar permanent waterproof adhesive. Two sided foam adhesive tape is not acceptable. Where the equipment size does not have space for mounting a nameplate the nameplate shall be permanently fastened to the adjacent mounting surface.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

### 3.01 SLEEVES AND FORMS FOR OPENINGS

- A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all slots for electrical work and form before concrete is poured.
- B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other subcontractors and locate the concealed conduit before the floor slab is poured.
- C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

### 3.02 CUTTING AND PATCHING

- A. Cutting and patching shall be done in a thoroughly workmanlike manner and be in compliance with modifications and repair to concrete as specified. Saw cut concrete and masonry prior to breaking out sections.

### 3.03 INSTALLATION

- A. Work not installed according to the Drawings and Specification shall be subject to change as directed by the Engineer at Contractor's expense.
- B. Electrical equipment shall be protected against mechanical and water damage. Store all electrical equipment in dry permanent shelters. Do not install electrical equipment in place until structures are weather-tight.
- C. Damaged equipment shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion and at the Contractor's expense.
- D. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer.

## 3.04 WORK SUPERVISION

- A. The Contractor shall designate in writing the qualified electrical supervisor who shall provide supervision to all electrical work on this project. The minimum qualifications for the electrical supervisor shall be a unlimited journeyman electrician as defined by Oklahoma Construction Industries Board. The supervisor or his appointed alternate possessing at least a journeyman electrician license shall be on site whenever electrical work is being performed. The qualifications of the electrical supervisor shall be subject to approval of the Owner and the Engineer.

END OF SECTION

## PART 1 GENERAL

## 1.01 SCOPE OF WORK

- A. Furnish and install complete raceway systems as shown on the Drawings and as specified herein.
- B. Home runs indicated are to assist the contractor in identifying raceways to be installed concealed or exposed. Raceways identified to be installed exposed on the Drawings shall be run near the ceilings or along the walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes and hoists, lighting fixtures, doors and hatches. Raceways indicated to be run concealed shall be run in the center of concrete floor slabs, in partitions, or above hung ceilings, as required.

## PART 2 PRODUCTS

## 2.01 RACEWAYS AND FITTINGS

- A. Steel Conduit and Fittings
  - 1. Rigid metal conduit (GRS), couplings, factory elbows and fittings shall be heavy wall steel tubing with a hot-dipped galvanized finish inside and out after threading and shall comply with ANSI C 80.1 and UL/6.
  - 2. Acceptable manufacturers:
    - a. Allied Tube & Conduit Corp.
    - b. LTV Steel Tubular Products Corp.
    - c. Triangular PWC Inc.
    - d. Or equal.
  - 3. Rigid metal and intermediate metal conduit fittings shall be of the threaded type, and shall be steel or malleable iron, with a hot-dipped galvanized finish. Threadless fittings and split couplings are not allowed except in specific applications as approved by the Engineer.
  - 4. Acceptable manufacturers:
    - a. Appleton Electric Co.
    - b. O-Z Gedney Co.
    - c. RACO Inc.
    - d. Gould/Efcor
    - e. Steel City
    - f. Or equal

**B. 316 Stainless Steel Conduit and Fittings**

1. Stainless Steel Conduit shall be manufactured in type 316 stainless steel.
2. Acceptable manufacturers:
  - a. Calbrite
  - b. Thomas & Betts
  - c. Or equal

**2.02 BOXES AND FITTINGS****A. Dry and Damp Location Boxes and Fittings**

1. Outlet boxes shall be zinc-galvanized, extra depth, pressed steel with knockouts and of size and type suitable for the intended application.
2. Boxes that are less than 100 cubic inches in size used for junction or pull boxes shall be zinc galvanized pressed steel not less than 14 USS gauge with appropriate blank covers, minimum size 4-11/16-in square by 2-1/8-in deep.
3. Boxes that are 100 cubic inches and larger shall be constructed of hot dip galvanized sheet steel without knockouts. Covers shall be secured with round head brass machine screws. All joints shall be welded and ground smooth.
4. Terminal cabinets shall be NEMA 12 sheet steel unless otherwise shown on the Drawings. Boxes shall be painted and have continuously welded seams. Welds shall be ground smooth and galvanized. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Terminal boxes shall be furnished with latching hinged doors, terminal mounting straps and brackets. Terminal blocks shall be rated not less than 20A, 600V.
5. Acceptable Manufacturers:
  - a. Appleton
  - b. Raco
  - c. Steel City
  - d. Hoffman
  - e. Electromate Division of Robroy Ind.
  - f. Wiegmann

**B. Wet Location Boxes and Fittings**

1. NEMA 4 terminal boxes, junction boxes, pull boxes, etc, shall be sheet Type 316 stainless steel unless otherwise shown on the Drawings. Boxes shall have continuously welded seams and mounting feet. Welds shall be ground smooth. Boxes shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Covers shall be gasketed and fastened with stainless steel quick latches (interface enclosures shall be pad lockable). Terminal boxes shall be furnished with hinged doors, terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20 Amps, 600 Volt.
2. Cast or malleable iron device boxes shall be Type FD. Boxes and fittings shall have cadmium-zinc finish with cast covers and stainless steel screws.
3. Cast aluminum device boxes shall be Type FD. Boxes and fittings shall be copper free aluminum with cast aluminum covers and stainless steel screws
4. Acceptable Manufacturers:
  - a. Appleton
  - b. Crouse-Hinds
  - c. Steel City
  - d. Hoffman
  - e. Electromate - Division of Robroy Ind.
  - f. Or equal

## 2.03 HARDWARE

### A. Conduit Mounting Equipment

1. In dry indoor areas, hangers, rods, backplates, beam clamps, channel, etc shall be galvanized iron or steel.
2. Stainless steel 316 S.S. channel with stainless steel hardware shall be used in areas designated "WET" or "CORROSIVE" on the Drawings and in outdoor locations.
3. Furnish any and all necessary supports, brackets, conduit sleeves, racks and bracing as required. All boxes and hardware shall be galvanized zinc plated steel except that stainless steel 316 S.S. shall be used in areas designated as "WET" or "CORROSIVE" on the Drawings.

## PART 3 EXECUTION

### 3.01 RACEWAY APPLICATIONS

- A. Refer to Table 16110-1 for specific raceway application requirements.
- B. All conduit of a given type shall be the product of one manufacturer.



## 3.02 BOX APPLICATIONS

- A. Terminal boxes, junction boxes and pull boxes shall have NEMA ratings suitable for the location in which they are installed.
- B. All conduit bodies and pulling outlets shall comply with NEC wire bending space requirements. Mogul type fittings shall be used for sizes 2-1/2-in and larger.

<b>TABLE 16110-1</b> <b>Raceway Application Guidelines</b>	
<b>Location/Circuit Type</b>	<b>Raceway Type</b>
<u>All locations</u> <ul style="list-style-type: none"> <li>▪ Class 2 and 3 signal wiring and 4-20 mA instrumentation cables, non-fiber (copper) data highway.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Exposed - Galvanized rigid steel (GRS) conduit. Use 316 stainless steel conduit in corrosive areas.</li> <li>▪ Concealed - Galvanized rigid steel (GRS) conduit.</li> <li>▪ Underground - Galvanized rigid steel (GRS)</li> <li>▪ Use PVC coated steel conduit for single conduit direct burial applications.</li> </ul>
<u>Clean, dry non-finished areas</u> - electrical rooms, generator rooms, mechanical rooms, pump rooms, shops, dry storage, etc.	<ul style="list-style-type: none"> <li>▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits – electrical metallic tubing (EMT)</li> <li>▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – Galvanized rigid steel GRS.</li> </ul>
<u>Corrosive areas</u> - chemical storage and handling areas, underground vaults, within tanks, wetwells, or clearwells, filter pipe galleries and locations where designated corrosive on the Drawings.	<ul style="list-style-type: none"> <li>▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits – 316 stainless steel conduit.</li> <li>▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – Galvanized rigid steel GRS</li> </ul>
<u>Hazardous areas</u> - all locations - Class 1, Division 1 and 2.	<ul style="list-style-type: none"> <li>▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits - 316 stainless steel conduit.</li> <li>▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits - 316 stainless steel conduit.</li> </ul>
<u>Outdoor areas</u> - all locations.	<ul style="list-style-type: none"> <li>▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits - Galvanized rigid steel (GRS).</li> <li>▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – Galvanized rigid steel (GRS)</li> </ul>

## 3.3 FITTINGS APPLICATIONS

- A. Combination expansion-deflection fittings shall be used where exposed conduits cross structure expansion joints or in straight runs where expansion is anticipated. Combination expansion-deflection fittings shall be installed where embedded conduits cross structural expansion joints. Refer to Structural Drawings for expansion joint locations. Provide bonding jumpers around fittings.
- B. All underground conduit penetrations at walls or other structures shall be sealed watertight. Conduit wall seals and sleeves shall be used in accordance with the manufacturer's installation instructions and the details shown on the Drawings.

- C. Conduit sealing bushings shall be used to seal conduit ends exposed to the weather and at other locations shown on the Drawings.
- D. Gas Containment Area Sealing
  - 1. Internally and externally seal each conduit entering or leaving any area containing noxious gases to prevent contamination into clean areas via the conduit system. Areas requiring this protection are rooms where chlorine, ammonia and ozone are stored, generated or handled. Caulking material for conduit internal use shall be synthetic elastomer type, 3M, Series CP25 or equal. External sealing shall be in accordance with the typical details shown on the Drawings.
- E. Insulated throat grounding bushings shall be used where specified herein and where conduits stub up into electrical equipment such as MCC's, switchgear, etc.

### 3.04 INSTALLATION

- A. No conduit smaller than 3/4-in electrical trade size shall be used, nor shall any have more than the equivalent of three 90 degree bends in any one run. Pull boxes shall be provided as required by the NEC after every 270 degrees of bends and for straight run not to exceed 200 feet or as directed.
- B. All conduit which may under any circumstance contain liquids such as water, condensation, liquid chemicals, etc, shall be arranged to drain away from the equipment served. If conduit drainage is not possible, conduit seals shall be used to plug the conduits. The ends of all conduits shall be temporarily plugged to exclude dust, moisture and debris from entering during construction.
- C. Conduit ends exposed to the weather shall be sealed with conduit sealing bushings.
- D. Conduits noted as spare shall be capped or plugged at both ends with easily removable fittings.
- E. Conduit terminating in NEMA 3R, 4, 4X enclosures shall be terminated with Myers type conduit hubs.
- F. Conduit terminating in pressed steel boxes shall have double locknuts and insulated bushings.
- G. Conduits containing equipment grounding conductors and terminating in sheet steel boxes shall have insulated throat grounding bushings.
- H. Conduits shall be installed using threaded fittings except for EMT.
- I. The use of running threads is prohibited. Where such threads are necessary, a 3-piece union shall be used.
- J. All conduits entering or leaving a motor control center, switchboard or other multiple compartment enclosure shall be stubbed up into the bottom horizontal wireway or other manufacturer's designated area, directly below the vertical section in which the conductors are to be terminated. The 3-in extension of conduit above the floor slab or concrete equipment pad may be reduced to a dimension that suits the equipment manufacturer's installation requirements if the 3-in stub-up interferes with the equipment being provided.

- K. Rigid galvanized steel conduits buried in earth shall be completely painted with bitumastic.
- L. Rigid galvanized steel conduits which have been field cut and threaded shall be painted with cold galvanizing compounds.
- M. PVC coated rigid galvanized steel conduit shall be used for elbows at risers at the utility pole for electrical and telephone service conduits. Rigid galvanized steel conduit shall be used at utility pole for electrical and telephone service and fire alarm conduits to a height of 10-ft above finished grade. Furnish and install weather heads at service pole riser if required by utility company.
- N. Liquid-tight flexible metal conduit shall be used for all motor terminations, the primary and secondary of transformers, generator terminations and other equipment where vibration is present or may require removal.
- O. Flexible couplings shall be used in hazardous locations for all motor terminations and other equipment where vibration is present.
- P. PVC coated rigid steel conduit shall be used as a transition section where concrete embedded conduit stubs out of floor slabs or through below grade walls or where conduit installed under building slabs on grade stub out of floors. The PVC coated rigid steel conduit shall extend a minimum of 3-in into and out of the floor slab, concrete pad, or wall to allow for proper threading of the conduit.
- R. Conduit supports, other than for underground raceways, shall be spaced at intervals not exceeding the distance required by the NEC to obtain rigid construction.
- S. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the surface. Multiple runs of conduits shall be supported on fabricated channel trapeze type racks with steel horizontal members and threaded hanger rods. The rods shall be not less than 3/8-in diameter. Surface mounted panel boxes, junction boxes, conduit, etc, shall be supported by spacers to provide a minimum of 1/2-in clearance between wall and equipment.
- T. Conduit Supports (Other than Underground Raceways)
  - 1. Flush Mounted Supports
    - a. Support shall be spaced 10-ft or less, as required to obtain rigid conduit construction.
    - b. Attachment to concrete shall be with cast-in-place inserts, cast-in place welded plates with welded studs or stainless adhesive anchors.
  - 2. Conduit Racks
    - a. Support shall be spaced 10-ft or less, as required to obtain rigid conduit construction.
    - b. Horizontal seismic restraints shall be spaced at 30-ft or less.
    - c. Attachment to concrete shall be with cast-in-place inserts, cast-in place welded plate with welded studs or stainless adhesive anchors.

4. Conduit Hangers
  - a. Conduit hangers shall be vertical supported 10-ft or less, as required to obtain rigid conduit construction.
  - b. Lateral seismic restraints (Sway Bracing) shall be spaced 20-ft or less.
  - c. Horizontal seismic restraints shall be spaced at 30-ft or less. There shall be at least one horizontal restraint per horizontal run.
  - d. Attachment to structural steel shall be by beam clamps or welded beam attachment. C-clamps will not be allowed for vertical hangers. Side beam clamps with beam hooks shall be used for seismic restraint only.
  - e. Attachment to concrete shall be cast-in-place inserts, cast-in place welded plates with welded studs or stainless steel adhesive anchors.
5. All reinforcing bars shall be located by the Electrical Subcontractor with the use of a rebar locator prior to installing adhesive capsule type anchors. Mark the location of all reinforcing bars in an area bounded by a line drawn at least 18-in from the edge of the support bearing/weld plates on all four sides of the bearing/weld plates prior to fabricating and installing bearing/weld plates.
6. Where interference occurs, adjust anchor locations to clear reinforcing bars and alter support configuration at no additional cost to the Authority.
- U. Miscellaneous steel for the support of fixtures, boxes, transformers, starters, contactors, panels and conduit shall be furnished and installed. Channel supports shall be ground smooth and fitted with plastic end caps.
- V. Steel hot dipped galvanized channels shall be furnished and installed for the support of all electrical equipment and devices, where required, including all anchors, inserts, bolts, nuts, washers, etc, for a rigid installation. Channel supports shall be ground smooth and fitted with plastic end caps.
- W. 3/16-in polypropylene pull lines shall be installed in all new conduits noted as spares or designated for future equipment. Conduit noted as spare shall be capped or plugged at both ends with easily removable fittings
- X. Where no type or size is indicated for junction boxes, pull boxes or terminal cabinets, they shall be sized in accordance with the requirements of NEC Article 314. Enclosure type and material shall be as specified herein.
- Y. Pull or junction boxes shall be furnished and installed where shown on the Drawings, in every 200 feet of straight conduit runs or in runs where more than the equivalent of four 90 degree bends occur or at any point necessary for wire pulling and splicing. Splices shall not be made in pulling elbows.

END OF SECTION

## PART 1 GENERAL

## 1.01 SCOPE OF WORK

- A. Furnish, install and test all wire, cable and appurtenances as shown on the Drawings and as specified herein.

## 1.02 DELIVERY, STORAGE AND HANDLING

- A. Carefully handle all conductors to avoid kinks and damage to insulation.

## PART 2 PRODUCTS

## 2.01 GENERAL

- A. Wires and cables shall be of annealed, 98 percent conductivity, soft drawn copper.
- B. All conductors shall be stranded, except that lighting and receptacle wiring may be solid.
- C. Except for control, signal and instrumentation circuits, wire smaller than No. 12 AWG shall not be used.
- D. Wire shall have 600 Volt insulation except where indicated otherwise.

## 2.02 BUILDING WIRE

- A. Wire for lighting, receptacles and other circuits not exceeding 150 Volts to ground shall be NEC type THHN/THWN as manufactured by General Cable.; American Insulated Wire Corp.; Southwire Co.; or equal.
- B. Wire for circuits over 150 Volts to ground within buildings and structures shall be NEC type THHN/THWN as manufactured by General Cable.; American Insulated Wire Corp.; Southwire Co.; or equal.
- C. Wire for circuits over 150 Volts to ground used underground or for service entrance shall be NEC type RHH-RHW-2/USE-2, flame retardant and CT rated as manufactured by The Okonite Co.; General Cable.; American Insulated Wire Corp.; or equal.
- D. Bare copper ground wire shall be stranded, annealed copper wire ASTM-B3 alloy coated soft copper electrical wire ASTM B189.
- E. Equipment grounding conductors shall be NEC Type THW green and sized in accordance with NEC Table 250-122. Ground grid conductors shall be insulated unless shown otherwise on the Drawings.

## 2.3 CONTROL, STATUS AND ALARM WIRE

- A. Wire shall be No.16 AWG NEC type THHN/THWN stranded as manufactured by The Okonite Co.; General Cable.; American Insulated Wire Corp.; Southwire Co.; or equal.

## 2.04 INSTRUMENTATION WIRE

- A. Wire for process instrumentation signals (i.e. 1-5 VDC, 4-20 mA DC), R.T.D., potentiometer and similar signals shall be:
1. Single pair cable:
    - a. Conductors: 2 No. 16 stranded and twisted on 2-in lay
    - b. Insulation: XLP with 600 Volt, 105 degrees C rating
    - c. Shield: 100% Aluminum/polyester foil with drain wire
    - d. Jacket: PVC with UL Subject 13, UL 1581 and manufacturers' identification
    - e. Max overall diameter: 0.262-in
    - f. Miscellaneous: UL Listed as Instrument Tray Cable for use in accordance with Article 727 and Article 725 of the NEC.
    - g. Manufacturers: Belden; Manhattan; General Cable; The Okanite Co.; or equal

## 2.5 SPLICES (POWER CONDUCTORS)

- A. Unless otherwise indicated on the Drawings, splices shall not be made in the cables without prior written approval of the Engineer. Where splicing is approved by the Engineer, splicing materials for all 600 Volt splices shall be made with long barrel, tin plated copper compression (hydraulically pressed) connectors and insulated with heavy wall heat shrinkable tubing. The conductivity of all completed connections shall be not less than that of the uncut conductor. The insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.
- B. Wire lugs shall be tin plated copper, long barrel compression type (hydraulically pressed) for wire sizes No. 8 AWG and larger. Lugs for No. 10 AWG and smaller wire shall be locking spade type with insulated sleeve. Lugs shall be as manufactured by the Thomas and Betts Co.; Burndy; Amp; or equal.
- C. Compression type connectors shall be insulated with a heat shrink boot or outer covering and epoxy filling. Splice kits shall be as manufactured by Raychem (Tyco); Ideal Industries; 3M Co. or equal.
- D. Solderless pressure connectors shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air. Connectors shall be sized according to manufacturer's recommendations. The connectors shall be UL listed and CSA approved, as manufactured by King Innovation; Ideal Industries, Inc., or equal.

## 2.06 MOTOR CONNECTIONS

- A. Motor connections shall be ring type mechanical compression terminations installed on the branch circuit wires and the motor leads and secured with bolt, nut and springwasher. Connections shall be insulated with a Raychem Type RVC, roll-on stub insulator; Thomas & Betts, Shrink-Kon MSCV20; or equal. For wire sizes NO. 8 and larger, long barrel, tin plated copper compression (hydraulically pressed) type connections Burndy Co., or equal) shall be installed on the branch circuit wires and the motor leads. Connections shall be insulated with heavy duty heat shrinkable material (Raychem Corp., or equal.

#### 2.07 TERMINATION AND SPLICES (CONTROL, STATUS AND ALARM CONDUCTORS)

- A. Termination connectors shall be of the locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.
- B. Insulated compression type connectors shall be of the expanded vinyl insulated parallel or pigtail type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.
- C. Solderless pressure connectors shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air. Connectors shall be sized according to manufacturer's recommendations. The connectors shall be UL listed and CSA approved, as manufactured by King Innovation; Ideal Industries, Inc or equal.

#### 2.08 TERMINATIONS (INSTRUMENTATION CABLES)

- A. Termination connectors shall be of the locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.

#### 2.09 WIRE AND CABLE MARKERS

- A. All wire and cable markers shall be heat shrink white with black numbers.
- B. Wire and cable markers shall be "Omni-Grip" as manufactured by the W.H. Brady Co.; Thomas & Betts Co., SMS; 3M Co., STD-TAG; or equal.
- C. Wire and cables with diameters exceeding the capacity of the "Omni-Grip" shall be marked with pre-printed, self-adhesive vinyl tapes as manufactured by the W.H. Brady Co.; Panduit Corp.; 3M Co.; or equal.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Uniquely identify all wires, cables and each conductor of multi-conductor cables (except lighting and receptacle wiring) at each end and in all manholes, hand holes and pull boxes with wire and cable markers.
- B. Use lubrications to facilitate wire pulling. Lubricants shall be UL approved for use with the insulation specified.

- C. Provide multi-conductor control and signal cables within the underground system. Cables shall be installed continuous from building to building without splices. Individual control conductors and twisted shielded pairs signal cables will not be allowed in underground systems.
- D. The crimping tools used in securing the conductor in the compression type connectors or terminal lugs shall be those made for that purpose and for the conductor sizes involved. The crimping tool shall be the ratchet type which prevents the tool from opening until the crimp action is completed. Such tools shall be a product of the connector manufacturer.
- E. Install an equipment grounding conductor in all raceways.
- F. Seal openings in slabs and walls through which wires and cables pass.
- G. Pull cables from the direction that requires the least tension. Use a feed-in tube and sheave designed for cable installation. Use sheaves with radii that exceed the cable manufacturer's recommended minimum bending radius. Use a dynamometer and constant velocity power puller. Velocity should not be less than 15-ft./min. or more than 50-ft./min. Do not exceed the cable manufacturer's maximum recommended tension.
- H. If cable can not be terminated immediately after installation, install heat shrinkable end caps.

### 3.02 WIRE COLOR CODE

- A. All wire shall be color coded or coded using electrical tape in sizes where colored insulation is not available. Where tape is used as the identification system, it shall be applied in all junction boxes, manholes and other accessible intermediate locations as well as at each termination.
- B. The following coding shall be used:

<u>System</u>	<u>Wire</u>	<u>Color</u>
240/120 Volts Single-Phase, 3 Wire	Neutral	White
	Line 1	Black
	Line 2	Red
208Y/120, Volts 3 Phase, 4 Wire	Neutral	White
	Phase A	Black
	Phase B	Red
	Phase C	Blue
240/120 Volts 3 Phase, 4 Wire delta, center tap ground on phase coil A-C	Neutral	White
	Phase A	Black
	Phase B (High)	Orange
	Phase C	Blue
480Y/277 Volts 3 Phase, 4 Wire	Neutral	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow



- C. Neutral or ground wires that terminate in a Panelboard and require color tape shall have the color tape extend at least 6-in from the termination point.

### 3.03 TERMINATIONS AND SPLICES

- A. Power conductors: Unless otherwise indicated on the Drawings, no splices may be made in the cables without prior written approval of the Engineer. Where splicing is approved, terminations shall be die type or set screw type pressure connectors as specified. Splices (where allowed) shall be die type compression connector and waterproof with heat shrink boot or epoxy filling for copper conductors # 4 AWG and larger. Splices shall be solderless pressure connectors with insulating covers for copper conductors # 6 AWG and smaller. Aluminum conductors (where specified) shall employ terminations and splices specifically designed for aluminum conductors.
- B. Control Conductors: Termination on saddle-type terminals shall be wired directly with a maximum of two conductors. Termination on screw type terminals shall be made with a maximum of two spade connectors. Splices (where allowed) shall be made with insulated compression type connectors.
- C. Instrumentation Signal Conductors (including graphic panel, alarm, low and high level signals): terminations same as for control conductors. Splices allowed at instrumentation terminal boxes only.
- D. Except where permitted by the Engineer no splices will be allowed in manholes, handholes or other below grade located boxes.
- E. Splices shall not be made in push button control stations, control devices (i.e., pressure switches, flow switches, etc), conduit bodies, etc.

### 3.04 INSTRUMENTATION CABLES

- A. Instrumentation cables shall be installed in rigid steel raceways as specified. All circuits shall be installed as twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever three wire circuits are required.
- B. Terminal blocks shall be provided at all instrument cable junction and all circuits shall be identified at such junctions.
- C. Shielded instrumentation wire, coaxial, data highway, I/O and fiber optic cables shall be run without splices between instruments, terminal boxes, or panels.
- D. Ground shielding on instrumentation wires at one end only as recommended by the instrument manufacturer and isolated at all other locations. Terminal blocks shall be provided for inter-connecting shield drain wires at all junction boxes. Where individual circuit shielding is required, each shield circuit shall be provided with its own block.
- E. Install shielded instrumentation wire in conduit and pull boxes that contain only shielded instrumentation wire. Instrumentation cables shall be separated from all other (i.e. power, control, etc.) cables in manholes by enclosing them within rigid steel raceways and boxes.
- F. Shielded cable terminations at each end shall be provided with heat shrinkable tubing placed over the exposed shield and conductors. The tubing shall extend 1-in minimum over the jacket

end and extend 0.5-in minimum from the jacket end over the exposed conductors.

3.05 FIELD TESTING

- A. Test all 600 Volt wire insulation with a megohmmeter after installation and prior to termination. Make tests at not less than 1000 Volts DC. Test duration shall be one minute. Submit a written test report of the results to the Engineer. Notify the Engineer in writing 48 hours prior to testing.
- B. Field testing and commissioning shall be done in accordance with the latest revision of the "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" published by the International Electrical Testing Association (NETA Standard ATS-1999) unless otherwise modified by this Section. Minimum wire insulation resistance shall not be less than 250 Megohms.

END OF SECTION

**PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Furnish all labor, materials, equipment and install wiring devices as shown on the Drawings and as specified herein.
- B. Provide all interconnecting conduit and branch circuit wiring for receptacle circuits in accordance with the NEC.

**1.02 REFERENCE STANDARDS**

- A. Wiring devices shall comply with the requirements of the National Electric Code (NEC) and shall be Underwriters Laboratories (UL) labeled.

**PART 2 PRODUCTS****2.01 MATERIALS**

- A. Wall switches shall be heavy duty, specification grade, toggle action, flush mounting quiet type. All switches shall conform to the latest revision of Federal Specification WS 896. Wall switches shall be suitable for the area classification indicated and shall be of the following types and manufacturer:
  - 1. Single pole, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
  - 2. Double pole, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
  - 3. Three way, 20 Amp, 120/277 Volt - Cooper Wiring Devices, Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
  - 4. Four way, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
- B. Receptacles shall be heavy duty, specification grade of the following types and manufacturer or equal. Receptacles shall conform to Fed Spec WC596-F.
  - 1. Duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire; Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
  - 2. Weatherproof/corrosion resistant single, 20 Amp, 125 Volt, 2 Pole, 3 Wire, with cover; Crouse-Hinds Co., Catalog No. WLRS-5-20; Appleton Electric FSKJ520; Pass & Seymour or equal.
  - 3. Weatherproof/corrosion resistant duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire, with cover; Crouse-Hinds Co., Catalog No. WLRD-5-20; Appleton Electric FSKD520; Pass & Seymour or equal.

4. Weatherproof/corrosion resistant ground fault interrupter, duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire, GFCI feed thru type with "test" and "reset" buttons. Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.

C. Device Plates

1. Plates for indoor flush mounted devices shall be of the required number of gangs for the application involved and shall be as follows:
  - a. Administration type buildings: Smooth, high impact nylon of the same manufacturer and color as the device. Final color shall be as selected by the Architect.
  - b. Where permitted in other areas of the plant, flush mounted devices in cement block construction shall be Type 302 high nickel (18-8) stainless steel of the same manufacturer as the devices.
2. Plates for indoor surface mounted device boxes shall be cast metal of the same material as the box, Crouse-Hinds No. DS23G and DS32G; Appleton FSK1DRC, FSK1TSEC; Pass & Seymour or equal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Switch and receptacles outlets shall be installed flush with the finished wall surfaces in areas with stud frame and gypsum board construction, in dry areas with cement block construction or when raceways are shown as concealed on the Drawings.
- B. Do not install flush mounted devices in areas designated DAMP, WET or WET/CORROSIVE on the Drawings. Provide surface mounted devices in these areas.
- C. Provide weatherproof devices covers in areas designated WET or WET/CORROSIVE on the Drawings.
- D. Convenience outlets shall be 15-in above the floor unless otherwise required.
- E. Convenience outlets installed outdoors and in rooms where equipment may be hosed down shall be 18-in above floor or grade.
- F. Switches and dimmer controls for lighting shall be mounted 48-in above the finished floor unless otherwise noted or required.
- G. The location of all devices is shown, in general, on the Drawings and may be varied within reasonable limits so as to avoid any piping or other obstruction without extra cost, subject to the approval of the Engineer. Coordinate the installation of the devices for piping and equipment clearance.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install all miscellaneous equipment as shown on the Drawings and as specified herein.

1.02 EQUIPMENT LIST

- A. This Section provides the requirements for miscellaneous equipment typically employed in a facility, however, not all components specified in this Section are necessarily utilized on this project.

PART 2 PRODUCTS

2.01 MATERIALS

A. Disconnect Switches

1. Disconnect switches shall be heavy-duty, quick-make, quick-break, visible blades, 600 Volt, 3 Pole with full cover interlock, interlock defeat and flange mounted operating handle. All current carrying parts shall be copper
2. NEMA 4 enclosures shall be 316 stainless steel.
3. NEMA 4X enclosures shall be 316 stainless steel.
4. Switches shall be as manufactured by the Square D Co. or Cutler-Hammer without exception.

B. Fused Disconnect Switches

1. Fused disconnect switches shall be heavy-duty, quick-make, quick-break, visible blades, 600 Volt, 3 Pole with full cover interlock, interlock defeat and flange mounted operating handle. All current carrying parts shall be copper.
2. Fuses shall be rejection type, 600 Volts, 200,000 A.I.C., dual element, time delay, Bussman Fusetron, Class RK-5 or equal.
3. NEMA 4 enclosures shall be 316 stainless steel.
4. NEMA 4X enclosures shall be 316 stainless steel.
5. Switches shall be as manufactured by the Square D Co. or Cutler-Hammer without exception.

C. Horsepower Rated, Toggle Switch Type Disconnect Switch

1. Toggle type disconnect switches shall be manufactured of thermoplastic materials with screw-type terminals. The switches shall be rated 600 VAC and 20A at 600 VAC.
2. Toggle type disconnect switches shall be similar to a manual non-reversing starter without overloads and shall be 3 Pole, capable of “on-off” control of a 10 horsepower motor at 460 VAC.
3. Enclosure shall be provided with lock off provisions.
4. NEMA 4 enclosures shall be die-cast zinc.
5. Switches shall be as manufactured by the Square D Co.; Cutler-Hammer or equal.

D. General Purpose Dry Type Transformers

1. Transformers shall be dry type, two-winding with kVA and voltage ratings as shown on the Drawings. Transformer shall incorporate a 220 degree C insulation system and be designed not to exceed 150 degrees C temperature rise above a 40 degree C ambient full load
2. Four full capacity taps shall be furnished, two 2-1/2 percent above and two 2-1/2 percent below rated primary voltage.
3. Windings shall be copper.
4. Transformers shall be built in accordance with ANSI C89.2 and NEMA ST-20 shall be UL listed and suitable for non-sinusoidal current loads with a K-factor of 4.
5. Transformers, other than K-rated units, shall meet the efficiency levels contained in Tables 4.1 and 4.2 of NEMA Standard TP1-1996 and shall contain an EPA “Energy Star” label. Efficiency shall be tested in accordance with TP1-1996.
6. Transformers shall have common core construction with low hysteresis and eddy current losses. The core flux density shall be below the saturation point to prevent overheating caused by harmonic distortion.
7. Transformer impedance shall be a minimum of 3 percent and a maximum of 5 percent.
8. Provide vibration isolators for transformers rated 112.5 kVA and higher.
9. Provide ground lug on frame and strap ground core assembly to frame of enclosure.
10. The neutral bus shall be sized and configured for 200 percent of secondary full load current.
11. Transformers shall be manufactured by Square D Co.; Cutler-Hammer, or equal.

E. Transient Voltage Surge Suppressors (TVSS)

1. TVSS unit shall be a hybrid device utilizing a linear array of balanced MOV (Metal Oxide Varistors) and a series assembly of silicon avalanche diodes.
2. The TVSS unit shall be tested and labeled in accordance with the following standards: ANSI/IEEE C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits, Category C; ANSI/IEEE C62.45, Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits; NEMA LS-1 (1992), Low-Voltage Surge Protective Devices; UL 1449-Current Edition; UL 1283 for noise attenuation devices and NEC Article 285.
3. Unit shall have:
  - a. Parallel Line-Neutral, Line-Ground and Neutral-Ground connection configuration.
  - b. One Nanosecond or less response time.
  - c. Extend noise filtration with a 10 kHz to 100 MHz range.
  - d. Fused internal disconnect switch with 60 Amps, 300,000 AIC rating.
  - e. Surge current rating of 100,000 Amps per mode at service entrance  
Surge current rating of 80,000Amps per mode at distribution panels  
Surge current rating of 65,000Amps per mode at branch panels
  - f. LED indications
  - g. Six digit surge counter
  - h. Form C output contacts
  - i. System voltage shall be 120/240 grounded neutral, 120/208 grounded wye, 277/480 grounded wye, 240 delta, or 480 delta as indicated on the Drawings
  - j. NEMA 4 enclosure (steel type)
  - k. The Maximum Continuous Operating Voltage (MCOV) for all voltage configurations shall be 125 percent of nominal or greater.
  - l. The fusing system shall be capable of allowing the rated maximum surge current to pass through without fuse operation.
  - m. TVSS devices at distribution panels or switchboards shall be mounted integral to the equipment with leads as short as possible (not to exceed 24-in) and the lead size shall be a minimum of 6 AWG or larger. The TVSS shall include an integral disconnect switch which has been tested to the surge current rating of the TVSS and shall match or exceed the fault current rating of the board. The disconnect switch shall switch the phases and neutral.

- n. TVSS devices at branch panels shall be direct bus-to-bus connected with leads as short as possible (not to exceed 24-in) and lead size shall be a minimum of 6 AWG or larger.
4. TVSS unit shall be RayVOSS RAYCRP MOD#277-3-M3-4-03-C-H.

F. Lightning Arrester and Surge Capacitor

1. Lightning arrester shall be 650 Volt, 3 Phase, L.A. McClean Powertec Cat #2-650.

G. Wireway

1. NEMA 1 wireway shall be painted steel with hinged covers.
2. NEMA 1 wireway shall be Square-Duct as manufactured by the Square D Co.; NEMA 4 and 4X shall be Bulletin F-22 as manufactured by the Hoffman Engineering Co.; Appleton; Killark, or equal.

H. Control Relays

1. Control relays shall be as required by the attached Tulsa standards.

I. Detectable Warning Tape

1. Each duckbank section shall be marked by means of a detectable warning tape (tracer tape) as shown on the Drawings. The detectable warning tape shall be capable of being detected or located by either conductive or inductive location techniques.
2. The detectable warning tape shall consist of 5 mil (.005-in) overall thickness; five-ply composition; ultra-high molecular weight; virgin polyethylene; acid; alkaline and corrosion resistant; with 150 pounds of tensile break strength minimum per 6-in width.
3. The top side of the tracer tape shall be color banded red for electrical and high voltage lines, and orange for signal, communication, telephone and fire alarm lines. Tracer tape shall be 4-in wide with four color bands. The tape shall be inscribed with the warning message for the utility such as "CAUTION – ELECTRICAL LINED BURIED BELOW". Tape shall be as manufactured by Mutual Industries, Inc.; Terra Tape, Div. of Reef Industries Inc. or equal.

J. Terminal Blocks

1. Terminal blocks shall be NEMA type rated at 20 amperes minimum, 600 Volt, channel mounted, with tubular screw and pressure plate.
2. Terminal blocks shall be Bulletin 1492 as manufactured by the Allen-Bradley Co.; ABB; Kukla, or equal.

K. Intrinsically Safe Relays



1. Intrinsically safe relays shall be solid state type with 5 Amp output contacts, suitable for use on a 120 Volt, 60 Hz power supply and shall be FM approved for pilot devices in Class I, Division 1, Group D hazardous atmospheres.
  2. Intrinsically safe relays shall be Flygt MTISB-10 and FLYGT #1440-322.
- L. Arc Flash Protection Warning Signs
1. Provide field-affixed arc flash warning labels on all switchboards, panelboards, industrial control panels, and motor control centers in accordance with National Electrical Code Article 110.16.
  2. A full arc flash hazard study shall be done and labels applied to all panels with required information per NFPA 70E. Also, a breaker coordination study shall be done and all breakers shall be set accordingly.
  3. Furnish and install a full laminated one-line drawings of the facility inclusive of the utility power pole to the lighting panels and transformers.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

##### A. Mounting Stands

1. Field mounted disconnects, pushbutton control stations, alarm panels, enclosed starters and circuit breakers, transformers, automatic transfer switches, wireways, contactors, terminal boxes, junction and pull boxes shall be mounted on galvanized or stainless steel stands as specified. Where clearance requirements for stands may not be maintained, the Engineer may direct electric control equipment to be wall-mounted adjacent to the driven equipment, but in no case shall the distance from the drive motor to the control station exceed 3-ft, all at no additional cost to the Owner.
2. Channel supports shall be ground smooth and fitted with plastic end caps.

- B. All panelboards located in pedestal cabinets or outdoors and panelboards that have branch circuits feeding exterior to the building shall be equipped with lightning arresters and surge capacitors.

#### 3.02 FIELD TESTING

- A. Before supplying power to the alarm panels, the following tests shall be done: Verify that all wiring connection interfaces that are required are present. Check for secure connections. Using a continuity device, verify that all discrete inputs and output to and from the control panel are wired in correct polarity and are operating in the correct state of operation (normally open or closed state). Check for any direct short circuits across all voltage supply sources. As each of the above tests are performed, the Electrical Contractor shall highlight and initial each circuit that is tested. This set of prints shall be signed and left inside the enclosure.
- B. Check mechanical interlocks for intended operation. Make any adjustments required.

- C. In the event of an equipment fault in the panel, notify the Engineer immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor and Engineer. Repair or replace the equipment as directed by the Engineer prior to placing the equipment back into service at no additional cost to the Owner.

END OF SECTION

## PART 1 GENERAL

## 1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install all panelboards as shown on the Drawings and as specified herein.

## 1.02 REFERENCE STANDARDS

- A. Panelboards shall be in accordance with the Underwriter Laboratories (UL) "Standard for Panelboards" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboards shall also comply with NEMA Standard for Panelboards and the National Electrical Code (NEC).
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

## 1.03 MANUFACTURERS

- A. 120/240 Volt, single phase, 3 Wire and 120/208 Volt, 3 Phase, 4 Wire panelboards shall be Type NQOD by Square D Co.; or Type Pow-R-Line C by Cutler-Hammer.
- B. 277/480 Volt, 3 Phase, 4 Wire panelboards shall be Type NF by Square D Co.; or Type Pow-R-Line C by Cutler-Hammer.
- C. 480 Volt, 3 Phase, 3 Wire Power panelboards shall be Type NF by Square D Co.; or Type Pow-R-Line C by Cutler-Hammer;
- D. NEMA 3, 4 and 12 panelboards shall be similar to those specified above with appropriate enclosure modifications as required by voltage application. Panel enclosures shall be provided as specified in Section 16000 and 16110.

## PART 2 PRODUCTS

## 2.01 GENERAL

- A. Rating
  - 1. Panelboard ratings shall be as shown on the Drawings. All panelboards shall be rated for the intended voltage.
  - 2. Circuit breaker panelboards shall be fully rated for the specified circuit breaker fault current interrupting capacity. Series connected short circuit ratings will not be acceptable.

## 2.02 MATERIALS (NEMA 1)

- A. Interiors

1. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and all shall be suitable for copper or aluminum wire of the sizes indicated.
2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.
3. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.
4. A nameplate shall be provided listing manufacturer's name, panel type and rating.
5. Install surge suppressors and lighting arrestors as required by the drawings and specification 16.5-Miscellaneous Equipment.

#### B. Buses

1. Bus bars for the mains shall be of copper. Full size neutral bars shall be included. Phase bussing shall be full height without reduction. Cross connectors shall be copper.
2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
3. Spaces, provision for future breakers, shall have bus straps bolted onto the bus so that future breakers can be bolted into the panel.
4. Equipment ground bars shall be furnished.

#### C. Boxes

1. Recessed or flush mounted boxes shall be made from galvanized code gauge steel having multiple knockouts, unless otherwise noted. Boxes shall be of sufficient size to provide a minimum gutter space of 4-in on all sides.
2. Surface mounted boxes and trims shall have an internal and external finish as specified in Paragraph 2.04D4 below. Surface mounted boxes shall be field punched for conduit entrances.
3. At least four studs for mounting the panelboard interior shall be furnished.

#### D. Trim

1. Hinged doors covering all circuit breaker handles shall be included in all panel trims.
2. Doors shall have semi flush type cylinder lock and catch, except that doors over 48-in in height shall have a vault handle and 3-point catch, complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Furnish two keys for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.

3. The trims shall be fabricated from code gauge sheet steel.
4. All exterior and interior steel surfaces of the panelboard shall be properly cleaned and finished with ANSI Z55.1, No. 61 light gray paint over a rust-inhibiting phosphatized coating. The finish paint shall be of a type to which field applied paint will adhere.
5. Trims for flush panels shall overlap the box by at least 3/4-in all around. Surface trims shall have the same width and height as the box. Trims shall be fastened with quarter turn clamps.
6. Door-in-door type construction shall be provided so that trim may be opened to access wire ways without removing the trim from the panel

### 2.03 CIRCUIT BREAKERS

- A. Panelboards shall be equipped with circuit breakers with frame size and trip settings as shown on the Drawings.
- B. Circuit breakers shall be molded case, bolt-in type.
- C. Circuit breakers shall be as manufactured by the panelboard manufacturer.
- D. Circuit breakers shall all have a permanently installed lock out provision.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Mount boxes for surface mounted panelboards so there is at least 1/2-in air space between the box and the wall.
- B. Connect panelboard branch circuit loads so that the load is distributed as equally as possible between the phase busses.
- C. Type circuit directories giving location and nature of load served. Install circuit directories in each panelboard.
- D. Install markers on the front cover of all panelboards which identify the voltage rating. Markers shall be made of self sticking B-500 vinyl cloth printed with black characters on an Alert Orange background, 2-1/4-in high by 9-in wide, Style A as manufactured by W.H. Brady Co. or equal.
- E. Install a 1-in by 3-in laminated plastic nameplate with 1/4-in white letters on a black background on each panelboard. Nameplate lettering shall be as shown on the Drawings. Nameplates shall be stainless steel screw mounted.

END OF SECTION

## **PART 1 GENERAL**

### **1.1 Summary**

- A This section includes the following items from a single supplier:
  - 1. Engine Generator Set.
  - 2. Enclosure
  - 3. Related Accessories as specified
  
- B Related Requirements
  - 1. It is the intent of this specification to secure an engine-driven generator set that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
  - 2. Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line by line summary description of all the items of compliance, any items that have been omitted or have been taken exception to, and a complete description of all deviations.
  - 3. It is the intent of this specification to secure a generator set system that has been tested during design verification, in production, and at the final job site. The generator set will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
  - 4. All equipment shall be new and of current production by an international, power system manufacturer of generators, transfer switches, and paralleling switchgear. The manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

### **1.2 Submittals**

- A Action Submittals
  - 1. Product Data
    - a The submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.
  
- B Informational Submittal
  - 1. Certificates
    - a The generator set shall be listed to UL 2200 or submitted to an independent third-party certification process to verify compliance as installed.
  
- C Closeout Submittal
  - 1. Maintenance Contracts
  - 2. Operation and Maintenance Data
  - 3. Warranty Documentation
  - 4. Record Documentation

### 1.3 Quality Assurance

#### A Regulatory Agency

1. The generator set shall conform to the requirements of the following codes and standards:
  - a CSA C22.2, No. 14-M91 Industrial Control Equipment.
  - b EN50082-2, Electromagnetic Compatibility-Generic Immunity Requirements, Part 2: Industrial.
  - c EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
  - d IEC8528 part 4, Control Systems for Generator Sets.
  - e IEC Std 61000-2 and 61000-3 for susceptibility, 61000-6 radiated and conducted electromagnetic emissions.
  - f IEEE446 Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
  - g NFPA 70, National Electrical Code, Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
  - h NFPA 99, Essential Electrical Systems for Health Care Facilities.
  - i NFPA 110, Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit. Component level type tests will not substitute for this requirement.
2. Qualifications
  - a The equipment shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.
  - b The power system shall be produced by a manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year.
3. Manufacturers
  - a The power system shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.

## 1.4 Warranty

### A Manufacturer's Warranty

1. The generator set shall include a standard warranty covering five (5) years or 3000 hours, whichever occurs first, to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from the date of initial startup.
2. The generator set manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and functional tests performed on all systems.

## PART 2 PRODUCTS

### 2.1 Equipment

#### A Equipment

1. The generator set shall be a MTU model. It shall provide 60 kW when operating at 277/480 volts, 60 Hz, 0.80 power factor. The generator set shall be capable of a 130°C Standby rating while operating in an ambient condition of less than or equal to 104 °F and a maximum elevation of 1000 ft above sea level. The standby rating shall be available for the duration of the outage.

#### B Engine

1. The minimum 3.4 liter displacement engine shall deliver a minimum of 94 HP at a governed engine speed of 1800 rpm, and shall be equipped with the following:
  - a. Electronic isochronous governor capable of 0.25% steady-state frequency regulation
  - b. 12-volt positive-engagement solenoid shift-starting motors
  - c. 90-ampere automatic battery charging alternator with a solid-state voltage regulation
  - d. Positive displacement, full-pressure lubrication oil pump, cartridge oil filters, dipstick, and oil drain
  - e. Dry-type replaceable air cleaner elements for normal applications
  - f. Engine-driven or electric fuel-transfer pump including fuel filter and electric solenoid fuel shutoff valve capable of lifting fuel
  - g. The turbocharged engine shall be fueled by diesel
  - h. The engine shall have a minimum of 4 cylinders and be liquid-cooled
2. The engine shall be EPA certified from the factory
3. The generator must accept rated load in one-step.

#### C Cooling System

1. The engine shall be liquid-cooled by a closed loop, unit mounted radiator rated to operate the generator set at full load at an ambient temperature of 50 degrees C (122 degrees F). The radiator fan and other rotating engine parts shall be guarded against accidental contact.

#### D Standard Air Cleaner

1. The air cleaner shall provide engine air filtration which meets the engine manufacturer's specifications under typical operating conditions.

#### E Battery

1. Each genset requires a quantity of one BCI group 24 batteries which must meet the engine manufactures' specifications for the ambient conditions specified in Part 1 Project Conditions and



shall comply with the NFPA requirements for engine cranking cycles. Each battery shall be rated according to SAE Standards J-537 with a minimum cold cranking amp of 650 amps and a minimum reserve capacity of 430 Minutes at 80F. The battery must contain two handles to aid in lifting and the case must be constructed of polypropylene to resist breakage and extend service life. Removable cell covers shall be provided to allow for checking of electrolyte specific gravity.

2. Battery rack and battery cables capable of holding the manufacturer's recommended batteries shall be supplied.

#### F Housing

##### 1. Level 2 Sound Attenuated Enclosure

- a The generator set shall be supplied with a Level 2 Sound Attenuated Enclosure, providing a sound level of 67 dB(A) while the generator is operating at 100% load at 7 meters (23 feet) using acoustic insulation and acoustic-lined inlet hoods, and using acoustic insulation and acoustic-lined inlet hoods, constructed from a minimum of 0.125 inch thick formed heavy duty aluminum panels. The acoustic insulation used shall meet UL 94 HF1 flammability classification. The enclosure shall be manufactured from bolted panels to facilitate service, future modifications, or field replacement. The enclosure shall use external vertical air inlet and outlet hoods with 90 degree angles to discharge air up and reduce noise. The enclosure shall have an integral rodent guard and skid end caps and shall have bracing to meet 241 kph (150 mph) wind loading.
- b The enclosure components and skid shall be cleaned with a two-stage alkaline cleaning process to remove grease, grit, and grime from parts. Components shall then be subjected to a Zirconium-based conversion coating process to prepare the metal for electrocoat (e-coat) adhesion. All enclosure parts shall receive an 100% epoxy primer electrocoat (e-coat) with high-edge protection. Following the e-coat process, the parts shall be finish coated with powder baked paint for superior finish, durability, and appearance with a Power Armor™ industrial finish that provides heavy duty durability in harsh conditions, and is fade-, scratch- and corrosion-resistant.
- c The enclosure must surpass a 3,000 hour salt spray corrosion test per ASTM B-1117.
- d Enclosures will be finished in the manufacturer's standard color.
- e The enclosures shall allow the generator set to operate at full load in an ambient temperature of 50°C with no additional derating of the electrical output of the generator set.
- f Enclosures shall be equipped with sufficient side and end doors to allow access for operation, inspection, and service of the unit and all options. Minimum requirements are two doors per side. When the generator set controller faces the rear of the generator set, an additional rear facing door is required. Access to the controller and main line circuit breaker shall meet the requirements of the National Electric Code.
- g Doors shall be fitted with hinges, hardware, and the doors shall be removable.
- h Doors shall be equipped with lockable latches. Locks shall be keyed alike. Door locks shall be recessed to minimize potential of damage to door/enclosure.
- i A duct between the radiator and air outlet shall be provided to prevent re-circulation of hot air.
- j The complete exhaust system shall be internal to the enclosure.
- k The critical silencer shall be fitted with a tailpipe and rain cap.

#### G Fuel oil storage

##### 1. Double Wall Secondary Containment Sub-base Fuel Tank

- a The generator set shall be supplied with a sub-base fuel tank of sufficient capacity to hold a minimum of 24 hours of fuel at 100% loading. No less than 133 gallons of diesel fuel.
- b The sub-base fuel system shall be listed under UL 142, subsection entitled Special Purpose Tanks EFVT category, and will bear their mark of UL Approval according to their particular classification.
- c The above ground steel secondary containment rectangular tank for use as a sub base for diesel generators is manufactured and intended to be installed in accordance with the

Flammable and Combustible Liquids Code—NFPA 30, the Standard for Installation and Use of Stationary Combustible Engine and Gas Turbines—NFPA 37, and Emergency and Standby Power Systems—NFPA 110.

- d The primary tank shall be rectangular in shape and constructed in clam shell fashion to ensure maximum structural integrity and allow the use of a full throat fillet weld.
- e Steel Channel Support System. Reinforced steel box channel for generator support, with a load rating of 5,000 lbs. per generator mounting hole location. Full height gussets at either end of channel and at generator mounting holes shall be utilized.
- f Exterior Finish. The sub-base tank exterior finish shall be Power Armor Plus™, a polyurea-textured rubberized coating.
- g Normal venting shall be sized in accordance with the American Petroleum Institute Standard No 2000, Venting Atmospheric and Low Pressure Storage Tanks not less than 1-1/4" (3 cm.) nominal inside diameter.
- h The emergency vent opening shall be sized to accommodate the total capacity of both normal and emergency venting and shall be not less than that derived from NFPA 30, table 2-8, and based on the wetted surface area of the tank. The wetted area of the tank shall be calculated on the basis of 100 percent of the primary tank. The vent is to be spring-pressure operated: opening pressure is 0.5/psig and full opening pressure is 2.5 psig. The emergency relief vent is to be sized to accommodate the total venting capacity of both normal and emergency vents.
- i There shall be a 2" NPT opening within the primary tank and lockable manual fill cap.
- j A direct reading, UL listed, magnetic fuel level gauge with a hermetically sealed, vacuum tested dial, to eliminate fogging, shall be provided.
- k A float switch for remote or local annunciation of a (50% standard) low fuel level condition shall be supplied.

#### H Controller

##### 1. Model Basler DGC 2020

- a. The generator set controller shall be a microprocessor based control system that will provide automatic starting, system monitoring, and protection. The controller system shall also provide local monitoring and remote monitoring. The control system shall be capable of PC based updating of all necessary parameters, firmware, and software.
- b. The controller shall be mounted on the generator set and shall have integral vibration isolation. The controller shall be prototype and reliability tested to ensure operation in the conditions encountered.

##### 2. Codes and Standards

- a. The generator set controller shall meet NFPA 110 Level 1 requirements and shall include an integral alarm horn as required by NFPA.
- b. The controller shall meet NFPA 99 and NEC requirements.
- c. The controller shall be UL 508 listed.

##### 3. Applicability

- a. The controller shall be a standard offering in the manufacturer's controller product line.
- b. The controller shall support 12-volt and 24volt starting systems.
- c. The controller's environmental specification shall be: -40°C to 70°C operating temperature range and 5-95% humidity, non-condensing.
- d. The controller shall mount on the generator or remotely within 40 feet with viewable access.

4. Controller Buttons, Display and Components
  - a. The generator set controller shall include the following features and functions:
    1. Push button Master Control buttons. The buttons shall be tactile-feel membrane with an indicator light to initiate the following functions:
      - a. Run Mode: When in the run mode the generator set shall start as directed by the operator.
      - b. Off/Reset Mode: When in the Off/Reset mode the generator set shall stop, the reset shall reset all faults, allowing for the restarting of the generator set after a shutdown.
      - c. Auto Mode: When in Auto the mode the generator set shall be ready to accept a signal from a remote device.
    2. Emergency Stop Switch. The remote stop switch shall be red in color with a "mushroom" type head. Depressing the stop button will immediately stop the generator set and lockout the generator set for any automatic remote starting.
    3. Push Button/Rotary Selector dial. This dial shall be used for selection of all Menus and sub-menus. Rotating the dial moves you through the menus, pushing the dial selects the menu and function/features in that menu. Pushing the button selects the feature/function and sub-menus.
    4. Digital Display. The digital display shall be alphanumeric, with 2 lines of data and approximately 24 characters. The display shall have back lighting for ease of operator use in high and low light conditions. The display shall display status of all faults and warnings. The display shall also display any engine faults. While the generator set is running, the display shall scroll all-important information across the screen for ease of operator use. The scroll can be stopped by pushing the rotary dial. The display shall fall asleep when the generator set is not running and will wake-up when the generator set starts or the rotary dial is depressed.
    5. Fault Light. The controller shall have an annunciator fault light that glows red for faults and yellow for warnings. These faults and warnings shall be displayed in the digital display. The fault light will also glow yellow when not in AUTO.
    6. Alarm Horn. The controller shall provide an alarm horn that sounds when any faults or warnings are present. The horn shall also sound when the controller is not in the AUTO mode.
    7. Alarm Silence/Lamp Test Button. When this button is depressed, it shall test all controller lamps. This button will also silence the alarm horn when the unit is not AUTO.
    8. USB Connection. The controller shall have a USB connection on the face of the controller. This connection shall allow for updating of all software and firmware. This port shall also allow for all servicing of generator set parameters, fault diagnostics and viewing of all controller information via use a laptop computer.
    9. Dedicated user inputs. The controller shall have dedicated inputs for remote emergency stop switch, remote 2-wire star for transfer switch and auxiliary shutdown.
    10. The controller shall have auto resettable circuit protection integral on the circuit board.
5. System Controller Monitoring and Status Features and Functions

- a. The generator controller shall display and monitor the following engine and alternator functions and allow adjustments of certain parameters at the controller:
  1. Overview menu
    - a. Active shutdowns and warnings shall be displayed if present and without the need of operator interface
    - b. Engine runtime with total hours
    - c. Average line to line voltage
    - d. Coolant temperature
    - e. Fuel level or pressure
    - f. Oil pressure
    - g. Battery voltage
    - h. Software version
    - i. Frequency
    - j. Average current
  2. Engine metering menu.
    - a. Engine speed
    - b. Oil pressure
    - c. Coolant temperature
    - d. Battery voltage
  3. Generator metering menu.
    - a. Total power in VA
    - b. Total power in W
    - c. Rated power % used
    - d. Voltage L-L and L-N for all phases
    - e. Current L1, L2, L3
    - f. Frequency
  4. Generator set information.
    - a. Generator set model number
    - b. Generator set serial number
    - c. Controller set number
  5. Generator set run time.
    - a. Engine run time total hours
    - b. Engine loaded total hours
    - c. Number of engine starts
    - d. Total energy in kW
  6. Generator set system
    - a. System voltage
    - b. System frequency 50/60Hz
    - c. System phase, single/three phase
    - d. Power rating kW
    - e. Amperage rating
    - f. Power type standby/prime
    - g. Measurement units, metric/English units adjustable
    - h. Alarm silence, always or auto only
  7. Generator set calibration, the following are adjustable at the controller.
    - a. Voltage L-L and L-N all phases
    - b. Current L1, L2, L3
    - c. Reset all calibrations
  8. Voltage regulation, +/-0.5% regulation, the following is adjustable at the controller.
    - a. Voltage Adjustable +/- 10%

9. Digital and Analog Inputs and outputs
    - a. Displays settings and status
  10. Event Log
    - a. Stores event history, up to 1000 events
6. Controller Engine control features and functions
- a. Automatic restart - the controller has automatic restart feature that initiates the start routine and re-crank after a failed start attempt.
  - b. Cyclic cranking - the controller shall have programmable cyclic cranking
  - c. Engine starting aid - the controller shall have the capability of providing control for an optional engine starting aid.
  - d. The control system shall include time delays for engine start and cool down.
  - e. The control system shall interface with the engine ECM and display engine fault codes and warnings. The ECM shall also include sender failure monitoring to help distinguish between failed senders and actual failure conditions.
  - f. The controller shall monitor and display engine governor functions with include steady state and transient frequency monitoring
7. Controller Alternator control features and functions
- a. Integrated hybrid voltage regulator. The system shall have integral microprocessor based voltage regulator system that provides +/- 5% voltage regulation, no-load to full load with three phase sensing. The system is prototype tested and control variation of voltage to frequency. The voltage regulator shall be adjustable at the controller with maximum +/- 10% adjustable of nominal voltage.
  - b. AC output voltage regulator adjustment. The system shall allow for adjustment of the integral voltage regulator with maximum of +/- 10% adjustment of the system voltage.
  - c. Alternator thermal overload protection. The system shall have integral alternator overload and short circuit protection matched to each alternator for the particular voltage and phase configuration.
  - d. Power metering. The controller digitally displays power metering of kW and kVA.
8. Other control features and functions
- a. Event logging. The controller keeps a record of up to 1000 events, for warning and shutdown faults. This fault information becomes a stored record of systems events and can be reset.
  - b. Historical data logging. The controller total number of generator set successful start shall be recorded and displayed.
  - c. Programmable access. The control system shall include a USB port that gives service technicians the ability to provide software and firmware upgrades. The system shall also be capable of allowing setting of all critical parameters using the service software and a laptop computer. All parameters and setting should be capable to being stored on a laptop for future upgrades of printing for analysis.
9. Generator Set Warning, Shutdown Alarm and Status
- a. The generator set shall have alarms and status indication lamps that show non-automatic status and warning and shutdown conditions. The controller shall indicate

with a warning lamp and or alarm and on the digital display screen any shutdown, warning or engine fault condition that exists in the generator set system. The following alarms and shutdowns shall exist as a minimum:

1. Engine functions
  - a. Critical high fuel level (alarm)
  - b. ECM communication loss (shutdown)
  - c. ECM diagnostics (alarm & shutdown)
  - d. Engine overspeed (shutdown)
  - e. Engine start aid active
  - f. Engine under speed (shutdown)
  - g. Fuel tank leak (alarm & shutdown)
  - h. High DC battery voltage (alarm)
  - i. High coolant temperature (alarm & shutdown)
  - j. High fuel level (alarm)
  - k. Low DC battery voltage (alarm)
  - l. Low coolant level (shutdown)
  - m. Low coolant temperature (alarm)
  - n. Low cranking voltage (alarm)
  - o. Low engine oil level (alarm & shutdown)
  - p. Low fuel level (alarm & shutdown)
  - q. Low fuel pressure (alarm)
  - r. Low oil pressure (alarm & shutdown)
  - s. No coolant temperature signal (shutdown)
  - t. No oil pressure signal (shutdown)
  - u. Overcrank (shutdown)
  - v. Speed sensor fault (alarm)
2. Generator functions
  - a. AC sensing loss over & under current (alarm & shutdown)
  - b. Alternator protection (shutdown)
  - c. Ground fault input (alarm)
  - d. kW overload (shutdown)
  - e. Locked rotor (shutdown)
  - f. Over-frequency (shutdown)
  - g. Over AC voltage (shutdown)
  - h. Under-frequency (shutdown)
  - i. Under AC voltage (shutdown)
  - j. Emergency stop (shutdown)
3. Other General functions
  - a. Battery charger fault (alarm)
  - b. Common fault (shutdown)
  - c. Common warning (alarm)
  - d. Master switch not in auto (alarm)
  - e. Generator running
  - f. Input/Output fault (alarm)
4. The generator set controller shall also be capable of meeting all necessary NFPA 110 level 1 requirements that include several of the above along with; EPS supplying load, Master switch “not in auto”, and contacts for local and remote common alarm.

## 10. Communications

- a. The controller shall communicate with the ECM for control, monitoring, diagnosis, and meet SAE J1939 standards
- b. Kohler proprietary RBUS communication shall be available.
- c. A RBUS shall be able to monitor and alter parameters, and start or stop a generator.
- d. The controller shall have the capability to communicate to a personal computer (IBM or compatible) and appropriate application software
- e. A variety of connections shall be available based on requirements:
  1. A single control connection to a PC via USB
  2. Internet connection via Ethernet
- f. Generator and transfer switch controls shall be equipped with communications modules capable of connecting to the same communication network.

#### I Generator Overcurrent and Fault Protection

1. The generator shall be provided with a factory installed, 100% rated line circuit breaker rated at 100 amperes that is UL489 listed. Line circuit breakers shall be sized for the rated ampacity of the loads served by the breaker per the NEC.
2. The circuit breaker(s) shall incorporate an electronic LSI trip unit
3. Load side lugs shall be provided from the factory.
4. When GFI is required per the NEC, additional neutrals shall be factory installed, and the alarm indication shall be integrated with the other generator set alarms.
5. Barriers to provide segregation of wiring from an emergency source to emergency loads from all other wiring and equipment, if required by the NEC, shall be provided.

#### J Alternator

1. The alternator shall be salient-pole, brushless, 2/3-pitch, with 4 bus bar provision for external connections, self-ventilated, with drip-proof construction and amortisseur rotor windings, and skewed for smooth voltage waveform. The ratings shall meet the NEMA standard (MG1-32.40) temperature rise limits. The insulation shall be class H per UL1446 and the varnish shall be a vacuum pressure impregnated, fungus resistant epoxy. Temperature rise of the rotor and stator shall be limited to 130°C Standby. The PMG based excitation system shall be of brushless construction controlled by a digital, three phase sensing, solid- state, voltage regulator. The AVR shall be capable of proper operation under severe nonlinear loads and provide individual adjustments for voltage range, stability and volts-per-hertz operations. The AVR shall be protected from the environment by conformal coating. The waveform harmonic distortion shall not exceed 5% total RMS measured line-to-line at full rated load. The TIF factor shall not exceed 50.
2. The alternator shall have a maintenance-free bearing, designed for 40000 hour B10 life. The alternator shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.
3. The generator shall be inherently capable of sustaining at least 300% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current-support devices.
4. Motor starting performance and voltage dip determinations shall be based on the complete generator set. The generator set shall be capable of supplying 261 LRKVA for starting motor loads with a maximum instantaneous voltage dip of 35%, as measured by a digital RMS transient recorder in accordance with IEEE Standard 115. Motor starting performance and voltage dip determination that does not account for all components affecting total voltage dip, i.e., engine, alternator, voltage regulator, and governor will not be acceptable. As such, the generator set shall

be prototype tested to optimize and determine performance as a generator set system.

## K Vibration Isolation

1. Vibration isolators shall be provided between the engine-alternator and heavy-duty steel base.

## 2.2 Accessories

- A. The generator set shall be supplied with a 10-ampere automatic float/equalize battery charger capable of charging both lead-acid and gel-cell type batteries, with the following features:
  - i. Automatic 3-stage float to equalization charge
  - ii. 1% steady-state voltage regulation from no load to full load over 10% AC input line voltage variation
  - iii. Indicator LED lamps for charge state indication (bulk charge/absorption/float)
  - iv. Ambient temperature operating range: -40°C to 70°C
  - v. Potting for durability and waterproofing
  - vi. Short-circuit and reverse polarity protection
  - vii. UL 1236 listed
  - viii. UL 2200 compliant
  - ix. CSA certified
  - x. Ring terminals for battery connection
- B. Battery rack and battery cables capable of holding the manufacturer's recommended batteries shall be supplied.
- C. The air cleaner restriction indicator shall indicate the need for maintenance of the air cleaners.
- D. The exhaust piping shall be gas proof, seamless, stainless steel, flexible exhaust bellows and includes the flex exhaust tube and the mounting hardware.
- E. Block Heater - The block heater shall be thermostatically controlled, 110-120 VAC, to maintain manufacturers recommended engine coolant temperature to meet the start-up requirements of NFPA 99 and NFPA 110, Level 1.
- F. Supply flexible fuel lines to provide a flexible connection between the engine fuel fittings and the fuel supply tank piping and for the fuel return lines from the injector pump per engine manufacturer's recommendations. Flex line shall have a protective steel wire braid to protect the hose from abrasion.
- G. Input/Output Module Board -- Generator controller shall be provided with board providing two analog or digital inputs and 5 digital outputs.
- H. The generator set shall be provided with a run relay which shall provide a three-pole, double-throw relay with 10-amp/ 250 VAC contacts to indicate that the generator is running. The run relay dry contacts can be used for energizing or de-energizing customer devices while the generator is running (e.g. louvers, indicator lamps, etc.)

## 2.3 Source Quality Control

### A. Non-Conforming Work

1. To ensure that the equipment has been designed and built to the highest reliability and quality standards, the manufacturer and/or local representative shall be responsible for three separate tests: design prototype tests, final production tests, and site tests.
  - a. **Design Prototype Tests.** Components of the emergency system, such as the engine/generator set, transfer switch, and accessories, shall not be subjected to prototype tests because the tests are potentially damaging. Rather, similar design prototypes and preproduction models shall be subject to the following tests:
    - i. Maximum power (kW)
    - ii. Maximum motor starting (kVA) at 35% instantaneous voltage dip.



- iii. Alternator temperature rise by embedded thermocouple and/or by resistance method per NEMA MG1-32.6.
  - iv. Governor speed regulation under steady-state and transient conditions.
  - v. Voltage regulation and generator transient response.
  - vi. Harmonic analysis, voltage waveform deviation, and telephone influence factor.
  - vii. Three-phase short circuit tests.
  - viii. Alternator cooling air flow.
  - ix. Torsional analysis to verify that the generator set is free of harmful torsional stresses.
  - x. Endurance testing.
- b. **Final Production Tests.** Each generator set shall be tested under varying loads with guards and exhaust system in place. Tests shall include:
- i. Single-step load pickup
  - ii. Safety shutdown device testing
  - iii. Rated Power @ 0.8 PF
  - iv. Maximum power
  - v. Upon request, a witness test, or a certified test record sent prior to shipment.
- c. **Site Tests.** The manufacturer's distribution representative shall perform an installation check, startup, and building load test. The engineer, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:
- i. Fuel, lubricating oil, and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
  - ii. Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include: block heaters, battery chargers, alternator strip heaters, remote annunciators, etc.
  - iii. Generator set startup under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during operation, normal and emergency line-to-line voltage and frequency, and phase rotation.
  - iv. Automatic start by means of a simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator set voltage, amperes, and frequency shall be monitored throughout the test.
  - v. Load bank testing. The test shall consist of four hours of continuous operation using a portable resistive load bank. Adjust the load bank load to provide one half hour each at zero load, 25 percent, 50 percent, and 75 percent of full load. Followed by two hours of operation at rated standby load. Furnish the portable load bank, all connecting cables, metering equipment, and other equipment or devices required to perform the on-site testing. During the test, readings shall be taken every 15 minutes showing % load, voltage, amps, oil pressure, water temperature, and battery charge.

**END OF SECTION**

## **PART 1 GENERAL**

### **1.1 Summary**

- A This section includes the following items from a single supplier:
  - 1. Automatic transfer switch
  
- B Related Requirements
  - 1. It is the intent of this specification to secure an automatic transfer switch that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
  - 2. Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line by line summary description of all the items of compliance, any items that have been omitted or have been taken exception to, and a complete description of all deviations.
  - 3. It is the intent of this specification to secure an automatic transfer switch that has been tested during design verification, in production, and at the final job site. The automatic transfer switch will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
  - 4. All equipment shall be new and of current production by an international, power system manufacturer of generators, transfer switches, and paralleling switchgear. The manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

### **1.2 Submittals**

- A Action Submittals
  - 1. Product Data
    - a The submittal shall include specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.
  - 2. Shop Drawings
  
- B Closeout Submittals
  - 1. Operation And Maintenance Data
  - 2. Warranty Documentation

### **1.3 Quality Assurance**

- A Regulatory Agency
  - 1. The automatic transfer switch shall conform to the requirements of the following codes and standards:
    - a UL 1008 - Standard for Transfer Switch Equipment

- b IEC 947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
  - c NFPA 70 - National Electrical Code
  - d NFPA 99 - Essential Electrical Systems for Health Care Facilities
  - e NFPA 110 - Emergency and Standby Power Systems
  - f IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
  - g NEMA Standard ICS 10-2005, Electromechanical AC Transfer Switch Equipment.
  - h EN61000-4-4 Fast Transient Immunity Severity Level 4
  - i EN61000-4-5 Surge Immunity Class 4 (voltage sensing and programmable inputs only)
  - j IEEE 472 (ANSI C37.90A) Ring Wave Test
  - k IEC Specifications for EMI/EMC Immunity (CISPR 11, IEC 1000-4-2, IEC 1000-4-3, IEC 1000-4-4, IEC 1000-4-5, IEC 1000-4-6, IEC 1000-4-8, IEC 1000-4-11)
  - l CSA C22.2 No. 178 certification
2. Qualifications
- a The automatic transfer switch shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.
  - b A manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year shall produce the automatic transfer switch.
3. Manufacturers
- a The automatic transfer switch shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.
  - b The manufacturer shall maintain a national service organization of employing personnel located throughout the contiguous United States. The Service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.
  - c The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

#### 1.4 Field or Site Conditions

##### A Ambient Conditions

1. Automatic transfer switch shall operate in the following conditions without any damage to the unit or its loads.
  - a Ambient Temperature: -4 to 158 Degrees F
  - b Relative Humidity: 5% to 95% noncondensing

#### 1.5 Warranty or Bond

##### A Manufacturer's Warranty

1. The ATS shall include a standard warranty covering one (5) years to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from the date of initial startup.
2. The ATS manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating

conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and functional tests performed on all systems.

## **PART 2 PRODUCTS**

### **2.1 Equipment**

#### **A Equipment**

1. Furnish and install an automatic transfer switches system(s) with 3-Pole / 4-Wire, Solid Neutral, 200 Amps, 480V/60Hz. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All transfer switches and controllers shall be the products of the same manufacturer.
2. Programmed Transition

#### **B Manufacturer**

1. Automatic transfer switches shall be Programmed Transition Kohler Model KCP-AMTC-0200S (or ASCO/Generac equal). Any alternate shall be submitted for approval to the consulting engineer at least 10 days prior to bid date. Alternate bids shall include a line-by-line clarification of the specification marked with "D" for deviation; "E" for exception, and "C" for comply.

#### **C Construction**

1. The transfer switch shall be electrically operated and mechanically held with double throw construction, and operated by a momentarily energized solenoid-driven mechanism.
2. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.
3. The switch shall be positively locked and unaffected by momentarily outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
4. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
5. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 800 amperes and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.
6. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources, are not acceptable.
7. For two and three pole switches, where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.
8. For four pole switches with a switching neutral, where neutral conductors must be switched as shown on the plans, the contactor shall be provided with fully rated switched neutral transfer contacts. Overlapping neutral contacts may be used as an alternative.

#### **D Enclosure**

1. The ATS shall be furnished in a NEMA 3R enclosure.
2. All standard door mounted switches and indicating LEDs shall be integrated into a flush-mounted, interface membrane or equivalent in the enclosure door for easy viewing & replacement. The panel shall be capable of having a manual locking feature to allow the user to

lockout all membrane mounted control switches to prevent unauthorized tampering. This cover shall be mounted with hinges and have a latch that may be padlocked. The membrane panel shall be suitable for mounting by others when furnished on open type units.

## 2.2 Operation

### A Controls

1. A four line, 20 character LCD display and dynamic 4 button keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and control through the communications interface port or USB. The following parameters shall only be adjustable via a password protected programming on the controller:
  - a Nominal line voltage and frequency
  - b Single or three phase sensing
  - c Operating parameter protection
  - d Transfer operating mode configuration (Standard transition, Programmed transition, or Closed transition)

### B Voltage and Frequency

1. Voltage (all phases) and frequency on both the normal and emergency sources shall be continuously monitored, with the following pickup, dropout, and trip setting capabilities (values shown as % of nominal unless otherwise specified):
 

a	Parameter	Dropout/Trip	Pickup/Reset
b	Under voltage	75 to 98%	85 to 100%
c	Over voltage	106 to 135%	95 to 100% of trip
d	Under frequency	95 to 99%	80 to 95%
e	Over frequency	01 to 115%	105 to 120%
f	Voltage unbalance	5 to 20%	3 to 18%
2. Repetitive accuracy of all settings shall be within  $\pm 0.5\%$  over an operating temperature range of -20°C to 70°C.
3. An adjustable dropout time for transient voltage and frequency excursions shall be provided. The time delays shall be 0.1 to 9.9 seconds for voltage and .1 to 15 seconds for frequency.
4. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad, remotely via the communications interface port or USB.
5. The controller shall be capable of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or BAC). Unacceptable phase rotation shall be indicated on the LCD; the service required LED and the annunciation through the communication protocol and dry contacts. In addition, the phase rotation sensing shall be capable of being disabled, if required.
6. The controller shall be capable of detecting a single phasing condition of a source, even though a voltage may be regenerated by the load. This condition is a loss of phase and shall be considered a failed source.
7. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases (phase to phase and phase to neutral), frequency, and phase rotation.

### C Time Delays

1. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 12 or 24 VDC power supply.
2. A time delay shall be provided on transfer to the emergency source, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

3. A time delay shall be provided on re-transfer to normal. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.
4. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.
5. A time delay activated output signal shall also be provided to drive external relay(s) for selective load disconnect and reconnect control. The controller shall be capable of controlling a maximum of 9 individual output time delays to step loads on after a transfer occurs. Each output may be individually programmed for their own time delay of up to 60 minutes. Each sequence shall be independently programmed for transferring from normal to emergency and transferring from emergency to normal.
6. All time delays shall be adjustable in 1 second increments.
7. All time delays shall be adjustable by using the display and keypad, with a remote device connected to the communications interface port or USB.
8. Each time delay shall be identified and a dynamic countdown shall be shown on the display. Active time delays can be viewed with a remote device connected to the communications interface port or USB.

#### D Additional Features

1. The controller shall have 3 levels of security. Level 1 shall allow monitoring of settings and parameters only. The Level 1 shall be capable of restricted with the use of a lockable cover. Level 2 shall allow test functions to be performed and Level 3 shall allow setting of all parameters.
2. The display shall provide for the test functions, allowed through password security. The test function shall be load, no load or auto test. The auto test function shall request an elapsed time for test. At the completion of this time delay the test shall be automatically ended and a retransfer sequence shall commence. All loaded tests shall be immediately ended and retransfer shall occur if the emergency source fails and the normal source is acceptable.
3. A contact closure shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.
4. Auxiliary contacts shall be provided consisting of a minimum of two contacts, closed when the ATS is connected to the normal source and two contacts closed, when the ATS is connected to the emergency source.
5. LED indicating lights shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).
6. LED indicating lights shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal (green) and emergency sources (red), as determined by the voltage, frequency and phase rotation sensing trip and reset settings for each source.
7. A membrane switch shall be provided on the membrane panel to test all indicating lights and display when pressed.
8. Provide the ability to select "commit/no commit to transfer" to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.
9. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which closes to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad, communications interface port or USB. A "not-in-auto" LED shall indicate anytime the controller is inhibiting transfer from occurring.

10. The programmed transition feature shall control the transfer so that mechanism is placed in a load disconnect position for an adjustable period of time, giving motor and transformer loads and opportunity to decay to acceptable levels. The programmed transition feature shall be specifically designed for and be the product of the ATS manufacturer. The programmed transition setting shall be capable of being enabled or disabled from the user interface, communications interface port of USB. The controller shall include a built-in time delay for programmed transition operation. This time shall be adjustable from the user interface. The default value shall be 1 second and shall be adjustable from 0 to 60 minutes.
11. A time based load control feature shall be available to allow the prioritized addition and removal of loads based during transfer. This feature may be enabled for either or both sources. The user shall be able to control up to nine loads with independent timing sequences for pre and post transfer delays in either direction of transfer.
12. The controller shall provide 2 inputs for external controls that can be programmed from the following values:
  - a Common fault, Remote test, Inhibit transfer, Low battery voltage, Peak shave, Time delay bypass, Load shed forced to OFF position (Programmed transition only)
13. The controller shall provide two form "C" contact outputs rated for up to 12A @ 240VAC or 2A @ 480VAC that can be programmed from the following values:
  - a Aux switch open, Transfer switch aux contact fault, Alarm silenced, Alarm active, I/O communication loss, Contactor position, Exercise active, Test mode active, Fail to transfer, Fail to acquire standby source, Source available, Phase rotation error, Not in automatic mode, Common alarm, In phase monitor sync, Load bank control active, Load control active, Maintenance mode active, Non-emergency transfer, Fail to open/close, Loss of phase, Over/under voltage, Over/under frequency, Voltage unbalance, Start signal, Peak shave active, Preferred source supplying load, Standby source supplying load
14. The controller shall be capable of expanding the number of inputs and outputs with additional modules.
15. Optional input/output modules shall be furnished which mount on the inside of the enclosure to facilitate ease of connections.
16. Engine Exerciser - The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to 21 different exercise routines based on a calendar mode. For each routine, the user shall be able to:
  - a Enable or disable the routine
  - b Enable or disable transfer of the load during routine.
  - c Set the start time, time of day, day of week, week of month (1st, 2nd, 3rd, 4th, alternate or every)
  - d Set the duration of the run.
  - e At the end of the specified loaded exercise duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. All loaded exercises shall be immediately ended and retransfer shall occur if the standby source fails. The next exercise period shall be displayed on the main screen with the type of exercise, time and date. The type of exercise and the time remaining shall be display when the exercise is active. It shall be possible of ending the exercise event with a single button push.
17. Date and time - The date shall automatically adjust for leap year and the time shall have the capability of automatically adjusting for daylight saving and standard times.
18. System Status - The controller shall have a default display the following on:
  - a System status
  - b Date, time and type of the next exercise event
  - c Average voltage of the preferred and standby sources
  - d Scrolling through the displays shall indicate the following:
    - 1) Line to line and line to neutral voltages for both sources

- 2) Frequency of each source
  - 3) Load current for each phase
  - 4) Single or three phase operation
  - 5) Type of transition
  - 6) Preferred source
  - 7) Commit or no commit modes of operation
  - 8) Source/source mode
  - 9) In phase monitor enable/disable
  - 10) Phase rotation
  - 11) Date and time
19. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual, are not permissible.
  20. Self-Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.
  21. Communications Interface - The controller shall be capable of interfacing, through a standard communication with a network of transfer switches and generators. It shall be able to be connected via an RS-485 serial communication (up to 4000 ft. direct connect or multi-drop configuration). This module shall allow for seamless integration of existing or new communication transfer devices and generators.
  22. The transfer switch shall also be able to interface to 3rd party applications using Modbus RTU open standard protocols utilizing Modbus register maps. Proprietary protocols shall not be acceptable.
  23. The controller shall contain a USB port for use with a software diagnostic application available to factory authorized personnel for downloading the controller's parameters and settings; exercise event schedules; maintenance records and event history. The application can also adjust parameters on the controller.
  24. Data Logging - The controller shall have the ability to log data and to maintain the last 2000 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory. The controller shall be able to display up to the last 99 events. The remaining events shall be accessible via the communications interface port or USB.
    - a Event Logging
      - 1) Data, date and time indication of any event
    - b Statistical Data
      - 1) Total number of transfers\*
      - 2) Total number of fail to transfers\*
      - 3) Total number of transfers due to preferred source failure\*
      - 4) Total number of minutes of operation\*
      - 5) Total number of minutes in the standby source\*
      - 6) Total number of minutes not in the preferred source\*
      - 7) Normal to emergency transfer time
      - 8) Emergency to normal transfer time
      - 9) System start date
      - 10) Last maintenance date
      - 11) \* The statistical data shall be held in two registers. One register shall contain data since start up and the second register shall contain data from the last maintenance reset.

### 2.3 Accessories



- A. Padlockable User Interface Cover. The user interface cover shall protect the controller user interface from the environment.
- B. Controller Disconnect Switch. A Logic disconnect switch shall be mounted inside the enclosure, and shall disconnect power to controller without disconnecting the load. The logic disconnect switch shall disconnect utility power to the controller during maintenance and service without disconnecting power to the load. The switch has two positions, auto and disconnect. The disconnect position shall disconnect the voltage sensing leads for the utility source (A, B, C, N). It is assumed that the user shall disable the generator by placing the controller in the OFF position.
- C. Programmable Exerciser. A programmable exerciser shall be supplied to allow programming of up to 56 on/off events.

## 2.4 Source Quality Control

- A Test and Inspection
  - 1. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.
  - 2. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001.

**END OF SECTION**

## PART 1 GENERAL

### 1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install a complete lighting system ready for operation as shown on the Drawings and as specified herein.

### 1.02 REFERENCE STANDARDS

- A. All lighting fixtures shall be in accordance with the National Fire Protection Association (NFPA) NFPA 70 "National Electrical Code" (NEC) and shall be constructed in accordance with the latest edition of the Underwriters Laboratories (UL) "Standards for Safety, Electric Lighting Fixtures."
- B. All lighting fixtures shall be UL labeled. Lighting equipment shall comply with UL standards pertaining to luminaires including: UL 1570 Fluorescent Lighting Fixtures; UL 1598 HID Lighting Fixtures; UL 1029 HID Ballasts; UL 542 Lampholders, Starters and Starter Holders for Fluorescent Lamps and UL 844 Standard for Electric Lighting Fixtures for Use in Hazardous (Classified) Locations

## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. Luminaires (Lighting Fixtures)
  - 1. See lift station standards for list of fixtures and types.
- B. Lamps shall be LED

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Each fixture shall be a completely finished unit with all components, mounting and/or hanging devices necessary, for the proper installation of the particular fixture in its designated location and shall be completely wired ready for connection to the branch circuit wires at the outlet.
- B. All flush mounted fixtures shall be supported from the structure and shall not be dependent on the hung ceilings for their support.
- C. Fixtures noted to be installed flush in suspended ceilings shall be of mounting types suited for the type ceiling involved. It shall be the responsibility of the electrical contractor to verify the ceiling types prior to ordering fixtures.
- D. Flexible fixture hangers shall be used for all pendant mounted fixtures. Fixtures 2-ft long and larger shall be supported with a minimum of two fixture hangers.

- E. Conduit run in areas with hung ceilings shall be installed in the space above the hung ceiling as close to the structure as possible. Conduits shall be supported from the structure.
- F. Exterior lighting poles shall be mounted plumb.
- G. Fixture locations are shown on the Drawings in approximate locations; however exact locations shall be coordinated so as to avoid conflicts with HVAC ducts, equipment and other obstacles.
- H. Where the Drawings state a particular mounting height, it shall imply that the bottom of the fixture shall be mounted at the stated mounting height above the finished floor, unless specifically noted otherwise.
- I. The minimum mounting height for the bottom of lights and exit signs shall be 80-in above the finished floor in compliance with Americans with Disabilities Act (ADA).

### 3.02 REPLACEMENT

- A. Lamps (except for HID) used during the building construction, prior to 2 weeks from completion of the work, shall be removed and replaced with new lamps.
- B. Metal halide lamps that produce a green, blue, or pink color shift after 100 hours of operation shall be replaced at no additional cost to the Owner.

### 3.03 CLEANING UP

- A. Plastic dust cover bags to be provided with new parabolic reflector lighting fixtures shall be removed after all construction activity that may cause dust formation on reflector surfaces has been completed.
- B. All fixtures shall be left in a clean condition, free of dirt and defects, before acceptance by the Engineer.

END OF SECTION

## PART 1 GENERAL

## 1.01 SCOPE OF WORK

- A. Furnish and install a complete underground system as shown on the Drawings and as specified herein.
- B. All underground systems shall be encased as shown on the drawings.
- C. Where referred in this Section, raceways are underground conduits – Ductbanks are a collection of underground raceways. Underground system is the collection of underground raceways, manholes and handholes.
- E. Ductbanks shall be constructed as shown on the drawings up to the building, structure, vault, manhole and handhole.
  - 1. Ductbank, depths vary. Coordinate with other utilities, yard piping, yard structures and field conditions to determine required depths and install raceways at that required depth at no additional cost to the Owner.
  - 2. Ductbank routing shown on the Drawings are diagrammatically depicted. Coordinate with other utilities, yard piping, yard structures and field conditions to determine required paths and depths at no additional cost to the Owner.

## PART 2 PRODUCTS

## 2.01 MATERIALS

- A. Raceways shall be **galvanized rigid steel**.
- B. Cable racks, supports, pulling-in irons, manhole steps and hardware shall be galvanized steel as manufactured by Line Materials Co.; Underground Devices, Inc.; Chance or equal.
- C. Ground rods and other grounding materials and methods shall be as specified.
- D. Bell ends and plastic duct spacers shall be as manufactured by Carlon; Underground Devices Inc. or equal.
- E. Pull line for spare conduits shall be 1/8-in nylon rope.
- F. Lighting Handholes (For Site Lighting Systems)
  - 1. Lighting handholes shall be constructed of polymer concrete and reinforced with heavy weave fiberglass, green finish, open bottom and minimal dimensions of 32-in long by 19-in wide by 30-in deep.

2. Lighting handhole cover shall be heavy duty type, green finish with stainless steel penta head bolts. Covers shall be marked "Roadway Lighting". Covers shall have a service load of 15,000 pounds over a 10-in square.
3. Lighting handholes and covers shall be as manufactured by Quazite; Christy; Easton Pre-Cast or equal.

J. Detectable Warning Tape

1. Each duckbank section shall be marked by means of a detectable warning tape (tracer tape) as shown on the Drawings. The detectable warning tape shall be capable of being detected or located by either conductive or inductive location techniques.
2. The detectable warning tape shall consist of 5 mil (.005-in) overall thickness; five-ply composition; ultra-high molecular weight; virgin polyethylene; acid; alkaline and corrosion resistant; with 150 pounds of tensile break strength minimum per 6-in width.
3. The top side of the tracer tape shall be color banded red for electrical and high voltage lines, and orange for signal, communication, telephone and fire alarm lines. Tracer tape shall be 4-in wide with four color bands. The tape shall be inscribed with the warning message for the utility such as "CAUTION – ELECTRICAL LINED BURIED BELOW". Tape shall be as manufactured by Mutual Industries, Inc.; Terra Tape, Div. of Reef Industries Inc. or equal.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install raceways to drain away from buildings. Raceways between manholes or handholes shall drain toward the manholes or handholes. Raceway slopes shall not be less than 3-in per 100-ft.
- B. Use plastic spacers located not more than 4-ft apart to hold raceways in place. Spacers shall provide not less than 2-in clearance between raceways and edge of envelope.
- C. The minimum cover for raceway banks shall be 24-in unless otherwise permitted by the Engineer.
- D. Raceway terminations at manholes shall be with end bells for PVC conduit and insulated throat grounding bushings for steel conduit.
- E. Where bends in raceways are required, use long radius elbows, sweeps and offsets.
- F. Swab all raceways clean before installing cable.
- G. Plug and seal spare raceways watertight at all manholes, buildings and structures.
- H. Seal the ends of raceways and make watertight at all manholes, buildings and structures.
- I. Install pulling-in irons opposite all raceway entrances to manholes.

- J. PVC Coated Rigid galvanized steel conduit shall be used for elbows and risers at the utility pole for electrical and telephone service conduits.
- K. PVC coated rigid galvanized steel elbows shall be used for pad-mounted transformer stub-ups and all stub-ups through concrete floors, walls and slabs.
- L. A pull line shall be installed and left in all spare raceways.
- M. Install detectable warning tape in all ductbanks as shown on the Drawings. Where trench exceeds 24-in width, provide additional detectable tape runs to mark each side of the ductbank in addition to the one in the center.

END OF SECTION

## PART 1 GENERAL

## 1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install a complete grounding system in strict accordance with Article 250 of the National Electrical Code NEC.
- B. All raceways, conduits, ducts and multi-conductor cables shall contain equipment grounding conductors sized in accordance with the NEC. Minimum sizes shall be No. 12 AWG.
- C. A supplemental grounding conductor shall be provided from each switchgear, switchboard, motor control center, power panelboard, lighting panelboard, to the buried ground grid. Supplemental grounding conductors shall be installed in PVC Schedule 80 conduit.

## PART 2 PRODUCTS

## 2.01 MATERIALS

- A. Conduit shall be as specified under Section 16110.
- B. Wire shall be as specified under Section 16120.
- C. Ground rods shall be 3/4-in by 10-ft copper clad steel and constructed in accordance with UL 467. The minimum copper thickness shall be 0.25 mm. Ground rods shall be Copperweld; Blackburn; Erico, Inc. or equal.
- D. Grounding conduit hubs shall be malleable iron type, and of the correct size for the conduit, as manufactured by Thomas & Betts Co.; Catalog No. 3940 Series, similar by Burndy; O.Z. Gedney Co. or equal.
- E. Water pipe ground clamps shall be cast bronze saddle type, and of the correct size for the pipe, as manufactured by Thomas & Betts Co. Cat. No. 2 (1/2-in, 3/4-in, or 1-in size), similar by Burndy; O.Z. Gedney Co. or equal and of the correct size for the pipe.
- F. Buried grounding connections shall be by Cadweld process, or equal exothermic welding system.
  - 1. Molds, cartridge materials and accessories shall be provided in kit form and selected per the manufacturer's written instructions for specific types, sizes and combinations of conductors and connected items. Molds and powder shall be furnished by the same manufacturer.
- G. Ground Rod Test Wells
  - 1. Ground rod test wells shall be complete with cast iron riser ring and traffic cover marked "GROUND ROD". Boxes and covers shall be suitable for H-20 wheel loading.
  - 2. Test wells shall be as manufactured by Erico, T416A; Christy Co., No. G5; Lightning and Grounding System, Inc., Series I-R.

## PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Run grounding electrode conductors in rigid steel conduits. Bond the protecting conduits to the grounding electrode conductors at both ends. Do not allow water pipe connections to be painted. If the connections are painted, dis-assemble them and re-make them with new fittings.
- B. Install equipment grounding conductors with all feeders and branch circuits.
- C. Bond all steel building columns in new structures together with ground wire in rigid conduit and connect to the distribution equipment ground bus, as shown on the Drawings.
- D. Ground wire connections to structural steel columns shall be made with exothermic welds.
- E. Metal conduits stubbed into a motor control center or floor mounted electrical enclosure shall be terminated with insulated grounding bushings and connected to the motor control center or electrical enclosure ground bus. Bond boxes mounted below motor control centers to the motor control center ground bus. Size the grounding wire in accordance with NEC Table 250-122, except that a minimum No. 12 AWG shall be used.
- F. Liquid tight flexible metal conduit in sizes 1-1/2-in and larger shall have bonding jumpers. Bonding jumpers shall be external, run parallel (not spiraled) and fastened with plastic tie wraps.
- G. Ground transformer neutrals to the nearest available grounding electrode with a conductor sized in accordance with NEC Article 250-66.
- H. Drive grounding electrodes as shown on the Drawings.
- I. All equipment enclosures, motor and transformer frames, conduits systems, cable armor, exposed structural steel and all other equipment and materials required by the NEC to be grounded, shall be grounded and bonded in accordance with the NEC.
- J. Seal exposed connections between different metals with No-Oxide Paint Grade A or equal.
- O. Ground metal poles supporting outdoor lighting fixtures to a supplemental grounding electrode (rod) in addition to the separate equipment grounding conductor run with the supply branch circuit.
- P. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate in accordance with NEC Paragraph 250.52 using a minimum of 20-ft of bare copper conductor not smaller than No. 4 AWG. Where base of foundation is less than 20-ft in length, coil excess conductor within base of concrete foundation. Extend grounding conductor below grade and connect to building grounding grid, ground loop, or grounding electrode external to concrete.

## 3.02 INSPECTION AND TESTING



- A. Inspect the grounding and bonding system conductors and connections for tightness and proper installation.
- B. Use Biddle Direct Reading Earth Resistance Tester or equivalent test instrument to measure resistance to ground of the system. Perform testing in accordance with test instrument manufacturer's recommendations using the fall-of-potential method.
- C. Resistance to ground testing shall be performed during dry season. Submit test results in the form of a graph showing the number of points measured (12 minimum) and the numerical resistance to ground.
- D. Testing shall be performed before energizing the distribution system.
- E. Test all grounded cases and metal parts associated with the electrical equipment for continuity with the ground system.
- F. Notify the Engineer immediately if the resistance to ground for any building or system is greater than five ohms.

END OF SECTION

## PART 1 GENERAL

## 1.01 SCOPE OF WORK

- A. Provide both a preliminary and a final short circuit, selective coordination and arc flash study of the complete electrical distribution system as specified herein and as shown on the Drawings.
- B. Obtain and pay for the services of the Low Voltage Equipment manufacturer, subject to the approval of the Engineer, to provide a complete fault current, distribution protective devices selective coordination and Arc Flash study. The selective coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and including the largest feeder circuit breaker and motor starter in the all low voltage motor control centers and power distribution panelboards. The study shall also include variable frequency drives, harmonic filters, Uninterruptible Power Supplies (UPS), power factor correction equipment, transformers and protective devices associated with emergency and standby generators, and the associated paralleling equipment and distribution switchgear. The arc flash study shall begin with the utility company's feeder protective device and include all of the electrical distribution equipment down to and including low voltage motor control centers and power distribution panelboards and lighting panels. All information required to perform the study shall be obtained by the entity performing the study.
- C. Submit the preliminary short circuit, selective coordination prior to submittal of 480 Volt equipment and panelboards shop drawings. The aforementioned shop drawings will not be reviewed until the preliminary power system study is approved by the Engineer. No exceptions will be allowed. The preliminary study shall include but not limited to:
  - 1. Short circuit, protective device coordination, arc flash study, shall be performed on nationally recognized computer software such as SKM System Analysis, EDSA, ETAP, or approved equal.
  - 2. Obtain and verify with the utility company all information needed to conduct the study. Obtain and verify with the Owner ratings of existing electrical equipment that shall be included in the study.
  - 3. Current transformers' ratio and burden calculations shall be based on a 10 percent maximum ratio error per ANSI C57.13. Identify current transformers that will not allow the protective devices to operate within acceptable ANSI error margins and recommend corrective action.
  - 4. The preliminary study shall verify equipment is being applied within their design ratings and electrical protective devices will coordinate.
  - 5. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit and protective device selective coordination studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments, and minor modifications to equipment that are required to accomplish conformance with the approved

short circuit and protective device selective coordination studies shall be carried out by the Contractor at no additional cost to the Owner.

- D. After release of electrical equipment by the manufacturer, but prior to energizing the electrical equipment, submit the final short circuit study, protective device selective coordination study, and arc flash study including all calculations, tabulations, protective devices coordination graphs, etc. as specified herein.
1. Provide a complete short circuit study, protective device selective coordination study, and arc flash study for both the utility power distribution system and the emergency/standby power distribution system under the scope of this study. The study shall include but shall not be limited to:
    - a. Full compliance with applicable ANSI and IEEE Standards.
    - b. Performed on nationally recognized computer software such as EDSA, SKM System Analysis, ETAP, or equal.
  2. Provide a report summarizing the short circuit study, protective device selective coordination study, and arc flash study including: one-line diagram of the system, relay and breaker setting tabulation, coordination curves, relay curves, circuit breaker curves, motor starting/running curves, protective device coordination and short circuit calculation, all prepared by the specialty firm.
  3. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit study, protective device selective coordination study, and arc flash studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments and minor modifications to equipment that are required to accomplish conformance with the approved short circuit study, protective device selective coordination study, and arc flash study shall be carried out by the Contractor at no additional cost to the Owner.

## 1.02 SUBMITTALS

- A. Submit, in accordance with Section 01300, the following:
1. The number of years the specialty firm has been in the business of performing coordination studies.
  2. Identification of each of the three qualifying projects for each of the past three years including:
    - a. A brief description of each study.
    - b. Name of owner of installation on which study was performed with address, telephone number, and contact person.

- c. Date of study.
  - d. Any other information indicating the firm's experiences and ability to perform the work and business status.
- B. Preliminary Short Circuit and Coordination Study Report shall include but not limited to:
1. The coordination study report shall be bound in a standard 8-1/2-in by 11-in size report.
  2. Electrical distribution system one-line diagram.
  3. Electrical distribution system impedance diagrams.
  4. Provide current transformers' ratio and burden calculations to confirm that the current transformers will not saturate prior to operation of the protective relays and confirming the current transformers used with differential protection will not saturate under any fault condition.
  5. Tabulation of each protective device, its short circuit rating, the available fault current available at the device and an indication whether or not the device is adequately rated for the available fault current and voltage at which it is applied.
  6. Preliminary graphic time-current curves showing how the protective devices proposed by the equipment suppliers will coordinate as being applied.
- C. Final Short Circuit and Selective Coordination Study Report shall include but not limited to:
1. The coordination study report shall be bound in a standard 8-1/2-in by 11-in size report. The selection of all protective relays types, current transformers, fuse types and ratings, shall be the responsibility of the manufacturer and shall be based on the preliminary coordination study, which shall be submitted prior to the equipment shop drawings in accordance with Section 01300. The complete study shall be approved by the Engineer before any equipment is shipped. The report shall include the following sections and information:
  2. An executive summary outlining the distribution system, the information received from the power company, assumptions made to complete the report, statement of the adequacy of the distribution equipment to safely clear any fault currents, the adequacy of the distribution equipment to close in on a fault, identify any problem areas with recommendations for resolving the problem.
  3. Electrical distribution system one-line diagram.
  4. Electrical distribution system impedance diagrams.
  5. Provide current transformers' ratio and burden calculations to confirm that the current transformers will not saturate prior to operation of the protective relays and to confirm the

current transformers used with differential protection will not saturate under any fault condition.

6. Transformer differential protection calculations including current transformer mismatch relay setting and charts. Provide differential current transformer wiring schematics including polarity and wiring connections based on the winding configuration of the actual power transformers being supplied.
  7. Tabulation of all protective devices, circuit breakers, fuses, current transformers, etc. The tabulation shall indicate the device, manufacturer, catalog number, recommended setting, etc.
  8. Industry standard graphic time current, protective relay and protective device curves, showing equipment and material damage curves, relay, circuit breaker, fuse curves, available fault currents at the equipment, transformer inrush currents, etc, for each piece of equipment.
  9. Tabulation of each protective device, its short circuit rating the available fault current available at the device and an indication whether or not the device is adequately rated for the available fault current and voltage at which it is applied.
  10. Calculations and required documentation
- D. Preliminary Arc Flash Study Report shall include but not limited to:
1. The Arc Flash study report shall be bound in a standard 8-1/2-in by 11-in size report
  2. An executive summary outlining the distribution system, the information received from the power company, assumptions made to complete the report and recommendations to reduce the arc flash values.
  3. Recommendations to reduce the arc flash incident energy levels
- E. The Final Arc Flash Study report shall be bound in a standard 8-1/2-in by 11-in size report. The report shall include the following sections and information:
4. An executive summary outlining the distribution system, the information received from the power company, assumptions made to complete the report and recommendations to reduce the arc flash values.
  5. Provide a detailed bus label for each fault location. Each label shall include a listing of the protective device settings and incident energy at several different working distances.
  6. Provide A NFPA 70 E work permit form for each fault location.
  7. Provide A bus label for each fault location. The label shall include a summary of the flash boundary, incident energy, PEE classification and the Limited, Restricted and Prohibited Approach boundaries based on the nominal system voltage.

8. PPE Table – Provided a PPE table that defines the Personnel Protective Equipment classes

#### 1.04 REFERENCED STANDARDS

- A. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
  1. Standard 141, Recommended Practice for Electrical Power Distribution for Industrial Plants
  2. Standard 241, Recommended Practice for Electrical Power Systems in Commercial Buildings
  3. Standard 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Systems
  4. Standard 399, Recommended Practice for Industrial and Commercial Power System Analysis
- B. American National Standards Institute (ANSI):
  1. Standard C37.90, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus
  2. Standard C37.91, IEEE Guide for Protective Relay Applications to Power Transformers
  3. Standard C37.95, IEEE Guide for Protective Relaying of Utility-Consumer Interconnections
  4. Standard C37.96, IEEE Guide for AC Motor Protection
  5. Standard C57.12.59, IEEE Guide for Dry-Type Transformer Through-Fault Current Duration
  6. Standard C57.13, IEEE Standard Requirements for Instrumentation Transformers
  7. Standard C57.109, IEEE Guide for Liquid-Immersed Transformer Through-Fault-Current Duration

#### 1.05 QUALITY ASSURANCE

- A. All electrical studies shall be stamped and signed by a professional electrical engineer.

#### 1.06 SHORT CIRCUIT STUDY

- A. Perform a short circuit study in accordance with ANSI Standards C37.010 and C37.13 to check the adequacy and to verify the correct application of circuit protective devices and other system components within the construction package. The study shall address the case when the system is being powered from the utility source as well as from the on-site generating facilities, normal

and alternate (bus tie closed) modes of operation. Minimum and maximum possible fault conditions shall be covered in the study.

- B. Consider the fault contribution of all motors operating during the maximum demand condition of the motors.
- C. Calculate short-circuit momentary duties and interrupting duties on the basis of an assumed bolted 3 phase short circuit at each high and medium voltage switchgear bus and controller, low voltage switchgear bus, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard and other significant locations throughout the systems. The short circuit tabulations shall include X/R ratios, asymmetry factors, KVA and symmetrical fault-current. Provide a ground fault current study for the same system areas, including the associated zero sequence impedance diagram. Include in tabulations fault impedance, X/R ratios, asymmetry factors, motor contribution, short circuit KVA, and symmetrical and asymmetrical fault-currents.
- D. The studies shall include representation of the site power system, the base quantities selected, impedance source data., calculation methods and tabulations, one-line and impedance diagrams, conclusions and recommendations.
- E. Provide the following:
  - 1. Overall system impedance diagram. The diagram shall include the power companies impedance and X/R ratio, circuit element impedances (e.g. transformers, generators, motors, VFDs, feeders, distribution buses, etc.).
  - 2. The available fault current at each bus within the limits of the study shall be identified and listed.
  - 3. The momentary and interrupting rating of all elements of the distribution system shall be listed. The maximum available fault current available at each element shall be calculated.
  - 4. Determine the adequacy of the electrical protective devices to withstand the maximum available fault at the terminals of the equipment. Provide an equipment list, the equipment rating (both momentary and withstand), the maximum available fault rating and the adequacy of the equipment to withstand the fault. Equipment that does not have adequate ratings shall be identified immediately and brought to the attention of the Engineer.
  - 5. The short circuit portion of the report shall include:
    - a. Separate positive, negative and zero sequence impedance diagrams for the utility and emergency/standby distribution systems.
    - b. Executive summary describing the distribution system, the procedures used to develop the study, utility related information furnished by the utility company including the name and telephone number of the individual supplying the information, identify all assumptions made in the preparation of the study, identify any problem areas and

provide a definitive statement concerning the adequacy of the distribution system to interrupt and withstand the maximum possible fault current.

- c. Computer printout of the input data.
- d. Computer printouts for the three phase and ground fault studies. Printouts shall indicate the fault current available at each major equipment, distribution bus within the high, medium and low voltage distribution systems.
- e. Table listing all the electrical distribution and utilization equipment (including VFDs), the equipment interrupting and withstand ratings, the available fault current at the terminals of the equipment and the ability of the equipment to interrupt and/or withstand the fault.
- f. The short circuit study shall be prepared using approved computer software and must include complete fault calculations as specified herein for each proposed and ultimate source combination. Source combinations may include present and future Power Company supply circuits, large motors, or generators.

F. Automatic Load Transfer

1. Provide a detailed study demonstrating the interrupting capacity of automatic transfer bus ties and switches, as well as the fault withstand capabilities. The following shall be considered:
  - a. X/R ratio fault-current of circuit at point of transfer.
  - b. X/R ratio and fault-current rating of the transfer device.
  - c. Length of time fault may persist prior to protective device opening.
  - d. Magnetic stress withstand rating.
  - e.  $I^2t$  withstand rating.
  - f. Transfer device maximum interrupting duty compared to load interrupting duty.

1.07 PROTECTIVE DEVICE COORDINATION

- A. Provide a protective device time-current coordination study in accordance with ANSI/IEEE Std. 242, with coordination plots of protective devices plus tabulated data, including ratings and settings selected. In the study, balance shall be achieved between the competing objectives of protection and continuity of service for the system specified, taking into account the basic factors of sensitivity, selectivity and speed.
- B. Provide separate plots for each mode of operation: (1) "double-ended mode" (double-ended substation with bus tie open); (2) "singled ended mode" (single incoming utility feeder energized all switchgears single ended with bus ties closed); (3) "stand-by mode" (on-site generation solely



providing power to the system; (4) "peak shaving modes" (a.) (double-ended substation with bus tie open with on-site generation paralleled) and (b) (single-ended with bus ties closed with on-site generation paralleled). Show maximum and minimum fault values in each case. Multiple power sources shown in one plot is not acceptable.

- C. Each primary protective device required for a delta-to-wye-connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI C37.91 withstand curve to afford protection for secondary line-to-ground faults. Separate low voltage power circuit breakers from each other and the associated primary protective device, by a 16 percent current margin for coordination and protection in the event of line-to-line faults. Separate the protective relays by a 0.3-second time margin for the maximum 3 phase fault conditions to assure proper selectivity. The protective device characteristics or operating bands shall be terminated to reflect the actual symmetrical and asymmetrical fault-currents sensed by the device. Provide the coordination plots for 3 phase and phase-to-ground faults on a system basis. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in each motor control center and/or power distribution panelboard. Include all adjustable setting ground fault protective devices.
- D. Select relay types (i.e. inverse, very inverse, extremely inverse, over current with or without voltage restraint, timers, etc), current transformer ratings and types, fuse, residually or zero sequence connected ground faults protection, etc, that will allow the system to be protected to within the equipment fault ratings and provide the maximum possible coordination between the protective devices.
- E. Generator Protective Devices
  - 1. The study shall address all of the protective devices provided for generator protection.
  - 2. Protective relays requiring settings shall be included.
  - 3. The Electrical Contractor shall obtain all necessary generator information to perform this study.
- F. Motor Protection and Coordination
  - 1. Provide a complete and independent set of current-time characteristic curves for all motors 25 Hp and above indicating coordination between the protective relays and the thermal and starting characteristics of the motor.
  - 2. The Contractor shall obtain from the motor supplier the necessary information to perform the study. Certified curves for "Safe Time vs. Current at 100% Voltage" and "Accelerating Time vs. Current at 100% Voltage" are necessary and shall become part of the final report.
- G. Call discrepancies to the attention of the Engineer in the conclusions and recommendations of the report.
- H. The Time current Characteristic Curves shall include:

1. The coordination plots shall graphically indicate the coordination proposed for the several systems centered on full-scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated upstream power system relays, fuse or system characteristics, significant motor starting characteristics, significant generator characteristics, complete parameters for power, and substation transformers, complete operating bands for low voltage circuit breaker trip devices, fuses, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required. The short-time region shall indicate the relay instantaneous elements, the magnetizing inrush, and ANSI transformer damage curves, the low voltage circuit breaker and instantaneous trip devices, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault-currents.
2. No more than six devices shall be shown on one coordination plot. Of these six curves, two (the largest upstream device and the smallest downstream device) shall repeat curves shown on other coordination plots in order to provide cross-reference. Give each curve in the study a study-unique number or letter identifier to permit cross-reference between plots.
3. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings. A tabulation shall include settings for every overcurrent protective device, timer, power system relays (e.g. ANSI 25, 27, 32, 67, 87, etc), circuit breaker, recommended fuse and current transformer ratings, etc. Include C.T. ratio, burden and all other calculations required for the determination of settings. Provide recommended settings for all protective devices furnished under Division 16 and furnished with those furnished with Variable Frequency Drives and associated transformers, generators and associated paralleling and distribution switchgear.

#### 1.08 ARC FLASH

- A. Provide an arc flash study that utilizes the fault current values calculated in the short circuit study and the minimum clear times of the upstream protective device selected in the coordination study to calculate the incident energy at each fault location.
- B. The Arc Flash study shall be in accordance with the procedure outlined in IEEE Standard 1584.
- C. Calculate the incident energy levels at each faulted bus for each mode of operation: (1) "double-ended mode" (double-ended substation with bus tie open); (2) "singled ended mode" (single incoming utility feeder energized all switchgears single ended with bus ties closed); (3) "stand-by mode" (on-site generation solely providing power to the system; (4) "peak shaving modes" (a.) (double-ended substation with bus tie open with on-site generation paralleled) and (b) (single-ended with bus ties closed with on-site generation paralleled). Determine arc flash incident energy values for both maximum and minimum fault values in each case.

#### PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 QUALITY ASSURANCE

- A. Adjust relay and protective device settings according to values established by coordination study. Setting shall be made in accordance with Section 16950.
- B. Make minor modifications to equipment as required to accomplish conformance with the short circuit and protective device coordination studies.
- C. Notify Consulting Engineer in writing of any required major equipment modifications.

END OF SECTION

## **PART 1 GENERAL**

### **1.1 Summary**

- A This section includes the following items from a single supplier:
  - 1. Automatic transfer switch
  
- B Related Requirements
  - 1. It is the intent of this specification to secure an automatic transfer switch that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
  - 2. Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line by line summary description of all the items of compliance, any items that have been omitted or have been taken exception to, and a complete description of all deviations.
  - 3. It is the intent of this specification to secure an automatic transfer switch that has been tested during design verification, in production, and at the final job site. The automatic transfer switch will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
  - 4. All equipment shall be new and of current production by an international, power system manufacturer of generators, transfer switches, and paralleling switchgear. The manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

### **1.2 Submittals**

- A Action Submittals
  - 1. Product Data
    - a The submittal shall include specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.
  - 2. Shop Drawings
  
- B Closeout Submittals
  - 1. Operation And Maintenance Data
  - 2. Warranty Documentation

### **1.3 Quality Assurance**

- A Regulatory Agency
  - 1. The automatic transfer switch shall conform to the requirements of the following codes and standards:
    - a UL 1008 - Standard for Transfer Switch Equipment

- b IEC 947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
  - c NFPA 70 - National Electrical Code
  - d NFPA 99 - Essential Electrical Systems for Health Care Facilities
  - e NFPA 110 - Emergency and Standby Power Systems
  - f IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
  - g NEMA Standard ICS 10-2005, Electromechanical AC Transfer Switch Equipment.
  - h EN61000-4-4 Fast Transient Immunity Severity Level 4
  - i EN61000-4-5 Surge Immunity Class 4 (voltage sensing and programmable inputs only)
  - j IEEE 472 (ANSI C37.90A) Ring Wave Test
  - k IEC Specifications for EMI/EMC Immunity (CISPR 11, IEC 1000-4-2, IEC 1000-4-3, IEC 1000-4-4, IEC 1000-4-5, IEC 1000-4-6, IEC 1000-4-8, IEC 1000-4-11)
  - l CSA C22.2 No. 178 certification
2. Qualifications
- a The automatic transfer switch shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.
  - b A manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year shall produce the automatic transfer switch.
3. Manufacturers
- a The automatic transfer switch shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.
  - b The manufacturer shall maintain a national service organization of employing personnel located throughout the contiguous United States. The Service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.
  - c The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

#### 1.4 Field or Site Conditions

##### A Ambient Conditions

1. Automatic transfer switch shall operate in the following conditions without any damage to the unit or its loads.
  - a Ambient Temperature: -4 to 158 Degrees F
  - b Relative Humidity: 5% to 95% noncondensing

#### 1.5 Warranty or Bond

##### A Manufacturer's Warranty

1. The ATS shall include a standard warranty covering one (5) years to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from the date of initial startup.
2. The ATS manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating

conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and functional tests performed on all systems.

## **PART 2 PRODUCTS**

### **2.1 Equipment**

#### **A Equipment**

1. Furnish and install an automatic transfer switches system(s) with **4-Pole / 4-Wire**, Solid Neutral, 200 Amps, 480V/60Hz. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All transfer switches and controllers shall be the products of the same manufacturer.
2. Programmed Transition

#### **B Manufacturer**

1. Automatic transfer switches shall be Programmed Transition Kohler Model KCP-AMTC-0800S (or ASCO/Generac equal). Any alternate shall be submitted for approval to the consulting engineer at least 10 days prior to bid date. Alternate bids shall include a line-by-line clarification of the specification marked with "D" for deviation; "E" for exception, and "C" for comply.

#### **C Construction**

1. The transfer switch shall be electrically operated and mechanically held with double throw construction, and operated by a momentarily energized solenoid-driven mechanism.
2. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.
3. The switch shall be positively locked and unaffected by momentarily outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
4. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
5. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 800 amperes and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.
6. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources, are not acceptable.
7. For two and three pole switches, where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.
8. For four pole switches with a switching neutral, where neutral conductors must be switched as shown on the plans, the contactor shall be provided with fully rated switched neutral transfer contacts. Overlapping neutral contacts may be used as an alternative.

#### **D Enclosure**

1. The ATS shall be furnished in a NEMA 3R enclosure.
2. All standard door mounted switches and indicating LEDs shall be integrated into a flush-mounted, interface membrane or equivalent in the enclosure door for easy viewing & replacement. The panel shall be capable of having a manual locking feature to allow the user to

lockout all membrane mounted control switches to prevent unauthorized tampering. This cover shall be mounted with hinges and have a latch that may be padlocked. The membrane panel shall be suitable for mounting by others when furnished on open type units.

## 2.2 Operation

### A Controls

1. A four line, 20 character LCD display and dynamic 4 button keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and control through the communications interface port or USB. The following parameters shall only be adjustable via a password protected programming on the controller:
  - a Nominal line voltage and frequency
  - b Single or three phase sensing
  - c Operating parameter protection
  - d Transfer operating mode configuration (Standard transition, Programmed transition, or Closed transition)

### B Voltage and Frequency

1. Voltage (all phases) and frequency on both the normal and emergency sources shall be continuously monitored, with the following pickup, dropout, and trip setting capabilities (values shown as % of nominal unless otherwise specified):
 

a	Parameter	Dropout/Trip	Pickup/Reset
b	Under voltage	75 to 98%	85 to 100%
c	Over voltage	106 to 135%	95 to 100% of trip
d	Under frequency	95 to 99%	80 to 95%
e	Over frequency	01 to 115%	105 to 120%
f	Voltage unbalance	5 to 20%	3 to 18%
2. Repetitive accuracy of all settings shall be within  $\pm 0.5\%$  over an operating temperature range of -20°C to 70°C.
3. An adjustable dropout time for transient voltage and frequency excursions shall be provided. The time delays shall be 0.1 to 9.9 seconds for voltage and .1 to 15 seconds for frequency.
4. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad, remotely via the communications interface port or USB.
5. The controller shall be capable of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or BAC). Unacceptable phase rotation shall be indicated on the LCD; the service required LED and the annunciation through the communication protocol and dry contacts. In addition, the phase rotation sensing shall be capable of being disabled, if required.
6. The controller shall be capable of detecting a single phasing condition of a source, even though a voltage may be regenerated by the load. This condition is a loss of phase and shall be considered a failed source.
7. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases (phase to phase and phase to neutral), frequency, and phase rotation.

### C Time Delays

1. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 12 or 24 VDC power supply.
2. A time delay shall be provided on transfer to the emergency source, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

3. A time delay shall be provided on re-transfer to normal. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.
4. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.
5. A time delay activated output signal shall also be provided to drive external relay(s) for selective load disconnect and reconnect control. The controller shall be capable of controlling a maximum of 9 individual output time delays to step loads on after a transfer occurs. Each output may be individually programmed for their own time delay of up to 60 minutes. Each sequence shall be independently programmed for transferring from normal to emergency and transferring from emergency to normal.
6. All time delays shall be adjustable in 1 second increments.
7. All time delays shall be adjustable by using the display and keypad, with a remote device connected to the communications interface port or USB.
8. Each time delay shall be identified and a dynamic countdown shall be shown on the display. Active time delays can be viewed with a remote device connected to the communications interface port or USB.

#### D Additional Features

1. The controller shall have 3 levels of security. Level 1 shall allow monitoring of settings and parameters only. The Level 1 shall be capable of restricted with the use of a lockable cover. Level 2 shall allow test functions to be performed and Level 3 shall allow setting of all parameters.
2. The display shall provide for the test functions, allowed through password security. The test function shall be load, no load or auto test. The auto test function shall request an elapsed time for test. At the completion of this time delay the test shall be automatically ended and a retransfer sequence shall commence. All loaded tests shall be immediately ended and retransfer shall occur if the emergency source fails and the normal source is acceptable.
3. A contact closure shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.
4. Auxiliary contacts shall be provided consisting of a minimum of two contacts, closed when the ATS is connected to the normal source and two contacts closed, when the ATS is connected to the emergency source.
5. LED indicating lights shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).
6. LED indicating lights shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal (green) and emergency sources (red), as determined by the voltage, frequency and phase rotation sensing trip and reset settings for each source.
7. A membrane switch shall be provided on the membrane panel to test all indicating lights and display when pressed.
8. Provide the ability to select "commit/no commit to transfer" to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.
9. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which closes to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad, communications interface port or USB. A "not-in-auto" LED shall indicate anytime the controller is inhibiting transfer from occurring.



10. The programmed transition feature shall control the transfer so that mechanism is placed in a load disconnect position for an adjustable period of time, giving motor and transformer loads and opportunity to decay to acceptable levels. The programmed transition feature shall be specifically designed for and be the product of the ATS manufacturer. The programmed transition setting shall be capable of being enabled or disabled from the user interface, communications interface port of USB. The controller shall include a built-in time delay for programmed transition operation. This time shall be adjustable from the user interface. The default value shall be 1 second and shall be adjustable from 0 to 60 minutes.
11. A time based load control feature shall be available to allow the prioritized addition and removal of loads based during transfer. This feature may be enabled for either or both sources. The user shall be able to control up to nine loads with independent timing sequences for pre and post transfer delays in either direction of transfer.
12. The controller shall provide 2 inputs for external controls that can be programmed from the following values:
  - a Common fault, Remote test, Inhibit transfer, Low battery voltage, Peak shave, Time delay bypass, Load shed forced to OFF position (Programmed transition only)
13. The controller shall provide two form "C" contact outputs rated for up to 12A @ 240VAC or 2A @ 480VAC that can be programmed from the following values:
  - a Aux switch open, Transfer switch aux contact fault, Alarm silenced, Alarm active, I/O communication loss, Contactor position, Exercise active, Test mode active, Fail to transfer, Fail to acquire standby source, Source available, Phase rotation error, Not in automatic mode, Common alarm, In phase monitor sync, Load bank control active, Load control active, Maintenance mode active, Non-emergency transfer, Fail to open/close, Loss of phase, Over/under voltage, Over/under frequency, Voltage unbalance, Start signal, Peak shave active, Preferred source supplying load, Standby source supplying load
14. The controller shall be capable of expanding the number of inputs and outputs with additional modules.
15. Optional input/output modules shall be furnished which mount on the inside of the enclosure to facilitate ease of connections.
16. Engine Exerciser - The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to 21 different exercise routines based on a calendar mode. For each routine, the user shall be able to:
  - a Enable or disable the routine
  - b Enable or disable transfer of the load during routine.
  - c Set the start time, time of day, day of week, week of month (1st, 2nd, 3rd, 4th, alternate or every)
  - d Set the duration of the run.
  - e At the end of the specified loaded exercise duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. All loaded exercises shall be immediately ended and retransfer shall occur if the standby source fails. The next exercise period shall be displayed on the main screen with the type of exercise, time and date. The type of exercise and the time remaining shall be display when the exercise is active. It shall be possible of ending the exercise event with a single button push.
17. Date and time - The date shall automatically adjust for leap year and the time shall have the capability of automatically adjusting for daylight saving and standard times.
18. System Status - The controller shall have a default display the following on:
  - a System status
  - b Date, time and type of the next exercise event
  - c Average voltage of the preferred and standby sources
  - d Scrolling through the displays shall indicate the following:
    - 1) Line to line and line to neutral voltages for both sources

- 2) Frequency of each source
  - 3) Load current for each phase
  - 4) Single or three phase operation
  - 5) Type of transition
  - 6) Preferred source
  - 7) Commit or no commit modes of operation
  - 8) Source/source mode
  - 9) In phase monitor enable/disable
  - 10) Phase rotation
  - 11) Date and time
19. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual, are not permissible.
20. Self-Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.
21. Communications Interface - The controller shall be capable of interfacing, through a standard communication with a network of transfer switches and generators. It shall be able to be connected via an RS-485 serial communication (up to 4000 ft. direct connect or multi-drop configuration). This module shall allow for seamless integration of existing or new communication transfer devices and generators.
22. The transfer switch shall also be able to interface to 3rd party applications using Modbus RTU open standard protocols utilizing Modbus register maps. Proprietary protocols shall not be acceptable.
23. The controller shall contain a USB port for use with a software diagnostic application available to factory authorized personnel for downloading the controller's parameters and settings; exercise event schedules; maintenance records and event history. The application can also adjust parameters on the controller.
24. Data Logging - The controller shall have the ability to log data and to maintain the last 2000 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory. The controller shall be able to display up to the last 99 events. The remaining events shall be accessible via the communications interface port or USB.
- a Event Logging
    - 1) Data, date and time indication of any event
  - b Statistical Data
    - 1) Total number of transfers\*
    - 2) Total number of fail to transfers\*
    - 3) Total number of transfers due to preferred source failure\*
    - 4) Total number of minutes of operation\*
    - 5) Total number of minutes in the standby source\*
    - 6) Total number of minutes not in the preferred source\*
    - 7) Normal to emergency transfer time
    - 8) Emergency to normal transfer time
    - 9) System start date
    - 10) Last maintenance date
    - 11) \* The statistical data shall be held in two registers. One register shall contain data since start up and the second register shall contain data from the last maintenance reset.

### 2.3 Accessories

- A. Padlockable User Interface Cover. The user interface cover shall protect the controller user interface from the environment.
- B. Controller Disconnect Switch. A Logic disconnect switch shall be mounted inside the enclosure, and shall disconnect power to controller without disconnecting the load. The logic disconnect switch shall disconnect utility power to the controller during maintenance and service without disconnecting power to the load. The switch has two positions, auto and disconnect. The disconnect position shall disconnect the voltage sensing leads for the utility source (A, B, C, N). It is assumed that the user shall disable the generator by placing the controller in the OFF position.
- C. Programmable Exerciser. A programmable exerciser shall be supplied to allow programming of up to 56 on/off events.

## 2.4 Source Quality Control

- A Test and Inspection
  - 1. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.
  - 2. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001.

**END OF SECTION**

SECTION 23000

DIVISION 23 - MECHANICAL

A. GENERAL

1. Provide equipment, material, and labor for the heating, ventilation, air conditioning, piping, and plumbing in strict accordance with the specifications and drawings.
2. Work shall be executed and inspected in accordance with local and state codes. Obtain permits and inspections required.
3. In case of discrepancies between the plans, applicable codes, or specifications, the most stringent shall govern.
4. Should the Contractor perform any work that does not comply with requirements of applicable authorities, Contractor shall correct the deficiencies at no additional cost to the Owner.
5. It is the responsibility of the Contractor to investigate any desired substitutions for specified equipment prior to submission of his bid. The Contractor shall be responsible for any changes required in mechanical, electrical, structural, or plumbing and shall bear costs for those changes. Substitution requests will not be taken before bid date.
6. Final decision as to whether or not a specific piece of equipment meets specifications shall rest with Engineer.
7. Submit 6 copies of submittals for equipment. (Electronically or in 3 ring binders. No loose sets accepted.)
8. The Contractor shall field verify existing conditions and review and compare drawings and specifications for all disciplines to avert possible installation conflicts. Changes required in the work of the Contractor caused by his neglect to do so shall be made by him at no additional cost to the Owner.
9. Lines that pitch such as drain piping shall have the right-of-way over those that do not pitch.
10. Provide and install accessories, and incidental items to complete the work and provide complete systems ready for operation.
11. Contractor shall be responsible for required cutting and patching incidental to his work and shall make satisfactory repairs. In no case shall the Contractor cut into any major structural element, beam, or column.
12. Use of the Owner's Existing and New, Permanent HVAC System During Construction:
  - a. **Use of the Owner's existing and currently being installed, permanent HVAC system during Construction is prohibited.** Provide temporary means for heating and cooling required by construction activities for curing or drying completed

installations or for protecting installed construction from adverse effects of temperature and humidity. Provide temporary dehumidification systems when required to reduce substrate moisture levels required to accommodate installation or application of finishes.

- b. Maintain a minimum ambient temperature of 50 DEG. F. in areas where construction is in progress, unless indicated otherwise in the specifications.
  - c. Prevent dust, fumes, construction debris, and odors from entering existing and newly installed HVAC equipment, ductwork, and control system components. Prior to commencing work, isolate HVAC equipment. Where existing HVAC systems will be affected, isolate existing supply, return, and exhaust ducts by disconnecting ductwork at point where existing duct shall remain. Cover ends of existing ductwork securely with black plastic material.
  - d. Newly installed ductwork shall be thoroughly cleaned before installation. Each section that is installed at the end of the day shall have open ends securely covered with black plastic material.
  - e. Newly installed HVAC equipment shall be securely covered and protected with black plastic material or by other approved method. After installation of air moving equipment, duct connections shall be securely covered with black plastic material. Connections to duct systems shall not be made until final finishes have been installed, areas served are clean, and building is ready for HVAC equipment start-up and use.
  - f. Securely cover control system components to prevent damage from construction debris, dust, and dirt. Control systems shall not be energized for testing and adjusting until HVAC system start-up.
  - g. **HVAC Equipment, Ductwork, and Control Components contaminated by construction debris, dirt, and construction dust shall not be acceptable and shall be replaced at no additional cost to the Owner. HVAC Equipment, Ductwork, and Control components shall be kept clean throughout construction. Cleaning after an HVAC system has been contaminated shall not be an acceptable alternate to replacement.**
13. Contractor shall include adequate time in construction schedule for HVAC system start-up; testing, adjusting, and balancing; and control system installation, programming, testing, and commissioning.
14. Contractor and control system provider shall coordinate with Commissioning Agent and provide assistance as required throughout the commissioning period.
15. Equipment and materials shall be new and shall bear the manufacturer's name, trade name, and the UL label in every case where a standard has been established for the particular material. Equipment shall be the standard product of a manufacturer regularly engaged in the production of the required type of equipment, and shall be the manufacturer's latest approved design.

16. Equipment and materials of the same general type shall be of the same throughout the work to provide uniform appearance, operation, and maintenance.
17. Install sleeves for pipes and ducts that pass through floors or roof, and for pipes which pass through masonry or concrete walls or partitions. Sleeves for ducts shall be 16-gauge galvanized sheet steel.
18. Sleeves shall be large enough so that pipe and insulation can pass through freely, but not larger than necessary. Sleeves in floor slabs shall be extended 2" above the surface of the floor, whether in finished rooms, concealed spaces, chases or partitions. Sleeves in roof slab, walls, and partitions shall be flush with the finished surfaces.
19. In the exterior walls and at floor slab penetrations, the space between sleeves and pipes passing through the sleeves shall be sealed with "link-seal" sleeve seals.
20. It is the responsibility of the Contractor to investigate the job site and become familiar with the location and inverts of existing site utilities prior to submitting a bid or starting construction.
21. Excavation and Trenching: Excavate to provide three (3) foot minimum cover or greater depths as required by code to provide adequate slope and burial depth. Grade bottom of trenches to provide uniform bearing and support for each section of pipe on undisturbed soil. Provide a 4 inch thick (minimum) layer of pea gravel aggregate bedding beneath buried piping. Bedding shall be compacted and leveled to provide required sloping. Backfill trenches with excavated materials of earth, sandy clay, sand, gravel or other approved materials, free from clods of earth or stones 2 ½-inches maximum dimension, deposited in 6-inch layers and compacted to 95% standard proctor compaction test.
22. Remove waste and rubbish from the job.
23. Test and adjust phases of the work.
24. Supervise and coordinate electrical work in connection with the mechanical work.
25. Furnish motor controllers and contactors.
26. Control wiring shall be in conduit.
27. Provide access panels where shown or as required for maintenance.
28. Exposed ironwork, pipes, hangers, and miscellaneous steel without factory finish shall be prepped, primed with one coat alkyd primer, and painted with two coats alkyd enamel gloss. Color shall be black.
29. Install ducts and piping to provide the maximum possible clear height underneath.
30. Provide a redline set of record drawings at the conclusion of the project which indicate the as-installed condition. Provide final drawings to Owner.

31. Any damage to existing buildings, equipment, grounds, or product, which is the result of the Contractor's operations, shall be repaired or replaced to the Owner's satisfaction without additional cost to the Owner.
32. Provide miscellaneous supporting systems for the equipment installed.
33. Instruct the Owner's representative in the proper operation and maintenance of elements of the mechanical systems.
34. The work herein specified shall be free from defects in workmanship and material under normal use and service. If within twelve (12) months from the date of acceptance by the Owner, any of the equipment or materials, or the installation thereof, is found to be defective in workmanship or materials, it shall be replaced or repaired at no charge to the Owner.
35. Drawings are diagrammatic; therefore, offsets, fittings, valves and accessories are not shown. Plan work around building details and other crafts.
36. It is the intention that the plans and specifications shall provide a complete installation. Accessories and apparatus necessary for complete operational systems shall be included. The omission of specific reference to any part of the work necessary for such complete installation shall not be interpreted as relieving this Contractor from furnishing and installing such part.

**B. ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT**

1. Conduit, wiring, disconnect switches, and electrical connections for electric motors and equipment and starters for motors are specified under electrical, unless specifically furnished by Contractor. Starting switches, protective devices and other means for the operation and control of equipment shall be furnished with the mechanical equipment unless otherwise specifically noted.
2. Electrical work shall comply with the N.E.C.
3. Variable Frequency Drives shall be ABB unless otherwise noted.

**C. MECHANICAL SUPPORTING SYSTEMS**

1. Pipe hangers shall be equal to Grinnell, designed for the weight and installation.
2. Provide saddles on insulated pipe.
3. Hanger spacing shall be:

<u>Pipe Size</u>	<u>Steel</u>	<u>Copper</u>
to 3/4	7'	5'
1	7	6
1-1/4	7	7
1-1/2	9	8
2 to 2-1/2	10	8
3	12	10

4. Pipe hangers and supports shall conform to MSS-SP-58 and MSS-SP-69 latest editions.
5. Provide insulation inserts on insulated piping.
6. Provide copper hangers on un-insulated copper piping.
7. Provide supports at concentrated loads.
8. Furnish auxiliary steel and paint.

D. MECHANICAL VIBRATION CONTROLS

1. Provide 4-inch minimum concrete pads for floor-mounted equipment.
2. Provide concrete inertia bases for fans and pumps located above the basement or ground floor level.
3. Provide flexible connections on connections of piping and ductwork to rotating equipment.
4. Provide vibration isolation at fans and equipment with internal fans. Provide vibration isolation hangers for suspended units.

E. SEISMIC PROTECTION OF MECHANICAL EQUIPMENT

1. Comply with seismic requirements of IBC 2000/2003.
2. Manufacturer of seismic restraints shall provide submittals for products as follows:
  - a. Catalog/data sheets on seismic restraints.
  - b. Support, anchor, and installation details.
  - c. Seismic restraint calculations stamped by registered Engineer licensed in Arkansas.
3. See specific equipment specifications for additional requirements.

F. EQUIPMENT, PIPE, AND VALVE IDENTIFICATION

1. Install pipe ID markers on plumbing, and HVAC piping.
2. Colors and descriptions shall comply with ANSI requirements.
3. Labels shall comply with OSHA standards and Owner requirements.
4. Equipment, switches, and controls shall have a laminated tag identifying the piece of equipment or the equipment the device controls.
5. Provide equipment ID for HVAC equipment.

G. MECHANICAL SYSTEMS INSULATION



1. HVAC PIPING
  - a. Refrigerant piping: 3/4" Armaflex AP
  - b. Condensate drain: 3/4" Armaflex AP
  - c. Provide rigid inserts at support points.
2. HVAC EQUIPMENT
  - a. Insulate chiller surfaces, chilled water pump bodies, air separator, chemical feeder, expansion tank, storage tank, and other surfaces subject to sweating with 3/4" Armaflex AP.
  - b. Insulate tops of ceiling supply air devices with R-6 foil-faced ductwrap.
3. Install systems of insulation in accordance with the manufacturer's instructions.
4. PIPE INSULATION EXPOSED TO WEATHER: Provide smooth aluminum jacket 0.016". Provide side and end laps of 2" minimum with cut edge of side lap turned under 1" for smooth edge. Seal laps with weatherproof sealant. Position laps to shed water. Secure jacket in place with bands 1/2" X 0.015" thick placed on 9" centers. Extend exterior insulation and jacketing 2" beyond sleeve inside building.

#### H. FIRESTOPPING AND SMOKE STOPPING

1. Provide the required fire and smoke stopping for mechanical systems penetrations of the fire and smoke construction of the building.
2. Submit shop drawings and product data sheets for system components.
3. Fire and smoke stopping systems and components shall be equal to 3M.

#### I. BUILDING SERVICES PIPING AND SPECIALTIES BASICS

1. Provide and install a complete system of piping and valves as indicated or as necessary to completely control the entire apparatus appurtenances. The piping drawings are diagrammatic and indicate the general location and connections.
2. Open ends of pipes and equipment shall be properly capped or plugged to keep dirt and other foreign materials out of the system.
3. Contractor shall take every precaution to remove dirt, grease, and other foreign matter from each length of piping before making field connections.
4. Maintain piping clean and dry.
5. Systems shall be free of noise.
6. Piping stored on site shall be protected from damage and weather.
7. Material shall be new and undamaged.

8. Materials and methods will comply with ASME and ANSI standards.
9. Route lines parallel or perpendicular with the building.
10. Piping with grades will take precedence. Maintain piping as close as possible to the structure.
11. Plans are diagrammatic and do not indicate offsets or arrangements required.
12. Conceal pipes unless indicated otherwise.
13. Install drains at low points. Install air vents at high points.
14. Seal pipe penetrations. Provide sleeves. Seal penetrations in fire or smoke construction to maintain rating.
15. Remove scale, slag, dirt and debris from the piping.
16. Provide unions or flanges at equipment.
17. Use standard fittings for joints and bends.
18. Provide dielectric unions for dissimilar metals. Provide shut-off valve on either side for service.
19. Fittings shall match the piping materials.
20. Clean, flush, and inspect piping systems.
21. Test piping systems.

J. PIPING SPECIALTIES

1. Automatic air vents shall be Spirotherm "Spirotop."

K. CONDENSATE DRAIN PIPING

1. Piping shall be type M hard drawn copper, or DWV copper with wrought copper fittings.
2. Piping shall be SCH 40 PVC with glued joints.
3. Provide with traps and vents.

L. HVAC EQUIPMENT

1. Submit equipment for approval.
2. See the plans for equipment schedules.
3. Install equipment in strict accordance with manufacturer's recommendations.
4. Refrigeration compressors shall have a 5 year factory warranty.

5. See other specific equipment specification sections.
6. See Section A for use of Owner's new and existing, permanent HVAC Equipment during construction.

M. HVAC CONTROLS

1. Coordinate installation with the equipment installed.
2. Control sequences are shown on the drawings.
3. Wiring shall be in conduit.
4. System shall be DDC type.
5. Provide controllers and operators for valves, dampers and other devices.
6. Interlock with fire alarm system as required.
7. Control, monitor, and alarm points shall be commissioned before system acceptance by Owner. Provide report.
8. Provide Owner's representative(s) with complete training in the operation and maintenance of the controls. Submit documentation of training provided to include training material provided, instructor's name(s), names of Owner's representatives attending, and Owner's acknowledgement that training was provided and completed. Coordinate with Owner for times and location of training.
9. Provide Owner's representative and Engineer with demonstration of each sequence of operation.
10. Submit final certification that control system has been installed complete, tested, and commissioned; and that the system and components are functioning and operating as required by the sequences of operation.
11. See Section A for use of Owner's new and/or upgrades to existing control system during construction.

N. TESTING, ADJUSTING, AND BALANCING

1. HVAC systems shall be tested, adjusted, and balanced by a company or individual approved by the Engineer.
2. All phases of the HVAC system shall be tested and balanced to the design conditions. A written report shall include the start up logs of the major equipment, the motor amps, installed cfm and static pressure, and the water flow rates at pumps and coils. Engineer shall not accept job until the report is received.
3. Provide the following as part of the tab work:

- a. Provide test data for air equipment
  - b. Balance air device to air flows indicated
4. If procedures were not performed during near peak summer or winter conditions, perform additional testing as required to confirm operation at peak seasonal conditions.

END OF SECTION

