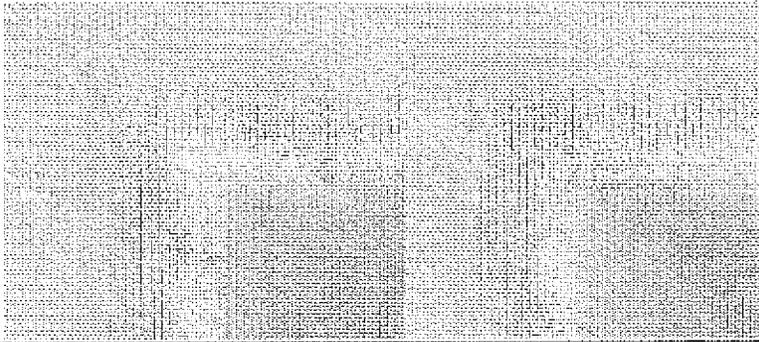


# EXHIBIT B

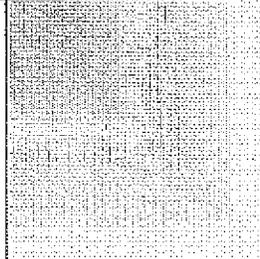


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**TP-03 Metering Station  
Improvements**

**COT Project No. 3202551**

**TECHNICAL  
SPECIFICATIONS**



Expires 3/31/2016

March 2013

CITY OF TEMPE TP03 METERING STATION IMPROVEMENTS

PROJECT No. 3202551

TECHNICAL SPECIFICATION

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SECTION 01171  
ELECTRIC MOTORS TO 250 HP

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Random wound, NEMA frame motors up to 250 Hp furnished under other Sections shall comply with the requirements listed in this Section.
- B. Motors connected to Variable Frequency Drive Controllers shall be designed for inverter duty.

1.02 RELATED WORK

- A. Section 01174 - Pulse Width Modulated Variable Frequency Drive (Low Voltage 6-Pulse).
- B. Section 16020 – Low Voltage Wires and Cables: for termination of power and control cables.
- C. Section 16950 - Electrical Systems Testing: for field commissioning.

1.03 SUBMITTALS

- A. Submit motor nameplate data and test characteristics per NEMA Standard MG1-12.54 "Report of Test Form for Routine Tests on Induction Motors" in accordance with MAG Uniform Standard Specification - Section 105, including:
  - 1. Efficiency at 1/2, 3/4 and full load
  - 2. Power factor at 1/2, 3/4 and full load
  - 3. Motor outline, dimensions and weight
  - 4. Descriptive bulletins, including full description of insulation system
  - 5. Bearing design data
  - 6. Special features (i.e., space heaters, temperature detectors, etc.)
  - 7. Power factor correction capacitor rating and type.

1.04 REFERENCE STANDARDS

- A. American Bearing Manufacturer's Association (ABMA)
  - 1. ANSI/ABMA 7 - Shaft and Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plans [1995]
  - 2. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings [1990]
  - 3. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings [1999]
- B. American National Standards Institute (ANSI)

1. ANSI/NCSL Z540-1 – Calibration Laboratories and Measuring and Test Equipment, General Requirements [1994]
- C. American Society for Testing Materials (ASTM)
1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) apparatus [1997]
- D. Institute of Electrical and Electronics Engineers (IEEE)
1. IEEE 1 - Recommended Practice - General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation [2000]
  2. IEEE 43 - Recommended Practice for Testing Insulation Resistance of Rotating Machinery [2000]
  3. IEEE 85 - Test Procedures for Airborne Sound Measurements on Rotating Electric Machinery [1986]
  4. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators [2004]
  5. IEEE 792 - Recommended Practice for the Evaluation of the Impulse Voltage Capability of Insulation Systems for AC Electric Machinery Employing Form-Wound Stator Coils [1995]
  6. IEEE 841 - Standard for Petroleum and Chemical Industry - Severe Duty Squirrel Cage Induction Motors - Up to and Including 500 HP [2001]
- E. International Organization for Standardization (ISO)
1. ISO 10012-1 - Quality assurance requirements for measuring equipment [1990]
  2. ISO 1940-1- Mechanical Vibration, Balance Quality Requirements of Rigid Rotors [1986]
  3. ISO 1940-2 - Determination of Permissible Residual Unbalance [1997]
  4. ISO 10816-1- Mechanical Vibration, Evaluation of Machine Vibration by Measurements on Non-Rotating Parts - Part 1: General Requirements [1995]
  5. ISO 9001- Quality Management Systems - Requirements [2001]
- F. National Electrical Manufacturers Association (NEMA)
1. NEMA MG1 - Motors and Generators [2006]
  2. NEMA MG2 - Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators [2001]
  3. NEMA MG3 - Sound Level Prediction for Installed Rotating Electrical Machines [2000]
  4. NEMA MG10 - Energy Management Guide for selection and use of Polyphase Motors [1999]

G. National Fire Protection Association (NFPA)

- I. NFPA 70 - National Electric Code [2005]

H. Underwriters Laboratories (UL)

- I. UL 674 - Motors and Generators, Electric, for Use in Hazardous Locations, Class I - Groups C and D, Class II - Groups E, F and G.

- I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. Motors shall be listed under UL recognized component file as applicable.
- B. The motor manufacturer shall maintain a documented ISO 9001 quality assurance program implementing suitable procedures and controls to monitor all aspects of production and testing.
- C. Motor manufacturer shall maintain authorized service centers capable of providing training, parts, and emergency maintenance and repairs.
- D. Electric motors driving identical machines shall be identical.

1.06 SYSTEM DESCRIPTION

- A. To assure unity of responsibility, the motors shall be furnished and coordinated by the manufacturer of the driven equipment. The Contractor shall assume responsibility for the satisfactory installation and operation of the entire system as specified.
- B. When electrically driven equipment differs from that indicated, adjust the motor size, wiring and conduit systems, disconnect devices, and circuit protection to accommodate the equipment actually installed, without additional cost.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Motors shall be shipped fully assembled with the driven equipment. Provide storage and handling per motor manufacturers installation instructions and [Section 01600 – Delivery, Storage and Handling].
- B. When furnished, energize motor space heaters to prevent moisture condensation throughout the storage and construction period. Perform periodic motor insulation resistance tests per manufacturer's storage recommendation.
- C. Maintain the bearings during storage and construction and periodically rotate the motor shaft according to manufacturer's instructions.

1.08 PROJECT/SITE REQUIREMENTS

- A. Power supply: 120 or 240 VAC single phase, 60 hertz.

B. Environmental Requirements: unless otherwise stated, suitable for continuous duty operation without derating under the following service conditions:

1. Environment: Class 1, Division 1 Metering Station underground vault.
2. Area classification: Class 1, Division 1.
3. Minimum outdoor ambient temperature: 5 degrees C.
4. Maximum ambient temperature: 40 degrees C.
5. Altitude: up to 1150 feet above MSL.

C. Coordination:

1. Coordinate motor installation and equipment layout with conduit and wiring, piping, other machinery equipment, and adjacent surfaces. Maintain required access clearances for cooling air, conduit box, lubrication and coupling.
2. Coordinate size and location of concrete pads for motors and equipment soleplates.
3. Coordinate voltage and current ratings of motors and accessories such as space heaters with power supply characteristics, and overcurrent and overload protective devices per the NEC.
4. Coordinate winding and bearing protective devices with ratings and characteristics of monitoring equipment circuits to which they connect. Coordinate control sequences.

#### 1.09 DEFINITIONS

A. Definition of terms used in this specification shall be in accordance with NEC Article 100, ANSI/IEEE Standard 100, and UL Standards Glossary.

B. Definitions of enclosure types for motors.

1. ODP - Open Drip-Proof
2. TEFC - Totally-Enclosed, Fan-Cooled
3. TEAO - Totally-Enclosed, Air Over
4. TEXP - Totally-Enclosed, Explosion-Proof
5. IP-22 - Open Drip-Proof
6. IP-44 - Totally-Enclosed
7. IP-54 - Splash Proof
8. IP-55 - Washdown

## PART 2 PRODUCTS

### 2.01 GENERAL

- A. Torque output: minimum performance characteristics for locked rotor and breakdown torque with rated voltage and frequency applied as defined by NEMA MG1, to accelerate and operate the load throughout its operating speed range, including conditions imposed by reduced voltage starting methods.
- B. Motors shall deliver the specified performance at rated load under the combinations of voltage and frequency variations and voltage unbalance specified in NEMA MG1.
- C. Horsepower rating: sized for operation within the full load nameplate rating without applying the service factor, throughout the full range of mechanical or hydraulic operating condition.
- D. Service Factor: 1.15 service factor on sine wave power and 1.0 service factor on VFD power in a 40 degree C ambient.
- E. Specific motor application data such as Hp, rpm, enclosure type, etc, is specified under the detailed driven mechanical equipment specification.
- F. Enclosures: conform to one of the following NEMA standard enclosure designs as specified under the detailed driven mechanical equipment specification. If no enclosure type is specified, provide TEFC enclosures:
  - 1. Open Drip Proof (ODP)
  - 2. Totally Enclosed Fan Cooled (TEFC)
  - 3. Totally Enclosed Explosion Proof (TEXP)
- G. Nameplates: engraved or embossed on stainless steel fastened to the motor frame with stainless steel screws or drive pins with information per NEMA MG1.

### 2.02 SINGLE PHASE MOTORS

- A. Application: motors smaller than 1/2 Hp shall be 115/230, continuous heavy duty, reversible, capacitor start. Small fan motors may be split-phase or shaded pole type if such are standard for the equipment. Wound rotor or commutator type single-phase motors are not acceptable unless their specific characteristics are necessary for the application.
- B. Overload protection: provide internal automatic thermal overloads unless otherwise noted.
- C. Insulation: Class F or better, with Class B temperature rise, 1.15 service factor. Locked rotor current shall not be greater than specified in NEMA Standard MG1, Design "N".
- D. Enclosure: provide fully gasketed, totally-enclosed air over or fan cooled in conformance with NEMA Standard MG1. Small fan motors may be open type if suitably protected from moisture, dripping water and lint accumulation.

- E. Washdown duty: Where motor is installed in wet or corrosive areas routinely exposed to washdowns, high humidity or caustic chemicals, provide stainless steel, paint free washdown motors with Inpro bearing isolators, stainless steel T-type condensation drains, nitrile conduit box gasket, and corrosion resistant fans.
- F. Bearings: sealed ball bearings permanently lubricated for 10 years normal use, furnished with shaft slinger.
- G. Class 1, Division 1 and 2 locations: Single phase motors installed in Class 1, Division 1 and 2 locations shall be explosion proof, marked with a T3B temperature code label, and UL listed for use in Class 1, Division 1, Groups C & D, and Class II, Groups E, F, & G hazardous location. The temperature code marking shall appear on the nameplate.

## 2.03 THREE PHASE INDUCTION MOTORS

### A. Applications

1. Energy efficiency: meet or exceed requirements of NEMA MG1 Part 12 for NEMA Premium Efficient motors, for 1 Hp and larger. Where State Energy Codes or Utility Company Energy Rebate Programs dictate higher efficiencies than those listed, comply with the more stringent standard.
2. Severe duty: Motors installed in process areas and wet or corrosive locations shall be of a type designated by the manufacturer as "Corro Duty", "Mill and Chemical", "Severe Duty", or similar quality designation.
3. Class 1, Division 2 locations: Motors in Class 1, Division 2 locations shall be marked with a temperature code label suitable for use in the hazardous area classification where installed. Motors shall also comply with IEEE 841 severe duty requirements, with the following additional requirements:
  - a. The Class, Group and Temperature Code shall be one of the following:
  - b. Class I Group D - T2B (260°C)
  - c. Class I Group D, Class II Groups F and G - T3B (165°C)
  - d. Class I Groups C and D, Class II Groups F and G - T3C (160°C)
  - e. Thermostats: Where winding thermostats are used to obtain surface temperature limitation, the thermostats shall be connected in series with the starter holding coil (stop button). Winding temperature detectors and switches shall be UL listed for use in Class 1, Division 1 locations.
  - f. The exposed surface of motor condensation heaters shall not exceed 80 percent of the nameplate temperature code value.
  - g. Ventilation fan shall be constructed of corrosion resistant, non-sparking material such as bronze.
4. Class 1, Division 1 locations: Motors installed in Class 1, Division 1 locations shall be explosion proof, temperature code T3C (160°C), listed for use in Class 1, Division 1, Group C & D locations in accordance with UL 674. The operating temperature or temperature range marking shall appear on the nameplate, indicating the maximum temperature for all conditions including overload, locked rotor and single-phasing.
5. Inverter Duty: Motors connected to Variable Frequency Drive Controllers shall be designed for inverter duty and shall comply with the following:

- a. **Definite purpose:** Motors operated on variable frequency drives shall be designed specifically for inverter duty, per NEMA MG1, Part 31, and comply with IEEE 841. Motors shall be designed for constant or variable torque over the speed range required by the driven equipment application. Motors shall be capable of across the line starting at the motor minimum terminal voltage with an acceptable maximum locked rotor current.
- b. **Torsional critical speed:** first or second torsional shall not be encountered within the operating speed range. Rotors shall be stiff shaft design, statically and dynamically balanced with the first lateral critical speed at least 15% above the maximum running speed.
- c. **Thermal protection:** provide three internal bi-metallic, temperature actuated switches, unless other type of thermal protective device is specified in the mechanical equipment section.
- d. **Cooling provisions:** maintain temperature rises at design levels while operating throughout the speed range. Ventilation system shall be designed for maximum heat transfer including larger fans or auxiliary cooling fans to maintain proper low speed cooling.
- e. **Inverter grade insulation system:** minimum Class F or better insulation materials with additional phase insulating material, extra end-turn bracing and Class H spike resistant wire. The resultant system shall withstand up to 2000 volt transients without premature motor failure and have no cable limitations in motor application.
- f. **Motor shaft currents:** insulate the ODE bearing and provide a shaft grounding strap. Insulate bearing probes to prevent shorting out bearing insulation.

#### B. Construction

1. **Stator core:** built up, fully processed, high grade, low loss silicon steel laminations keyed or dovetailed to the stator frame and securely held in place at each end.
2. **Stator winding:** assembled using random wound copper coils. A split component epoxy insulation system shall be used in order to provide high resistance to moisture and other contaminants.
3. **Insulation:** manufacturer's premium grade non-hygroscopic, chemical and humidity resistant insulation system consisting of Class F or H materials, operated at Class B temperature rise, with at least one impregnation cycle using solventless resin, and multiple additional dip and bake cycles using polyester varnish.
4. **Motor leads:** non-wicking type, minimum Class F temperature rating and permanently numbered for identification.
5. **Rotor shaft:** forged or rolled steel, accurately machined, smoothly finished, with sufficient strength to withstand all stresses resulting from normal operation at any speed up to and including a 25 percent overspeed condition. Coordinate shaft end details with driven equipment coupling.
6. **Rotor core:** solid, built-up stack of fully processed and coated, high-grade, low-loss silicon steel laminations, with die cast aluminum or fabricated copper bars or their respective alloys. Rotors on frames 213T and above shall be keyed to shaft and rotating assembly dynamically balanced.

7. Cooling fan: corrosion-resistant, bi-directional, keyed, clamped and shouldered on the shaft.
8. Rotor assembly: coated with a corrosion resistant epoxy insulating varnish or other protective coating, thermally stable, statically and dynamically balanced. Balance weights shall be securely attached to the rotor resistance ring by welding or similar permanent method.

C. Bearings

1. Horizontal bearings.
  - a. Bearings: anti-friction open or single-shield, vacuum-degassed steel ball or roller bearings, electric motor quality. Metric size bearings are not acceptable.
  - b. Maximum bearing temperature rise: 50 degrees C for two pole motors, 45 degrees C for all other motors, measured at rated load by RTD or thermocouple at bearing outer race.
  - c. Lubrication: factory lubricated with a premium moisture resistant polyurea thickened grease containing rust inhibitors and suitable for operation over temperatures from -30 to 150 degrees C. with standard lube and relief fittings for re-greasing external lubrication while machine is in operation. Motors shall be NEMA size 140 frame motors and smaller than may be permanently lubricated.
  - d. Minimum Rated fatigue life: L10 life of 100,000 hours per ABMA 9 or ABMA 11 for direct coupled applications and 26,000 hours for belted applications based on NEMA belting application limits per NEMA MG1. Severe duty motors shall have increased bearing life of 150,000 hours for direct coupled applications and 50,000 hours for NEMA belted applications per IEEE 841.
  - e. Shaft seals: prevent grease leakage and the entrance of foreign materials, such as water and dirt, into the bearing area while running, coasting, or at rest. Severe duty motors shall have improved sealing per IEEE 841.
2. Vertical bearings.
  - a. Bearings: manufacturer's standard design, constructed with thrust bearings on top to allow inspection and/or replacement without requiring complete disassembly of motor, of type and size to satisfy thrust loading requirements, rated for an in-service B-10 life of 8800 hours per ABMA, designed to support the weight of the rotor plus, if required, the weight of the rotating driven equipment parts and the hydraulic thrust created by the driven equipment, with a 40 degrees C maximum temperature rise. Metric bearings are not acceptable.
  - b. Coordinate all thrust conditions, including shutoff, and shaft requirements with the manufacturer of the driven equipment.
  - c. Normal thrust applications: use grease lubricated deep-groove ball type thrust bearings only on normal thrust design motors, capable of handling thrust loads in either direction.
  - d. High thrust applications: use single or multiple angular contact ball bearings. Anti-friction thrust bearings shall be designed for an L10 life of 100,000 hours including rotor weight. For applications with higher thrust loads which cannot meet the L10 life, spring loaded spherical roller thrust bearings may be used.
  - e. Guide bearings: deep-groove ball type located at the bottom of the motor, capable of withstanding all stresses incident to the normal operation of the unit and to the specified overspeed condition, with sufficient means for preventing the leakage of lubricant or entrance of foreign matter along the shaft. When furnished as guide

- bearings for high thrust units, they shall be oil lubricated. Hollow shaft motors shall have a steady bushing to support the head shaft at the lower end of the motor.
- f. Grease lubricated bearings: furnished with provisions for in-service positive lubrication and a drain to guard against over lubrication.
  - g. Oil lubricated bearings: contained in an oil reservoir with sight level gauge, fill and drain openings with plugs, designed to prevent leakage and excessive aeration of the oil.
  - h. Anti-backspin device: when specified or requested by the pump manufacturer, provide a shaft mounted, mechanical non-reverse ratchet rated at 100 percent of motor full load torque for immediate protection against reversing due to phase reversals or from backspin at shutdown.

#### D. Enclosures

1. Motor frames: cast iron or welded heavy plate steel construction, stiff enough to withstand the rotating forces and torques generated and shall be designed to limit or avoid any undesirable harmonic resonances. Provide a threaded, forged steel, shouldered eyebolt blind tapped into the motor frame for lifting.
2. Condensate drain openings: locate drain holes at the low points in the end brackets to allow removal of accumulated moisture from enclosures. Provide corrosion resistant, breather drain plugs for severe duty motors.
3. Enclosure type: as specified in the mechanical equipment section, designed in accordance with NEMA MG1. Totally enclosed designs shall be suitable for outdoor use.
4. Hardware: hex head, SAE Grade 5 or better, plated for corrosion protection.
5. Main terminal box: fabricated steel or cast iron, sized per the NEC for number and size of conduit connections as indicated on the drawings, arranged to accommodate conduit entry from any quadrant, with a grounding terminal and gaskets between the box and motor frame and between the box and its cover.
6. Bearing housings: provide machined surfaces for attaching a magnet mounted accelerometer in order to monitor the motor vibration in the vertical, horizontal, and axial directions at each bearing housing.
7. Space heaters: provide silicone rubber strip type enclosure heaters for outdoor motors, or where otherwise specified. Heaters shall be rated 120 Volt, single phase, designed to prevent condensation inside the enclosure when the motor is idle, with leads brought out to the motor terminal box. The heater wattage and voltage shall be embossed on the motor nameplate.
8. Frame grounding: provide motor frame grounding pad or threaded stud where supplemental grounding to frame is indicated on the drawings.

#### 2.04 SURFACE PREPARATION AND SHOP COATINGS

##### A. Cast and Fabricated Components

1. Motor cast iron and fabricated metal components shall be cleaned; free of grease, oil, dirt, or other contaminants, then oxide primed and painted with manufacturers standard finish coating.
2. Severe duty motors: surpass the 250 hour salt spray test per ASTM B117.

B. Internal Surfaces

1. Internal surfaces: shaft, rotor, end bells and parts shall be covered with a corrosion resistant coating of epoxy paint or equal material of 2 mils minimum dry film thickness for increased life against adverse environmental conditions. The stator bore and end turns shall be coated with clear epoxy varnish in addition to the insulating varnish treatment.
2. Shaft extension: protected with a rust preventive strippable coating capable of being peeled off or unwrapped.
3. Machined joints and threaded parts: coated with rust inhibiting compound.

2.05 FACTORY TESTING

- A. Each motor shall be given an unwitnessed routine short commercial test per NEMA MG1 and IEEE 112.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install the motors per manufacturer's installation instructions.
  1. Prepare rigid foundation or mounting surface to minimize vibration and maintain alignment between motor and load shaft.
  2. Align the motor shaft with driven equipment according to manufacturers' written instructions. Adjust axial position of motor frame with respect to load shaft.
  3. Accurately adjust flexible couplings for direct drive according to machine manufacturers' guidelines. Check alignment to minimize vibrations. Coupling spacing shall be according to coupling manufacturer guidelines.
  4. Anchor motor base to load bearing surface with grade 5 steel bolts or better.
- B. Electrical Connections
  1. Install motor branch circuit conduits and conductors in accordance with NEC and local code requirements.
  2. Terminate the motor leads per the manufacturers' connection diagrams.
  3. Install equipment grounding conductors per NEC and local code requirements.

4. Tighten electrical connections and terminals according to manufacturers' published torque values.
5. Install conduit and wiring between motor auxiliary devices and associated indicators, controllers and protective devices in accordance with shop drawings.

C. Pre-Commissioning Inspection

1. Inspect for physical damage. Verify all shipping materials and braces are removed.
2. Compare equipment nameplate information with site conditions and report any discrepancies.
3. Inspect for proper mounting, grounding, and wiring connections. Check all hardware for looseness and re-tighten as necessary.
4. Verify that the motor and the coupled load are properly aligned. Inspect bearings for proper lubrication and rotate motor shaft by hand to check for binding. Oil lubricated bearing housings that have been filled with preservative oil shall be drained and re-filled with the proper grade of bearing oil before putting the machine into service.
5. Clean motor externally, on completion of installation. Vacuum dirt and debris; do not use blown compressed air to assist in cleaning.

D. Field Commissioning

1. Perform insulation resistance tests in accordance with manufacturer's instructions. If the test fails consult the manufacturer and dry out the machine.
2. Perform a phase rotation test to ensure proper shaft direction with load uncoupled.
3. Check all connections with wiring diagrams prior to energizing.
4. Inspect for unusual mechanical or electrical noise or signs of overheating during initial test run.
5. Measure running current and evaluate relative to load conditions and nameplate full load amperes

END OF SECTION

SECTION 01174  
LOW VOLTAGE PULSE WIDTH MODULATED (PWM)  
VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Provide labor, equipment, supervision and materials for the installation, testing and start-up of the variable frequency drive (VFD) systems as specified and as shown on the drawings.
- B. The VFD equipment specified in this Section shall be furnished by the Contractor. All VFDs shall be products of the same manufacturer. The VFD supplier shall obtain motor information from the driven equipment supplier(s) and shall ensure compatibility between the VFD and the driven equipment.
- C. Provide a factory trained technician to start-up each VFD. The technician shall be present through the duration of the field acceptance testing of the driven equipment. Start-up service shall include overtime charges, travel and living expenses and replacement parts.
- D. Provide 8-hours of on-site training instructions on VFD operation for the Owner's personnel. The training shall be conducted by personnel employed by the VFD manufacturer, unless prior approval of alternate instructors has been granted by the Engineer.

1.02 RELATED WORK

- A. Electrical work is included in Division 16.
- B. Instrumentation and controls, other than those specified herein, are specified under Division 16.
- C. Concrete for equipment pad is included in Division 3.
- D. Squirrel cage motors are specified in Section 01171.

1.03 SUBMITTALS

- A. Submit, in accordance with MAG Uniform Standard Specification - Section 105, shop drawings and product data showing materials of construction and details of installation for:
  - 1. Shop drawings, showing sizes of members, method of assembly, anchorage and connection to other members.
  - 2. Equipment outline drawings showing elevation, plan and interior views, front panel arrangement, dimensions, weight, shipping splits, conduit entrances and anchor bolt pattern. Indicate all options, special features, ratings and deviations from the specifications.
  - 3. Power and control schematics including external connections. Show wire and terminal numbers and color coding.
  - 4. Product literature on VFD and all accessories, filters, reactors, control devices, components, etc. Clearly indicate which components or options are being provided.

5. Drive performance specifications.
6. True (not displacement) power factor and efficiency curves.
7. Instruction and replacement parts books.
8. Certified shop test reports.
9. As-built final drawings.
10. Field test and inspection reports.
11. The VFD supplier shall submit written verification that the pulse voltage rate of rise will not produce voltage spikes at the motor terminals and that the motor terminal voltage will remain within the motor manufacturer's published data.
12. The VFD supplier shall submit written confirmation that the motor characteristics (i.e. torque type, FLA, etc.) have been coordinated with the supplier of the driven equipment and that the VFDs being supplied are matched properly for the driven load.

#### 1.04 REFERENCE STANDARDS

- A. IEEE Standard 519 (latest revision) - "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."
- B. National Electrical Code (NFPA 70) latest edition.
- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

#### 1.05 QUALITY ASSURANCE

- A. Variable frequency drives shall utilize a field proven design. The VFD manufacturer shall demonstrate at least 3 years of continuous field operating experience with equipment of similar size and design. The entire VFD system described herein shall be factory assembled and tested to assure a properly coordinated system. .
- B. A factory authorized service and parts organization shall be located within 100 miles of the project location. Provide the name and address of the factory authorized service and parts organization nearest to the project location at the time of the bid.
- C. Equipment components and devices shall be UL labeled to the extent possible wherever UL standards exist for such equipment.

#### 1.06 SYSTEM DESCRIPTION

- A. Refer to the driven equipment specifications for description of system operation.
- B. Refer to the control schematic diagrams on the Electrical Drawings for control system operation.

#### 1.07 DELIVERY, STORAGE AND HANDLING

- A. Package the equipment for maximum protection during delivery and storage.
- B. Store the equipment indoors in a clean, dry, heated storage facility until ready for installation. Do not install the equipment in its final location until the facilities are permanently weather tight. Furnish, install and wire temporary electric space heaters in the equipment until the permanent heating equipment is operational. Protect the equipment at all times from exposure to moisture, chemicals, hydrogen sulfide and chlorine gas.
- C. If required in the driven equipment specifications, the VFD manufacturer shall ship equipment to the driven equipment manufacturer's testing facility for use during the factory acceptance test.

#### 1.08 PROJECT/SITE REQUIREMENTS

- A. All VFDs shall be 6-pulse PWM VFDs.

#### 1.09 MAINTENANCE

- A. Provide the following spare parts for each size drive in the quantities specified:
  - 1. One of each type of microprocessor and gate driver printed circuit board.
  - 2. Two power diodes.
  - 3. One pair power transistors.
  - 4. One diagnostic portable test set (when this feature is not microprocessor based).
  - 5. Two can(s) of aerosol touch-up paint.
  - 6. 100 percent replacement fuses, all types and sizes.
- B. Spare parts shall be boxed or packaged for long term storage. Identify each item with manufacturer's name, description and part number on the exterior of the package.

#### 1.10 QUALIFICATION

- A. It is the intent of this Section that the VFDs be supplied by one system supplier.

#### 1.11 OPERATING INSTRUCTION

- A. After approval, during and after construction, operating manuals covering instruction and maintenance on each type of equipment shall be furnished in accordance with Section 16020.
- B. The instructions shall be bound and shall provide at least the following as a minimum:
  - 1. A comprehensive index.
  - 2. A complete "as-built" set of approved shop drawings.

3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
4. Full specifications on each item.
5. Updated system schematic drawings "as built", illustrating all components and electrical connections of the systems supplied under this Section.
6. Detailed service, maintenance and operation instructions for each item supplied.
7. A table listing of the "as left" drive set up parameters, timing relay settings and alarm and trip setpoints.
8. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
9. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
10. Complete parts list with stock numbers, including spare parts.

#### 1.12 WARRANTY

- A. Provide a one year minimum warranty on all parts and labor upon start-up and customer acceptance of the equipment.

### PART 2 PRODUCTS

#### 2.01 RATING

##### A. Service Conditions

1. Input power: 240 VAC, plus 10 percent, minus 10 percent, 1 Phase, 60 Hz.
2. Output power: 240 VAC, plus 10 percent, minus 10 percent, 3 Phase, 60 Hz.
3. Input frequency: 57 to 63 Hz.
4. Ambient temperature: 0 to 40 degrees C.
5. Elevation: Up to 3300 feet above mean sea level.
6. Relative humidity: Up to 90 percent non-condensing.

- B. Minimum drive efficiency: 97 percent or better at full load speed and rated torque. Losses shall include all control power and cooling system losses associated with the drive.
- C. True power factor: 95 percent or higher at full speed and full load, measured at drive input terminals.
- D. Drive output: 100 percent rated current continuous, suitable for operation of the driven equipment over the required speed range without overloading unless indicated otherwise on the

drawings. Drives shall be capable of a 60 second overload for up to 110 percent rated current for variable torque loads, or 150 percent rated current for constant torque loads. Starting torque shall be matched to the load.

- E. Voltage regulation: Plus or minus 1 percent of rated value, no load to full load.
- F. Output frequency drift: No more than plus or minus 0.5 percent from setpoint.
- G. Drives shall withstand five cycle transient voltage dips of up to 15 percent of rated voltage without an undervoltage trip or fault shutdown, while operating a variable torque load.
- H. Power transistor PRV rating shall be 1200 Volts, minimum.
- I. Drive sound level: 80 dBA (maximum) at 3-ft, test method A. This shall include noise made from the entire drive enclosure including filters, capacitors, fans, transformers, etc, and all other components associated with the enclosure. The VFD manufacturer shall provide sound attenuation equipment necessary.
- J. Combined pump and motor sound level: 3 dBA above published average motor noise at 10-ft, test method A. Pump and motor manufacturer shall provide sound attenuation equipment necessary as dictated by the VFD manufacturer.

## 2.02 CONSTRUCTION

### A. General

1. The general arrangement of the equipment is shown on the Drawings. Variable frequency drives shall be one of the following products:
  - a. Siemens/Robicon
  - b. Allen Bradley
  - c. ABB Drives Division
  - d. Eaton Cutler Hammer
  - e. Square D/Group Schneider
  - f. Mitsubishi Electric Automation
  - g. Engineer approved equal
2. The VFDs shall utilize a digital pulse width modulated (PWM) design to convert the fixed AC input to a variable voltage, variable frequency AC output. Construction shall be modular, component mounting or keyed ribbon cable connections wherever possible to minimize downtime during repair.
3. The VFD operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 10 percent total harmonic voltage distortion and commutation notches up to 36,500 Volt-microseconds, or when other VFDs are operating from the same bus. The drive shall include transient voltage suppression to allow reliable operation on a typical commercial power distribution system.
4. The output shall be generated by power transistors which shall be controlled by identical, optically isolated base driver circuits. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine-wave

operation. The VFD shall have an output voltage regulator to maintain correct output Volt/Hertz despite incoming voltage variations. The VFD shall have a continuous output current rating equal to or greater than the motor full load nameplate current.

#### B. Structure

1. Each drive shall be designed for stand alone operation. Multiple drive units shall not utilize shared components. Drive components shall be mounted in free standing or wall mounted, front accessible, NEMA 1A, force ventilated with filtered air, single or multi-bay, sheet steel cabinets with hinged front doors. Doors shall have concealed hinges and three-point latching mechanism with lockable handle. Rear access shall not be required.
2. Incoming line power cables shall enter at the bottom of the cabinet. Outgoing load cables shall exit from the bottom of the cabinet.
3. Each VFD shall have a molded case, circuit breaker type main power disconnect switch, with an external operating handle. The circuit breaker shall have a short circuit rating of 10,000 Amps RMS symmetrical and shall be labeled in accordance with UL Standard 489. Disconnect enclosure shall be explosion proof suitable for a Class 1, Division 1 environment.
4. Provide the following safety features:
  - a. Provision to padlock main disconnect handle in the OFF position.
  - b. Mechanical interlock to prevent opening cabinet door with disconnect in the ON position, or moving disconnect to the ON position while the unit door is open.
  - c. Mechanical or electrical interlocks on doors of auxiliary sections of multi-bay cabinets interlocked with the main circuit breaker power disconnect.
  - d. Auxiliary contact on main disconnect to isolate control power when fed from an external source.
  - e. Barriers and warning signs on terminals that are energized with the power disconnect OFF.
5. Provide an equipment ground bus or lug connectors in each structure, suitable for connection to the copper grounding conductors shown on the Drawings.

#### C. Control Wiring

1. Wiring: 600 Volt, stranded copper, 105 degree C color coded insulation, minimum size No. 14 AWG (120 VAC control power only).
2. Identification and termination: Crimp type wire lugs with sleeve type markers at each termination point. Provide numbered terminal blocks for external connections.
3. Control power: Provide a 120 VAC, control power transformer fused on the primary and secondary for cooling fans, motor space heaters and external control circuits. Control circuits shall be isolated from power circuits.
4. Controls shall, as a minimum, perform the control logic indicated on the Contract Drawings and as specified herein.

#### D. Operator Interface

1. Provide a door-mounted, plain English, digital keypad/display capable of controlling the drive and setting drive parameters. The digital display shall normally display:
  - a. Speed demand in percent
  - b. Output current in amperes
  - c. Frequency in Hz
  - d. Control mode - manual or automatic
  - e. Total 3 phase kW
  - f. Output voltage
2. The digital keypad shall allow operators to enter exact numerical settings in English engineering units. A user menu shall be provided as a guide to parameter settings. Coded messages on keypad will not be acceptable. Parameters are to be factory set in EEPROM and resettable in the field. Parameters shall be password protected. The EEPROM stored variables shall be transferable to new and spare boards.
3. The following controls and indicators shall be provided, either separately or as part of the keypad/display:
  - a. POWER ON, RUN AND READY indication.
  - b. FAULT RESET indication.
  - c. Local/Remote or Hand/Off/Auto control mode selector switch.
  - d. Push-pull maintained contact EMERGENCY STOP button.
  - e. Manual START/STOP controls.
  - f. Manual speed adjust capability.
  - g. Five digit, non-reset, elapsed time meter.
  - h. Percent speed indicator.

#### E. Auxiliary Contacts

1. Provide [one] set(s) of Form C auxiliary dry contacts for remote indication of VFD running status.
2. Provide [one] set(s) of Form C auxiliary dry contacts for remote indication of VFD fault.

#### F. Marking and Identification

1. Provide 2-in by 5-in, nominal, engraved lamicoid master nameplates on each VFD fastened with stainless steel screws or rivets. Nameplates shall be black with white core, 3/8-in high lettering and shall indicate equipment designation as shown on the Drawings.
2. Provide legend plates or 1-in by 3-in engraved nameplates with 1/4-in lettering for identification of pilot devices and meters.
3. Provide permanent warning signs as follows:
  - a. "Danger-High Voltage-Keep Out" on all cabinet doors.
  - b. "Warning-Hazard of Electric Shock - Disconnect power before opening or working on this unit" on main power disconnect.

### 2.03 OPERATIONS AND FEATURES

- A. Make provisions for field adjustment of the following parameters through the keypad/display:

1. Current limit and boost.
  2. Voltage (Minimum/Maximum, Volts/Hz.)
  3. Speed profile (Minimum/Maximum speed, On/Off delay, Entry/Exit speeds).
  4. Independently adjustable acceleration and deceleration rates.
  5. Auto restart delay.
  6. Inverse time overload (current, time and speed), I<sup>2</sup>T.
  7. Undervoltage trip level.
- B. Make provisions to accept a remote dry contact closure to start and stop the drive(s) with the drive control system in the AUTO mode.
- C. Make provisions to accept a 4-20 mADC input signal for remote speed control. Input shall be isolated at the drive and active with the drive control system in the AUTO mode. Zero and span adjustability shall be provided.
- D. Provide a 4-20 mADC isolated output signal proportional to speed for remote speed indication. The signal shall have a minimum of 750 ohm load capability.
- E. Provide the following short circuit and input protective features:
1. High speed current limiting input fuses and line reactors.
  2. Solid state instantaneous overcurrent trip.
    - a. Variable Torque - 225 percent RMS
    - b. Constant Torque - 265 percent RMS
  3. Undervoltage protection with automatic restart (65 percent of rated voltage).
  4. Phase sequence lockout.
  5. Phase loss lockout.
  6. Overvoltage trip (130 percent of drive rated voltage).
  7. Ground fault, either running or at start.
- F. Provide the following internal protective features:
1. Transient surge protection.
  2. Semi-conductor overtemperature and overcurrent protection.
  3. Current limit, inverse time type.
  4. DC bus fuse protection and discharge circuit.

5. DC bus overvoltage trip.

G. Provide the following output protective features:

1. Inverse time motor overload protection.
2. Static overspeed protection.
3. Stall protection on overload with inverse time overcurrent trip.
4. Protection against opening or shorting of motor leads.
5. Pre-alarm warning and shutdown on motor overtemperature.
6. Critical speed avoidance circuit (3 zones).

#### 2.04 DIAGNOSTIC AND FAULT CAPABILITY

A. The following conditions shall cause an orderly drive shutdown and lockout.

1. Incorrect phase sequence.
2. Blown input fuse or single phasing of supply.
3. Control power supply failure.
4. Instantaneous overcurrent.
5. Sustained overload or motor overtemperature.
6. Semi-conductor overtemperature.

B. Provide complete built-in diagnostic and test capability to enable maintenance personnel to rapidly and accurately identify the cause of equipment failure. Diagnostic features shall include, but not be limited to the following:

1. Fault annunciator with alphanumeric or coded display.
2. Communication port (RS-485) for host computer connection.

C. Indication shall be provided via the door-mounted keypad to identify transistor and diode failures, blown fuses and control failures.

#### 2.05 SURFACE PREPARATION AND SHOP COATINGS

- A. All non-current carrying metal parts of the equipment cabinet shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pre-treatment to inhibit rust.
- B. Indoor equipment shall be finish painted with one coat of manufacturers standard electrocoated, heat cured enamel.

- C. Unpainted non-current carrying parts shall receive a protective zinc plating to prevent corrosion.
- D. All printed circuit boards shall be coated with a protective conformal epoxy.
- E. All power bus shall be nickel-plated copper.
- F. All device contacts shall be gold or silver plated.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. The equipment shall be leveled and anchored directly to the concrete equipment pad or finished floor. Provide hardware and metal shims for installation. Grout and caulk all voids beneath the equipment base. Anchor bolts shall be 1/2-in galvanized steel.
- B. Install the equipment in accordance with the manufacturer's instructions.
- C. Remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.
- D. Make wiring interconnections between shipping splits.

#### 3.02 FIELD TESTING

- A. Make the following minimum test and checks before the manufacturer's representative is called in for testing and adjustment:
  - 1. Verify that all connections are completed in accordance with shop drawings.
  - 2. Verify supply voltage and phase sequence are correct.
  - 3. Check mechanical interlocks for proper operation.
  - 4. Test ground connections for continuity and resistance.
  - 5. Adjust unit compartment doors.
  - 6. Check control circuit interlocking and continuity.
- B. The manufacturers' service technician shall perform start-up and adjustment of the drive(s).
- C. In the event of an equipment fault, notify the Owner immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor, the Owner and the equipment manufacturers factory service technician. Repair or replace the equipment as directed by the Owner.
- D. The operation of the motors and driven equipment shall be inspected as a part of this test procedure to ensure that no problems with this equipment are created due to the drives. Any problems such as overheating, excessive current, excessive motor noise, vibration, etc, attributable to the drives shall be corrected under this Section at no additional cost to the Owner. Voltage surges at motor terminals shall be within acceptable limits of the motor manufacturer.

- E. If, in the opinion of the Engineer, a driven motor produces an excessive amount of objectionable noise or pure tone (noise dominated by one particular frequency), the VFD manufacturer shall conduct sound tests to determine the frequency range of the objectionable noise, and shall make corrections to the drives such that the noise is reduced to the level as specified in Paragraph 2.01 above.

### 3.03 ADJUSTMENT

- A. Make all VFD internal adjustments and all adjustments necessary for manual and automatic operation of the entire system of driven equipment.
- B. The VFD units' internal protection parameters listed below shall be set as follows:
  - 1. Loss of speed control (reference) signal: Run at preset speed. (determined at startup)
  - 2. Loss of drive panel control signal: Run at preset speed. (determined at startup)
  - 3. Automatic Reset
    - a. Number of fault reset trials: 3
    - b. Time within which resets allowed: 30 sec.
    - c. Delay time before reset-retry: 5 sec.
    - d. Auto-reset on motor over-current: Yes
    - e. Auto-reset on DC bus over-voltage: Yes
    - f. Auto-reset on DC bus under-voltage: Yes
    - g. AI Signal < minimum (loss of speed signal): Yes
  - 4. On restoration of power after a power failure, the drive shall automatically reset to be controlled by a remote start/stop dry contact.

### 3.04 CLEANING

- A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

END OF SECTION

SECTION 05500  
MISCELLANEOUS METAL

PART 1 GENERAL

1.01 SCOPE OF WORK

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

1.02 RELATED WORK

- A. Concrete Structures MAG Section 505.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 105, shop drawings and product data showing materials of construction and details of installation for:
  - 1. Shop drawings, showing sizes of members, method of assembly, anchorage and connection to other members.
- B. Design Data
  - 1. Submit calculations or test data demonstrating that the railings will resist the loads specified in the OSHA at the post spacing provided. Calculations shall be stamped by a professional engineer registered in Arizona.
  - 2. Submit for review, structural calculations for the stair system, signed and sealed by a licensed professional engineer registered in the State of Arizona.
  - 3. Submit for review, structural calculations for planking system and supports, signed and sealed by a licensed professional engineer registered in the State of Arizona. Calculations to include any manufacturer's load and deflection tables for planking.
  - 4. Submit manufacturer's load and deflection tables for grating.
- C. Test Reports
  - 1. Certified copy of mill test reports on each aluminum proposed for use showing the physical properties and chemical analysis.
- D. Certificates
  - 1. Submit certification that the railing system is in compliance with OSHA requirements.

1.04 REFERENCE STANDARDS

- A. Aluminum Association (AA)
  - 1. AA M31C22A41

- a. M31: Mechanical Finish, Fine Satin
- b. C22: Finish, Medium Matte
- c. A41: Clear Anodic Coating, Class I

B. ASTM International

1. ASTM A36 - Standard Specification for Carbon Structural Steel.
2. ASTM A48 - Standard Specification for Gray Iron Castings.
3. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
4. ASTM A108 - Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality.
5. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
6. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
7. ASTM A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Plate, Sheet, and Strip Pressure Vessels.
8. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.
9. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 Psi Tensile Strength.
10. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
11. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
12. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
13. ASTM A536 - Standard Specification for Ductile Iron Castings.
14. ASTM A570 - Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
15. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
16. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

17. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles and Tubes.
  18. ASTM B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
  19. ASTM F1554 -Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
  20. ASTM F2329 - Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon Screws, Washers, Nuts, and Special Threaded Fasteners
- C. American Institute of Steel Construction (AISC)
1. Specification for Structural Steel Buildings – Allowable Stress Design and Plastic Design.
- D. American Welding Society (AWS)
1. AWS D1.1 - Structural Welding Code - Steel.
  2. AWS D1.2 - Structural Welding Code - Aluminum.
  3. AWS D1.6 - Structural Welding Code - Stainless Steel
- E. Federal Specifications
1. FS-FF-B-575C - Bolts, Hexagonal and Square
- F. Occupational Safety and Health Administration (OSHA)
- G. International Code Council (ICC)
1. International Building Code (IBC)
- H. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.
- 1.05 QUALITY ASSURANCE
- A. The work of this Section shall be completely coordinated with the work of other Sections. Verify, at the site, both the dimensions and work of other trades adjoining items of work in this Section before fabrication and installation of items herein specified.
  - B. Furnish to the pertinent trades all items included under this Section that are to be built into the work of other Sections.
  - C. All welding shall be performed by qualified welders and shall conform to the applicable AWS welding code. Welding of steel shall conform to AWS D1.1 and welding of aluminum shall conform to AWS D1.2 and welding of stainless steel shall conform to AWS D1.6.
- 1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver items to be incorporated into the work of other trades in sufficient time to be checked prior to installation.
- B. Store materials on skids and not on the ground and block up so that they will not become bent or otherwise damaged. Handle materials with cranes or derricks. Do not dump material off cars or trucks nor handle in any other way that will cause damage.
- C. Repair items that have become damage or corroded to the satisfaction of the Engineer prior to incorporating them into the work.

#### 1.07 PROJECT/SITE REQUIREMENTS

- A. Field measurements shall be taken at the site, prior to fabrication of items, to verify or supplement indicated dimensions and to ensure proper fitting of all items.

### PART 2 PRODUCTS

#### 2.01 GENERAL

- A. The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.
- B. Like items of materials shall be the end products of one manufacturer in order to provide standardization for appearance, maintenance and manufacturer's service.

#### 2.02 MATERIALS

- A. Unless otherwise noted, materials for miscellaneous metals shall conform to the following standards:
  - 1. Aluminum Extruded Pipe                      ASTM B429, Alloy 6063 T6 and Alloy 6061 T6 as indicated
  - 2. Aluminum Extruded Shapes                ASTM B221, Alloy 6061 T6
  - 3. Aluminum Sheet and Plate                ASTM B209, Alloy 6061 T6
  - 4. Stainless Steel Plates, Sheets, and Structural Shapes
    - a. Exterior, Submerged or Industrial Use            ASTM A240, Type 316 (Type 316L for welded)
    - b. Interior and Architectural Use                    ASTM A240, Type 304
  - 5. Stainless Steel Bolts, Nuts, and Washers    ASTM A276, Type 316

#### 2.03 ANCHORS, BOLTS AND FASTENING DEVICES

- A. Unless otherwise noted, anchor bolts shall be ASTM F1554, Grade 36. Provide standard headed bolts with heavy hex nuts and Grade A washers.
- B. Unless otherwise noted, bolts for the connection of carbon steel or iron shall be steel machine bolts; bolts for the connection of galvanized steel or iron shall be galvanized steel or stainless

steel machine bolts; and bolts for the connection of aluminum or stainless steel shall be stainless steel machine bolts.

- C. Unless otherwise noted, expansion anchors shall be zinc plated carbon steel wedge type anchors complete with nuts and washers. Type 316 stainless steel wedge type anchors shall be used where they will be submerged or exposed to the weather or where stainless steel wedge type anchors are shown or specified. When the length or embedment of the bolt is not noted on the Drawings, provide length sufficient to place the wedge and expansion cone portion of the bolt at least 1-in behind the concrete reinforcing steel. Expansion anchors shall be Hilti, Kwik-Bolt III; Simpson Strong-Tie Wedge-All; Powers Power-Stud or equal.
- D. Adhesive anchor system, for fastening to solid concrete substrate, shall be a system manufactured for the installation of post installed studs including anchoring hardware and chemical dispenser. Injection adhesive shall be a two-component epoxy system including a hardener and a resin, furnished in pre-measured side-by-side cartridges which keep the two components separate. Side-by-side cartridges shall be designed to accept a static mixing nozzle which thoroughly blends the two components and allows injection directly into the drilled hole. Provide zinc plated carbon steel or Type 316 stainless steel stud assemblies as indicated on the Drawings consisting of an all-thread anchor rod with nut and washer. Adhesive anchor system shall be Hilti RE 500 SD; Simpson Strong Tie SET-XP; ITW Ramset Red Head Epcon G5; or equal. Unless otherwise noted, anchorage designs shown on the Drawings are based on Hilti RE 500 SD.
- E. Machine bolts and nuts shall conform to Federal Specification FF-B-575C. Bolts and nuts shall be hexagon type. Bolts, nuts, screws, washers and related appurtenances shall be Type 316 stainless steel.
- F. Toggle bolts shall be Hilti, Toggler Bolt or equal.

#### 2.04 ALUMINUM STAIR

- A. Stairs and hand railing shall conform to OSHA requirements.
- B. Design stair assembly to support a minimum concentrated live load of 1000 lbs.
- C. Design hand railing to meet OSHA Standards and to withstand 200 lbs load applied anywhere on the system and in any direction.
- D. Fabrication
  - 1. Size members as required by design calculations and job conditions.
  - 2. Stringers and Headers: Aluminum channel stringers shall be clip angled to concrete walls. Stringers shall furnish support to intermediate landing, unless otherwise indicated on the Drawings.
  - 3. Metal Risers and Treads: Form metal risers and treads of minimum 14 gauge structural sheet steel and shop weld to stringer in an approved manner.
  - 4. Landings: Construct platforms of loose structural aluminum channels, side-supported headers and miscellaneous framing members framing into the stair stringers. Provide

minimum 14 gauge landing decking complete with shop welded reinforcing rods topside and perimeter screed members.

5. Construct stairs to conform to sizes and arrangements indicated; join pieces together by welding unless otherwise indicated. Provide complete stair assemblies including metal framing, hangers, columns, struts, clips, brackets, bearing plates and other components necessary for the support of stairs and platforms and as required to anchor and contain the stairs on the supporting structure.
6. Fabricate stringers of structural steel channels, or plates, or a combination thereof, as indicated. Provide closures for exposed ends of stringers. Construct platforms of structural steel channel headers and miscellaneous framing members as indicated. Bolt or weld headers to stringers and framing members to stringers and headers. Fabricate and join so that bolts, if used, do not appear on finish surfaces.
7. Metal pan risers, subtreads and subplatforms: Shape metal pans for risers and subtreads to conform to configuration shown. Provide thicknesses of structural steel sheet for metal pans indicated but not less than that required to support total design loading.
8. Attach risers, subtreads and subplatforms to stringers by means of brackets made of steel angles or bars. Weld brackets to stringers and attach metal pins to brackets by welding, or bolting.
9. Form work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to radius of approximately 1/32-in. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
10. Weld all assemblies in accordance with recommendations of AWS. Grind all exposed welds to match and blend with adjoining surfaces.

## 2.05 ALUMINUM GRATING

- A. Grating shall have rectangular, 3/16-in thick, bearing bars spaced 1-3/16-in on center with cross bars spaced at 4-in on center. All grating panels shall be banded with a bar the same size as the bearing bars.
  1. Grating shall not exceed the fabricator's maximum recommended span, and meet or exceed the following load and deflection criteria for the maximum span length at the opening being covered by the grating.
    - a. The grating shall produce a deflection of 1/360 of the span or less under a concentrated live load of 1000 lbs applied at the mid point of the maximum span.
  2. Openings 2-in or greater in diameter/dimension and grating edges shall be banded with a bar of the same depth and thickness as the bearing bars. Cut bearing bars or cross bars shall be welded to the banding bar.
  3. Grating clamps, nuts, bolts, washers and other fastening devices for grating and grating supports shall be Type 316 stainless steel. All grating shall be anchored to the supporting system using saddle clips or welding.

- B. Aluminum grating material shall be aluminum alloy 6063-T6 with an anodized finish. Cross bars shall be attached to the bearing bars with interlocked swaged joints. The grating shall be Type BS by Harsco Industrial IKG, Houston, TX; Type 19 SG-4 by Ohio Gratings, Inc., Canton, OH; Type 19S4 by Seidelhuber Metal Products, San Carlos, CA or equal.
- C. Metal frames and supports for grating shall be of the same material as the grating unless otherwise shown on the Drawings. Where aluminum supports are used, they shall be fabricated from aluminum alloy 6061-T6.

## 2.06 ALUMINUM PLANKING

- A. Planking shall not exceed the fabricator's maximum recommended span, and meet or exceed the following load and deflection criteria for the maximum span length at the opening being covered by the grating.
  - 1. The planking shall produce a deflection of 1/360 of the span or less under a concentrated live load of 300 lbs applied at the midpoint of the maximum span.
  - 2. The planking shall produce a deflection of 1/360 of the span or less under a uniform live load of 100 lbs/sq ft on the maximum span.
  - 3. The planking shall be designed for a uniform uplift load of 180 lbs/sq ft on the maximum span.
  - 4. Openings 2-in or greater in diameter/dimension and planking edges shall be banded with a bar of the same depth and thickness as the bearing bars. Cut bearing bars or cross bars shall be welded to the banding bar.
- B. Planking shall be removable. Each removable section shall not exceed in weight 50 lbs. Provide (2) lifting handles each end of planks.
- C. Aluminum planking material shall be aluminum alloy 6063-T6 with an anodized finish. The Planking shall be by Harsco Industrial IKG; Ohio Gratings, Inc.; CST Covers, Hallsten Corporation or equal.
- D. Metal frames and supports for grating shall be of the same material as the grating unless otherwise shown on the Drawings. Where aluminum supports are used, they shall be fabricated from aluminum alloy 6061-T6.

## 2.07 RAILINGS

- A. Handrail and railing systems shall comply with the requirements of OSHA.
- B. Aluminum railing and handrail shall be a welded or mechanically fastened, seamless, extruded aluminum pipe system. Rails shall be 6063-T6 alloy. Posts shall be 6061-T6 alloy. Splice and reinforcing sleeves, brackets, end caps, toeboards, etc, shall be aluminum alloy 6063-T6 or 6061-T6. Railing system fastening hardware shall be Type 304 stainless steel. After welding, aluminum shall be anodized.
- C. Railings shall be 2 rail welded railing systems, fabricated with 1-1/2-in nominal diameter pipe. Posts shall be Schedule 80 pipe, minimum and rails and handrail shall be Schedule 40 pipe,

minimum. Posts and top rails shall be continuous. Spacing of posts shall not exceed 5-ft on center and shall be uniformly spaced except as otherwise shown on the Drawings. All railing posts shall be vertical.

- D. Welds shall be circumferential welds ground smooth and even to produce a railing that is neat in appearance and structurally sound. Welding methods shall be in conformity with AWS standards for the materials being joined. For welding aluminum, use a weld filler alloy that is compatible with the alloys to be joined, that will not discolor the pieces to be joined and that will not be discolored by anodizing. All rails to post connections shall be coped and fastened by continuous welds. There shall be no burrs, sharp edges or protrusions on any weld on any part of the handrail system. After fabrication, the welds and surrounding area shall be cleaned and hand buffed to blend with the adjacent finish. All mechanical fasteners shall be unobtrusively located in countersunk holes with the top flush with the surface of the rail. Bends in the railing shall be as indicated by the Drawings. No distortion of the circular railing shape will be allowed. Bends and terminal sections shall be made without the use of fittings. Corner bends shall be mitered and welded bends.
- E. Railing shall be assembled in sections as long as practical but shall not be greater than 24-ft in length. A field splice shall be used when an assembled section is to be attached to another section.
  - 1. Field splices shall use internal splice sleeves located within 8-in of railing posts. The sleeve shall be welded to the rail on one side and fastened with a set screw to the rail on other side. The field splice shall be detailed to take the differential expansion between the railing system and the supporting structure.
- F. The bases or supports for railing posts and handrail shall be the types indicated on the Drawings.
- G. Toeboards shall be provided on all railing adjacent to a drop in elevation of 4-ft or more. Toeboards are not required on the inclined portion of stairway railings or where concrete or steel curbs, 4-in or more in height, are present. Toeboards shall be 4-in high channels of the same material as the railing. The channels shall have a minimum thickness of 1/8-in and have flanges of not less than 3/4-in nor more than 1-1/2-in in width. Toeboards shall be positioned with a maximum clearance of 1/4-in from the floor and fastened to railing posts with 1/4-in stainless steel U-bolts, with J-bolts at corner posts and with clip angles and two 1/4-in stainless steel expansion bolts at walls.
- H. All railings shall be properly protected by paper, or by an approved coating or by both against scratching, splashes or mortar, paint, or other defacements during transportation and erection and until adjacent work by other trades has been completed. After protective materials are removed, the surfaces shall be made clean and free from stains, marks, or defects of any kind.

## 2.08 ACCESS HATCHES

- A. Access hatches shall have single leaf doors as indicated by the Drawings. The doors shall be 1/4-in aluminum diamond pattern plate with welded stiffeners, as necessary, to withstand an AASHTO H20 wheel load. Hatches shall have a 1/4-in aluminum channel frame with a perimeter anchor flange or strap anchors for concrete embedment around the perimeter. Unless otherwise noted on the Drawings, use spring operators for easy operation along with automatic door hold open. Hardware shall be durable and corrosion resistant with Type 316 stainless steel

hardware used throughout. Finish shall be the factory mill finish for aluminum doors and frames with bituminous coating on the exterior of the frames in contact with concrete. Hatches shall be watertight and have a 1-1/2-in drainage coupling to the channel frame. Provide a section of aluminum handrail mounted to the underside of the hatch cover lid matching slope of stair. The transition between handrails below shall be made as smooth as possible to minimizing gaps. Hatch egress width shall be 3'-0" absolute clear, excluding the handrail mounted to underside of cover lid. Extend frame width to account for increase in width. Access hatches shall be Type JALH20 aluminum by Bilco Company, New Haven, CT or equal.

## 2.09 MISCELLANEOUS ALUMINUM

- A. All miscellaneous metal work shall be formed true to detail, with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture and free from defects impairing strength or durability. Holes shall be drilled or punched. Edges shall be smooth and without burrs. Fabricate supplementary pieces necessary to complete each item though such pieces are not definitely shown or specified.
- B. Connections and accessories shall be of sufficient strength to safely withstand the stresses and strains to which they will be subjected. Exposed joints shall be close fitting and jointed where least conspicuous. Threaded connections shall have the threads concealed where practical. Welded connections shall have continuous welds or intermittent welds as specified or shown. The face of welds shall be dressed flush and smooth. Welding shall be on the unexposed side as much as possible in order to prevent pitting or discoloration of the aluminum exposed surface. Grind smooth continuous welds that will be exposed. Provide holes for temporary field connections and for attachment of the work of other trades.
- C. Miscellaneous aluminum items shall include: beams, angles, closure angles, grates, hatches, floor plates, stop plates, stair nosings and any other miscellaneous aluminum called for on the Drawings and not otherwise specified.
- D. Angle frames for hatches, beams, grates, etc, shall be complete with welded strap anchors attached.
- E. Stair treads for aluminum stairs shall have abrasive non-slip nosing as approved.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install all items except those to be embedded in concrete or other masonry which shall be installed under MAG Section 505. Items to be attached to concrete after such work is completed shall be installed in accordance with the details shown. Fastening to wood plugs in masonry will not be permitted.
- B. Abrasions in the shop primer shall be touched up immediately after erection. Areas left unprimed for welding shall be painted with primer after welding.
- C. Zinc coating which has been burned by welding, abraded, or otherwise damaged shall be cleaned and repaired after installation. The damage area shall be thoroughly cleaned by wire brushing and all traces of welding flux and loose or cracked zinc coating removed prior to painting. The cleaned area shall be painted with two coats of zinc oxide-zinc dust paint

conforming to the requirements of Military Specifications MIL-P-15145. The paint shall be properly compounded with a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight.

- D. Specialty products shall be installed in accordance with the manufacturer's recommendations.
- E. Expansion bolts shall be checked for tightness a minimum of 24 hours after initial installation.
- F. Install adhesive anchor system in strict compliance with the manufacturer's recommendations, including drill bit diameter, surface preparation, temperature, moisture conditions, injection and installation of bolts. Use oil free compressed air to blast out loose particles and dust from the drilled holes. Bolts must be clean and free of dirt, oil, grease, ice or other material which would reduce bond.
- G. Headed anchor studs shall be welded in accordance with manufacturer's recommendations.
- H. All railings shall be erected to line and plumb.
- I. All steel surfaces that come into contact with exposed concrete or masonry shall receive a protective coating of an approved heavy bitumastic troweling mastic applied in accordance with the manufacturer's instructions prior to installation.
- J. Where aluminum contacts a dissimilar metal, apply a heavy brush coat of zinc-chromate primer followed by two coats of aluminum metal and masonry paint to the dissimilar metal.
- K. Where aluminum contacts masonry or concrete, apply a heavy coat of approved alkali resistant paint to the masonry or concrete.
- L. Between aluminum gratings, aluminum stair treads, or aluminum handrail brackets and steel supports, insert 1/4-in thick neoprene isolator pads, 85 plus or minus 5 Shore A durometer, sized for full width and length of bracket or support.

END OF SECTION

SECTION 15500  
HVAC

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. These Sections and Drawings cover(s) the requirements of the HVAC Work to be performed and shall not void any of the requirements specified under the General Conditions or General Requirements.
- B. The areas where work is to be accomplished are specified and shown in the following:
1. Drawing Number

H-1	HVAC / Plumbing Abbreviations and Legend
H-2	HVAC Plan and Sections
H-3	HVAC Schedule and Details
H-4	HVAC / Plumbing Demolition & Plumbing Modifications
- C. The requirements specified herein shall be modified only if specified otherwise for particular application in other Divisions.
- D. This HVAC specification is incomplete without the information contained on the Drawings and in the Schedules. Schedules are located on the drawings.
- E. Work included under the "Scope of Work" of this HVAC Section includes all labor, material, equipment, tools and services necessary to furnish, deliver, unload, install, test and place in satisfactory operation, the equipment, services and systems as called for under the HVAC Section(s) including any incidental work not shown, or not specified but which can reasonably be inferred as belonging to the various systems and necessary in good practice to provide complete and fully operational systems. Cutting and patching is included in this Section.
- F. Equipment shall consist of the following:
1. Fans
  2. The following work descriptions are not intended to in any way limit the above broad statement, but are intended as a more specific mention of the most important items included therein.
- G. The functions of the HVAC systems are as follows:

The ventilation system serves to ventilate an electrically classified space for the purposes of operator inspection and work on the flow meter associated with a sanitary sewer.

System Description: The system comprises a supply fan, an exhaust fan, both operated at two speeds by means of Variable Frequency Drives (VFDs) for three modes as follows:

1. Unoccupied Mode
2. Occupied Mode with Access Openings to Sewer in Closed Position
3. Occupied Mode with Access Openings to Sewer in Open Position

Interconnecting ductwork to the fans delivers and exhausts air to and from the space through louvered openings in intake and exhaust shafts located near the meter pit.

- H. This Section is incomplete without the information contained in the HVAC equipment schedules. Provide equipment of the type, size, capacity and arrangement as shown on the Drawings and as scheduled. Equipment shall consist of the particular components listed in the schedules in addition to those components normally required for the type of unit. The order of component assembly will be as stated in the schedule. Particular attention must be paid to the remarks and notes in the schedules and on the Drawings.
- I. All ductwork and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

#### 1.02 RELATED WORK

- A. For temporary electric power and lighting, refer to Electrical Drawings and Specifications.
- B. Trenching, excavation and backfill is included in MAG Uniform Standard Specification-Part 200, except for items specified herein.
- C. Concrete work is included in MAG Uniform Standard Specification-Section 505, except for required HVAC anchor bolts, sleeves and templates which shall be furnished under this Section.
- D. Structural steel and miscellaneous metal is included in MAG Uniform Standard Specification-Section 515, except for supplementary steel required for HVAC hangers, equipment supports, anchors and guides, which shall be furnished under this Section.
- E. Painting is included in MAG Uniform Standard Specification-Section 530 & 790, except for factory finished HVAC equipment, HVAC shop painting and HVAC identification labeling.
- F. Exterior louvers are specified on Structural Drawings.
- G. Plumbing work is included under the Plumbing Section (Division) of this Division (Specification) except for water and drain closing in connections to HVAC equipment.
- H. Electrical field wiring is included in Division I6, except for field wiring for automatic temperature controls as specified herein or as shown on the HVAC Drawings.

1.03 SUBMITTALS

- A. Submit, in accordance with Section MAG Uniform Standard Specification - Section 105, shop drawings and product data for the following:
1. Catalog cuts and data sheets for all equipment.
  2. Complete damper schedules for damper submittals including the following for each type or model of damper to be furnished for the project: materials of construction for blades, frames, bearings, linkages and seals; flow and leakage characteristics; typical operating torque requirements or characteristics; options to be furnished; general installation and maintenance instructions. Damper schedules shall include damper type; unit served; damper service; damper size; duct size; drive linkage location; installation arrangement (flanged or in duct) and damper operator type.
  3. All fans, submit all data on the fan schedules. In addition the submittal shall include catalog data, fan data sheets with a description of the proposed fan, fan size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, and frame size. Provide catalog data and selections for vibration isolators, include materials of construction. Each submittal shall include pertinent equipment dimensional data, fan performance (operating data information, and a performance curve showing the fan operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included on each submittal. Copies of operating and maintenance manuals shall be submitted. Significant dimensional differences between the specified equipment and the proposed equipment shall be noted on the equipment submittal. The contractor shall provide data to show the dimensionally different equipment will fit within the space and still provide suitable clearance. Where corrosion resistance is required, provide conformation of material suitability for the specified service.
  4. Detailed equipment and ductwork layout drawings; minimum scale 1/4-in = 1-ft-0-in for interior systems and equipment, dimension clear service spaces for motors and drives, and spacer section access doors, and ductwork access panels and doors.
  5. Standard shop and field installation details for transitions, elbows, takeoffs, discharge nozzles, turning vanes, access panels and doors, volume control and splitter dampers and extractors.
  6. Ductwork materials, joining methods, reinforcing and material gauges. Where options are allowed by SMACNA, the proposed option shall be clearly defined. Indicate proposed materials and methods for ductwork and equipment hangers.
  7. Prepare dimensional comparisons between proposed equipment and scheduled equipment when the proposed equipment is dimensionally larger than that scheduled. Do not propose dimensionally larger equipment from an alternate manufacturer for installation in confined areas, or when the installation of alternate equipment will result in reduction of service access below that recommended by the manufacturer.
  8. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

9. When special hangers, supports, anchors, or hold downs are required that are not covered by standards provide signed and sealed calculations and details for record purposes.
10. All submittals shall contain a statement that Section 15500 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.
11. Submit air system testing, adjusting and balancing reports for review and approval.
12. Operation and Maintenance Data
  - a. Submit to the Engineer as provided in MAG Uniform Standard Specification - Section 105, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.
    - 1) Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.
    - 2) Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.
    - 3) Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.
  - b. Contents - Each volume shall contain the following minimum contents:
    - 1) Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.
    - 2) Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.
    - 3) Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.
  - c. Spare Parts List
  - d. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.
13. All materials deliveries must have accompanying manufacturer's certifications attesting to satisfactory results of product testing showing conformance with this Section.
14. Provide a recommended list of spare parts to be provided
15. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

#### 1.04 REFERENCE STANDARDS

- A. These standards shall be considered as minimum requirements. This is a general list and not all standards listed are necessarily referenced elsewhere in this Section. Specific requirements of this Section and/or Drawings shall have precedence. In case of conflict between published requirements, the Engineer shall determine which is to be followed.
- B. Abbreviation and the title of Federal, State and industry standards, technical societies, associations and institutes and other organizations which may be used are as follows:
1. Associated Air Balance Council (AABC)
  2. American Conference of Governmental Industrial Hygienists (ACGIH)
  3. Air Diffusion Council (ADC)
  4. American Bearing Manufacturers Association (ABMA)
  5. Air Movement and Control Association (AMCA)
  6. American National Standards Institute (ANSI)
  7. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
  8. American Society of Mechanical Engineers (ASME)
  9. ASTM International
  10. Factory Mutual (FM)
  11. Institute of Electrical and Electronic Engineers (IEEE)
  12. National Institute of Standards and Technology (NIST)
  13. National Environmental Balancing Bureau (NEBB)
  14. National Electrical Code (NEC)
  15. National Electrical Manufacturers Association (NEMA)
  16. National Fire Protection Association (NFPA)
  17. Occupational Safety and Health Administration (OSHA)
  18. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
  19. Underwriters Laboratories (UL)
- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

#### 1.05 QUALITY ASSURANCE

- A. Provide single source supplier/installer responsibility for systems where specified in other related Sections.
- B. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules
- C. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.
- D. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.
- E. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.
- F. All rotating parts of equipment shall be statically and dynamically balanced at the factory.

#### 1.06 DELIVERY, STORAGE AND HANDLING

- A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.
- B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.
- C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.
- D. All equipment shipped that is exposed such as on a flatbed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.
- E. Instruction for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.
- F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.]

#### 1.07 COORDINATION

- A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary, details of such departures and the

reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

- B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.
- C. The Contractor shall assume full responsibility for coordination of the HVAC systems, including; scheduling, and verification that all structures, ducts, piping and the mounting of equipment are compatible.

#### 1.08 ENGINEERING SERVICES

- A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.
- B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

#### 1.09 MAINTENANCE

- A. Maintain and service all equipment and systems until the particular equipment or the system has been accepted by the Owner.
- B. Maintenance shall include compliance with the manufacturers operating and maintenance instructions as well as periodic cleaning or replacement of air handling system filters.
- C. Compile records of all maintenance and lubrication work performed on Owner or Contractor furnished equipment. Maintain records at the construction or installation site and make available at all times for review by the Owner or Engineer. At the request of the Owner or Engineer submit copies of these records to the Owner for information and/or review.
- D. Provide all special tools required for normal maintenance. Tools shall be packaged in a steel case, clearly and indelibly marked on the exterior to indicate equipment for which tools are intended.
- E. Provide to the Owner a list of all spare and replacement parts with individual prices and location where they are available. Prices shall remain in effect for a period of not less than 1 year after start-up and final acceptance.

#### 1.10 WARRANTY

- A. In the event that the equipment or components fail to perform satisfactorily at any time within the Defects Liability Period, the Contractor shall replace it with one capable of operating as specified, and shall comply with the requirements in Division 1. The Contractor shall be responsible for all cost incurred in furnishing and installing the replacement equipment.]

## 1.11 DEFINITIONS

### A. Particular terminology used under this Section is defined as follows:

1. Traffic Level and Personnel Level - Areas, including process areas, equipment rooms, boiler rooms and other areas where insulation may be damaged by normal activity and local personnel traffic. Area extends to 8-ft above floor, walkways, platforms and stairs, and horizontally 3-ft beyond the edge of walkways, platforms, and stairs.
2. Exposed Piping and Ductwork - Piping and ductwork visible from the floor level and includes all piping and ductwork in equipment rooms, boiler rooms, etc.
3. Supply Air Ductwork - Ductwork carrying air from a fan or air handling unit to the space or spaces to which it will be introduced. This air may have been heated or cooled or in the case of ventilation system the air would be neither heated nor cooled. Supply air ductwork extends from the fan or air handling unit to the registers, grills or diffusers at the end of the ductwork.
4. Exhaust Air Ductwork - Ductwork carrying air from a space to a fan and then to be discharged to the outdoors. Exhaust air ductwork extends from the registers of grills at the end of the ductwork to the fan. From the fan exhaust ductwork extends to the discharge point, exhaust air damper, or exhaust air plenum, whichever comes first.
5. Outdoor Air Ductwork - Ductwork carrying untreated air from the outside to a fan or air handling unit. Outdoor air ductwork starts at the intake point, outdoor air damper, or outdoor air plenum, whichever comes last. The outdoor air ductwork extends to the fan, air handling unit, or connection with a return air duct, whichever comes first.
6. Ventilated Spaces - Areas supplied with outdoor air on a continuous or intermittent basis. The outdoor air may be heated and/or cooled or untreated.
7. Unheated Spaces - Areas where heat is not applied and there is no minimum temperature during the heating season.
8. Non-Conditioned Spaces - Areas that are not provided with mechanical cooling.

## PART 2 PRODUCTS

### 2.01 ELECTRICAL EQUIPMENT

#### Process Areas

Div. 1 or 2

Explosion Proof

#### A. Electric Motors

1. Electric motors in NEMA frame sizes shall conform to the requirements in Section 01171, unless otherwise specified herein.

2. The motor manufacturer shall confirm that motors used to power equipment are provided with bearings that will provide a bearing life equal to the driven equipment or better. Confirmation shall be included with shop drawing submittal.
3. Motors will be selected to be non-overloading over the entire operating range of the equipment. A safety factor of 25 percent will be added to all motors up to and including 50 horsepower. A safety factor of 15 percent will be added to all motors over 50 horsepower. Motors indicated on the schedules are to be considered a minimum. This sizing is not to limit compliance with the above requirements

B. Electrical Equipment

1. Electrical equipment which is furnished under this Section shall meet the requirements specified in Division 16:
  - a. Disconnect switches, motor starters and combination motor starters (starters with disconnecting means and short circuit protection) shall be as specified in Section 16020.
  - b. Raceways, boxes, fittings and supports shall be as specified in Section 16020.
  - c. Wires and cables shall be as specified in Section 16020.
- C. Electrical enclosures and panels to include automatic temperature control panels and components shall be suitable for the environment and electrical classification for the space they are located in. The type of enclosure for the various spaces shall be as specified in Division 16. Refer to the electrical drawings for the space classifications.
- D. Where noted in the HVAC equipment schedules, or when shown on the Drawings, provide fan speed control switches and integral unit thermostats.

2.02 EQUIPMENT VIBRATION ISOLATOR AND MOUNTINGS

A. General

1. Unless otherwise specified in this Division all machinery or vibrating mechanical equipment shall be isolated from the building structure by vibration isolators with a minimum deflection as specified. Operating equipment that can transmit objectionable vibration and noise must be installed with special types of vibration isolators such as flexible connectors to ductwork, piping and wiring. In more critical areas and under particular conditions, additional vibration isolators shall be installed as specified in other related Sections in this Division, or in specific equipment schedules.
2. All equipment shall be provided with attachment points for floor or suspended mounting that will safely transmit all loads including seismic to the supports.
3. The vibration isolator manufacturer shall be responsible for the proper selection of vibration isolators suitable for the particular application. Selection of the vibration isolator shall include the following factors.
  - a. Equipment Weight
  - b. Equipment operating frequencies
  - c. Type of building support structure
  - d. Seismic forces as required by the applicable building codes to include shear, tension and compression due to the code specified loads.

4. All floor mounted vibration isolators shall be bolted to the floor or framing on which they rest. Bolts shall be arranged to prevent transmission of vibration through the bolts.
  5. All isolation devices for a single piece of equipment shall be selected for a uniform static deflection according to distribution of weight in the equipment.
  6. All pieces of equipment that have a variation in weight during operation or maintenance such as, but not limited to, cooling towers and hoppers, shall have built-in vertical limit restraints to limit motion to a maximum of 1/4-in.
  7. Isolators exposed to the weather, in rooms classified on electrical drawings as damp, wet, or corrosive or where called for on the Drawings shall be provided with corrosion protection. Steel parts other than springs shall be galvanized. Parts subject to wear, rubbing, shall be non-corrosive material such as rubber or stainless steel. Springs and hardware shall be cadmium plated or otherwise provided with an approved coating.
  8. After installation of equipment, isolators shall be adjusted for proper loading and distribution of weight.
- B. Types - The following types of vibration isolators may be used.
1. Isolation for Suspension
    - a. Isolation hangers for suspension of equipment and piping shall have a single element of elastomer for 1/4-in deflection, a double or a single molded element of 1/2-in deflection, a single spring element with an elastomer grommet for up to 3/4-in deflection and a combination of an elastomer and spring elements in series for 1-in deflection and up contained within a structural rigid one piece steel hanger box. Springs shall have a minimum ratio of outside diameter to operating spring height of 0.8 and an additional travel to solid equal to 50 percent of the specified deflection.
    - b. The neoprene element shall have a bushing to prevent hanger rod contact with the housing box. The lower rod shall be free to swing in a 30 degree arc without touching the spring or the housing.
  2. Rails and Bases - Rails and bases shall be of the following types based on the equipment and deflection required.
    - a. Steel spring type shall be steel rails running the full length of the supported equipment and extending under any overhang to counteract cantilever effects. The rails shall consist of structural members supported by individual free standing springs. The rails shall be drilled to accept the supported equipment and shall serve as a template.
    - b. Fans and their driving motors shall be mounted on structural steel channel members forming a rigid base. A common member parallel to the V-belt drive shall run the full length of the fan and motor and shall be of sufficient rigidity to resist the bending stress of belt pull. The structural steel base shall incorporate single or double deflection elastomer-in-shear elements or free standing springs located for proper weight distribution. The base shall be drilled and tapped to accept the fan and motor and shall serve as a template. Integral motor slide rails shall be provided and welded in place.

- c. Unless specifically noted in other sections of the specification or on specific equipment schedules, all equipment will be provided with vibration isolation as defined by the following table:

Type of Equipment	Vibration Isolation Type	Minimum Deflection for Slab on Grade Inches	Minimum Deflection for up to 20-ft floor span inches	Minimum Deflection for 20-ft to 30-ft Floor Span Inches	Minimum Deflection for 30-ft to 40-ft Floor Span Inches
Duct Mounted Fans					
600 CFM and greater	Spring	0.75	0.75	0.75	0.75

C. Rigidly Mounted Equipment

1. When equipment does not require vibration isolation, it shall be firmly attached to the building structure. Bolts and support structure shall include allowances for seismic loads as required by the applicable building codes to include shear and moment loads.

D. Vibration Isolation for Ducts

1. The first three supports for ducts shall be connected to supply, exhaust and/or return fans shall be resiliently suspended from spring and elastomer combination hanger equivalent to "Kinetics" Type "SRH." If supported from floor, use "Kinetics" Type "S" with deflections equaling those of fan vibration isolators, but not more than 1.5-in.
2. The remaining ductwork up to a distance of 30 ft. from vibrating equipment shall be suspended or supported by isolators equivalent to "Peabody" Type "FH" or "RH."
3. Isolators shall be Korfund; Mason; Peabody Noise Control Inc.; Vibration Eliminator Co.; Vibration Mountings & Controls Inc.; Vibron or equal.

2.03 FLAME AND SMOKE RATINGS

- A. All materials, including adhesives, surface coatings, sealers, assemblies of several materials, insulation, jacketing, finish, etc, shall have flame spread ratings not over 25 (fire resistive), and smoke development ratings not over 50 and fuel contributed rating not over 50, as established by tests conducted in accordance with the Federal Standard 00136B, National Bureau of Standards Radiant Energy Fire Test and the National Fire Code of the NFPA.

- B. These requirements apply to all circumstances whether the materials are field applied or applied by a manufacturer in his/her shop, or elsewhere, prior to delivery to the project.

2.04 NOISE CRITERIA

- A. The following sound criteria shall be met for all of the following listed equipment. Data shall be the sound power level (reference 10 x-12 watts).

Equipment Identification	63	125	250	500	1000	2000	4000	8000	LwA
SAF-1	74	71	71	75	76	74	70	62	80
EAF-1	74	71	71	75	76	74	70	62	80

- 1. The equipment supplier shall provide actual data for the equipment submitted. If the space does not meet the required criteria, and the noise level of the equipment is found to be the cause, the equipment supplier shall be responsible for the modifications required to correct the condition.

2.05 BEARINGS

- A. General - Furnish equipment bearings suitable for the intended equipment service. Furnish bearings designed to carry both thrust and radial loads for equipment designed for all angle operation.
- B. Provide extended lube lines with pressure relief equipped grease fittings for all bearings which are not readily accessible from outside the equipment.
- C. Bearings for all equipment in the schedule below shall have heavy-duty grease lubricated self aligning ball or roller bearings. Bearings shall have ample thrust provision to prevent end play during the normal life of the bearing. Unless specifically noted otherwise, all fans shall have bearings for both the equipment and motors with the following ABMA L-50 life.
  - 1. Fans over 1500 cfm - 100,000 hours.
  - 2. Fan impellers greater than 10-in diameter
  - 3. Continuous duty fans with motors over 25 horse power 200,000 hours.
  - 4. All fans with motors over 50 horse power 200,000 hours.
- D. Belt driven fans, including air handling unit fans shall be equipped with self aligning single row ball bearings, double row tapered or spherical roller bearings.
- E. For systems with bearings requiring L-50 lives of 200,000 hours or greater, the equipment supplier shall provide calculations for both the equipment bearings and the motor bearings to confirm the bearing selections. For belt drives, the calculations shall include the effect of the

sheave size, number of belts, the sheave location on the shaft, and the location of the motor to the driven sheave.

- F. Provide seals for bearings installed in airstreams, exposed outdoors, and for applications in corrosive or dusty atmosphere.
- G. Provide bearings suitable for high temperature service where heat fan construction is required.

2.06 HANGERS, SUPPORTS AND ANCHORS

A. General

1. Furnish supports, hangers and other devices necessary to support and anchor firmly and substantially the piping, equipment and ductwork described in this Section. Piping and duct support systems shall include restraints as required by the applicable building codes to withstand seismic and wind loading. Design shall be provided by a professional engineer hired by the Contractor as specified in other Sections. Signed and sealed calculations shall be submitted for record purposes.
2. All equipment shall be provided with lugs or brackets to allow the equipment to be firmly fastened to the structure. The lugs and brackets shall be sized to withstand the expected seismic and wind loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.
3. Design of hangers, supports, anchors and hold downs shall include the effect of all loads applied to the equipment, pipe or duct as well as the load of the component. These loads include, but are not limited to wind, seismic and internal dirt or liquid buildup.
4. Provide galvanized steel hanger rods, hangers, supplementary steel, anchors and guides in areas classified as corrosive, wet, and in outdoor exposed applications.
5. Provide the following material for hanger rods, hangers, supplementary steel, anchors, hold downs and guides in specified areas.

Area	System	Material
Entire Meter Pit	Fan supports & anchors	316 SS
Entire Meter Pit	Ductwork supports & straps	Aluminum
Entire Meter Pit	Ductwork anchors	316 SS

B. Hangers and Suspension

1. Furnish and install all miscellaneous metalwork in accordance with Division 5 requirements.
2. Where C-clamp type hangers are used, furnish with a retainer strap.
3. Hangers shall not be supported from roof decking or bulb tees. Where required, provide supplemental steel to span between the building structures.

4. All piping supported at a maximum of 10-ft-0-in intervals.
5. Anchor piping mains where indicated or wherever necessary to limit pipe expansion and to prevent vibration. Furnish anchors constructed of stainless steel securely bolted to masonry and welded to pipes.
6. Rectangular, Round and Flat-Oval Ductwork - Spacing and size of hangers shall be as called for in the SMACNA standards.

#### 2.07 PAINTING AND COATINGS

- A. Unless otherwise specified, all machinery and factory finished equipment such as pumps, fans, air handling units, air conditioning units, and other items of manufacture shall be hot dipped galvanized or will have a factory applied finish, color as standard with the manufacturer. Components fabricated from stainless steel do not require a coating finish unless otherwise specified. All tanks, supporting steel, hangers, rods and all other uncoated or non galvanized steel other than standard piping and fittings shall have a shop coat consisting of a suitable primer and finish coat. If not factory applied, the prime coat shall be as specified in Division 9. All items not factory or shop primed prior to installation shall be suitably cleaned of rust and mill scale by wire brushing, sanding, or other means and prime painted, immediately after installation.
- B. The Contractor shall be responsible for the repair of all defects, blemishes, holidays and the like apparent in manufactures coatings and shall ensure that the materials used for such repair shall match and be compatible with the manufacturer's standard color, coatings and practices. Surfaces to be repaired or recoated are to be prepared as recommended by the paint or coating supplier. Care shall be taken not to paint over nameplates.
- C. Furnish touch up paint for the various types of equipment furnished and deliver unopened paint to the Owner at completion of the project. The amount of touch-up paint supplied shall be sufficient to cover 15 percent of the applicable painted surfaces or one pint, whichever is greater.

#### 2.08 TESTING, ADJUSTING AND BALANCING

- A. Furnish the services of an AABC or NEBB certified agency for the testing, adjusting and balancing of all HVAC air systems installed under this Section.
- B. The testing, adjusting and balancing agency shall be independent of all suppliers, installers and contractors on the project.

#### 2.09 PIPE AND FITTINGS

- A. Miscellaneous Plumbing Piping
  1. Pipe – Schedule 40 PVC for all plumbing drains and vent.

#### 2.10 FANS

- A. General

1. Fans shall be factory assembled, complete with fan wheel, fan housing or cabinet, bearings, drives, drive guard, motor, motor base, unit base and vibration isolators, dampers and bird screens unless otherwise specified. All fans shall be provided with lugs, brackets or field supplied devices to allow the fan to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.
2. All fans shall be statically and dynamically balanced before shipment.
3. All fans shall be AMCA rated for sound and air performance per AMCA 210-85 and 330-86.
4. Fans shall be assembled with OSHA shaft and motor guards. Provide access for greasing bearings, tachometer readings of fan and motor speed without removing the cover. Cover shall be properly ventilated to prevent motor overheating.
5. Where shown on the Drawings and Schedules, fans shall be of spark resistant construction. Bearings shall not be placed in the air stream. Construction shall conform to AMCA 99-0401-82 Classifications. All electrical components shall be explosion proof.
  - a. TYPE A (only shall be accepted) - All parts in contact with the gas stream shall be non-ferrous material.
6. Inlet and/or discharge screens shall be provided for fans that are not directly duct connected.
7. Fans shall be of aluminum construction.
8. Electric motors and electrical disconnects shall be provided as specified elsewhere in this Section.
9. Fans shall be UL listed when noted in the schedules or when code required for the specific application.
10. The noise level of the equipment operating in the field shall not exceed 85 dBA overall sound pressure level (referenced to 20 micro pascals) at a distance of 3-ft from equipment surfaces. Provide octave band sound data if another noise level is specified in the schedule or if sound data submission is specified in the schedules.

B. Tubeaxial and Vaneaxial Fans

1. Axial fans shall have flanged inlet and discharge, access door in fan tube. Belt drive fans shall have shroud over the belt drive in the air stream. Mounting brackets shall be provided based on fan mounting orientation. Fans shall be of aluminum construction with cast aluminum wheels.
2. Provide OSHA approved Inlet screen and inlet bell for SAF-1. Space limitations limit the size of the inlet bell. Refer to drawings for height limitations of assembly. Entire assembly

shall allow minimum clearance of 7'-0" over landing where fan will be mounted from the ceiling.

3. Provide Aluminum Companion Flanges to ductwork.
4. Provide Flexible connectors with aluminum flange assembly. Flexible connector material shall be neoprene, minimum 12 gauge.
5. Manufacturers shall be Aerovent, Inc.; Hartzell Fan, Inc.; New York Blower Co.

## 2.11 DUCTWORK

- A. Sheet metal ductwork shall be constructed of the materials specified using the gauges or thicknesses and reinforcing called for by SMACNA for the material specified. Unless otherwise specified, all components of duct systems shall be constructed of the same material as the ductwork. This is to include braces and turning vanes.
  1. Aluminum ductwork shall be constructed of 3003H-14 alloy B&S Gauges.
- B. Ductwork shall be constructed of the following materials and to the following standards:

System	Location	Static Pressure	Construction Material	SMACNA Standard
Supply	In Pit	2.0	Aluminum	IRD & IRT (as shown on dwg)
Exhaust	In Pit	2.0	Aluminum	IRD & IRT (as shown on dwg)
OA Intake	Underground	4.0	HDPE*	
Exhaust	Underground	4.0	HDPE*	

Notes: \* A.K. Duct (Blue Duct) or equal rated for buried HVAC ductwork applications

### Abbreviations

- IRD - SMACNA Round Industrial Duct Construction Standards  
IRT - SMACNA Rectangular Industrial Duct Construction Standards

2.12 DESIGN OF DUCTWORK SHALL INCLUDE ALL LOADS APPLIED TO THE DUCTWORK, IN ADDITION TO THE LOAD OF THE DUCT.

## 2.13 CONSTRUCTION

- A. All ductwork shall be substantially built with joints and seams smooth on the inside and given a neat appearance on the outside. Inside surfaces and joints shall be smooth and free from pockets, burrs and projections. All joints shall be substantially air tight with laps made in the

direction of air flow and no flanges projecting into the air stream. All changes in direction and duct transitions shall be shaped to permit the easiest possible air flow.

B. Pressure Classes

1. Pressure classes for determination of sheet metal gauge and reinforcing shall be as defined by the latest issue of the SMACNA standards for duct construction.
2. For ductwork with a static pressure higher than 2-in water gauge, pressure class shall be as shown on the Drawings. For ductwork with a static pressure 2-in water gauge or less pressure class shall be equal to the maximum pressure indicated for the fans or air handling units on the Schedules and the pressure class shall be the same for the entire length, including branches, of the specific duct system.

C. Rectangular Ductwork

1. Ductwork shall be constructed as shown on the Drawings in accordance with the specified SMACNA Construction Standard, latest edition.
2. Cross-breaking shall conform to SMACNA Standard. Cross-breaking shall be applied to the sheet metal between the standing seams or reinforcing angles. The center of the cross-break shall be of the required height to assure rigidity for each panel.
3. All square elbows for rectangular ductwork shall be provided with turning vanes unless otherwise noted on the Drawings. Turning vanes shall be as detailed in the SMACNA Manual and or as shown on the Drawings.
4. Alternate Construction (Rectangular Only) - Factory-fabricated joint systems may be offered as an alternate form of construction. The system offered shall meet all requirements of SMACNA. Alternate joint systems shall be "Ductmate System" as manufactured by Ductmate Industries, Inc., installed in accordance with the manufacturer's recommendations. The system shall be sealed for zero leakage and angle attachment to the main duct section shall be by tack welding. The use of screws is not allowed.

D. Round Ductwork

1. Ductwork shall be constructed as shown on the Drawings in accordance with the specified SMACNA Construction Standard latest edition.
2. Round Ductwork
  - a. Round ductwork shall be either lock type, welded longitudinal seam construction or spiral ductwork.
  - b. Gauges of ductwork and fittings shall be as specified in SMACNA. Draw bands will not be permitted. Slip joint shall be used on ductwork up to 36-in in diameter and the "loose flange" or Vanstone joint shall be used on ducts over 36-in in diameter.
  - c. All seams and joints shall be continuously welded.
  - d. Round ductwork shall be manufactured by United Sheet Metal; SEMCO or equal.

E. Round Ductwork Fittings

1. All 90 degree turns shall be made of five piece mitered welded construction made by the manufacturer of the conduit. Fittings less than 90 degrees in the riser shall be made of multiple pieced mitered welded construction.
2. All fittings in the round duct system shall be of the male and female type and in assembling these together, there shall be applied an approved synthetic rubber sealing compound on the joint. Also, on the outside of the duct apply this synthetic rubber sealing compound in order to further make these joints air tight. Mechanically fasten the conduits together using sheet metal screws not less than four per fitting 6-in on centers maximum and equally spaced around the circumference of fitting.
3. Round duct fittings shall be manufactured by United Sheet Metal; SEMCO or equal.

#### F. Volume Dampers

1. Dampers shall be standard opposed or parallel multi-blade type on 2-in channel frame, flanged connection with external damper position indicator, manual adjustment, and position locking arrangement. Damper blades shall not exceed 6-in in width. Dampers shall be constructed of the same material as the ductwork, or of a material of equal corrosion resistance. Balancing and balancing/shutoff dampers shall be opposed blades and shutoff dampers shall be parallel blade.
2. Locking quadrants shall have a positive method of holding the damper in its selected position such as a bolt through both the quadrant and the lever arm. Systems using springs or other devices that can vibrate loose are not acceptable.
3. Where manual dampers are used for shut off service, dampers shall have a replaceable butyl rubber or bulb vinyl seals provided with the damper. Install seals along the top, bottom and sides of the frame and along each blade edge.

#### G. Access Doors

1. Access doors shall be 24-in by 24-in minimum, except where the duct size is less than 26-in, where the largest door that will fit the duct will be used. Unhinged access panels are not acceptable, except where shown on the Drawings. Access doors shall be of the same material as the duct, pan type construction for metal ductwork, with smooth edges and fitted seals, constructed and installed for air-tight fit with ease of opening and closing. Doors shall be substantially butt hinged, with heavy sash locks and substantial door pulls. Door openings and door frames shall be reinforced with bar stock or angle. Where ductwork is installed with duct liner or exterior duct insulation, the access door shall be of the insulated type. Access doors may be factory fabricated. Where ductwork is constructed of aluminum or stainless steel, access door hardware shall be of similar material.

#### H. Fasteners

1. Sheet metal screws, drive cleats, cinch bands and other fasteners shall be fabricated from materials with an equal or greater corrosion resistance than the ductwork in which they are installed. Where a material other than the duct material is used, it shall be approved by the Engineer before installation.

## 2.14 DIFFUSERS, REGISTERS AND GRILLES

### A. General

1. All diffusers, registers and grilles shall be of the shape, sizes, capacity and type as shown on the Drawings.
2. On all duct openings that do not have a specific diffuser, register, grill or mesh covers, provided a wire mesh cover.
3. Finish—All diffusers, registers and grilles shall have baked aluminum enamel finish.

### B. Supply Air Grilles

1. In general, grilles shall be a factory-assembled unit consisting of a grille with double deflecting adjustable airfoil vanes to diffuse supply air in the various directional patterns as shown on the Drawings. Grilles shall be of aluminum frame and border with aluminum louver blades. All grilles shall be furnished with a sponge rubber gasket to prevent streaking. Front and rear louver blades shall be individually adjustable. Where wall mounted, front blades shall be vertical and rear blades shall be horizontal. Where ceiling mounted, front blades shall be parallel to long dimension.
2. Grilles shall be Series 300FL by Titus Manufacturing Corp.; Carnes, Model RAFA Series; Air Devices Inc. or equal.

### C. Return Air Grilles

1. Stamped Metal Return Air Grilles
  - a. Grilles shall be a factory-fabricated unit consisting of a stamped aluminum lattice face. All grilles shall be furnished with a sponge rubber gasket to prevent streaking. Minimum free area shall be 50 percent.
  - b. Acceptable manufacturers shall be as listed or equal:
    - 1) Model 300ZFL - Titus Manufacturing Corp.

## 2.15 ISOLATION DAMPER AND DAMPER ACTUATOR

### A. Area Classification

1. Where specific area classifications are called for or shown on the electrical drawings, all equipment and wiring shall be in conformance with the requirements for that classification as specified in Division (26) (16). Special attention shall be given to hazardous areas specifically "Class I Div. 1 Group D" and "Class I Div. 2 Group D" to comply with code requirements for equipment selection and installation procedures.
2. Automatic dampers shall be opposed blade.
3. All damper frames are to be constructed of the same material as the duct or a material with greater corrosion resistance sheet metal and shall have flanges for duct mounting. Damper blades shall not exceed 6-in in width. All blades are to be of corrugated type construction, fabricated from two sheets metal, spot welded together. Blades are to be suitable for high velocity performance. Maximum blade length in any section shall be 48-in. Additional

stiffening or bracing shall be provided for sections exceeding 48-in in height. Multi-section dampers shall be provided with sufficient interconnecting hardware to provide unison operation of blades in the entire assembly.

4. All damper bearings shall be made of nylon.
5. Replaceable butyl rubber or bulb vinyl seals are to be provided with the damper. Seals are to be installed along the top, bottom and sides of the frame and along each blade edge. Seals shall provide a tight closing, low (1 percent) maximum leakage damper.
6. Dampers shall be selected for the velocity and pressure differential required without excessive deflections.
7. Dampers shall be furnished for flange mounting with exposed jamb mounted blade linkages for any of the following applications:
  - a. Where installation clearances do not allow the installation of full size access doors to allow inspection and adjustment of face linkages.
  - b. For corrosive, dirty or particle laden air service.
  - c. Where called out on the Drawings.

#### B. Electronic Damper Actuators

1. Electronic actuators, less than 600 in-lb of rated torque, shall have ISO 9001 quality certification and be UL listed under standard 873, CSA C22.2 No. 24 and have CE certification. Electronic actuators used on dampers shall be designed to directly couple and mount to a stem, shaft or ISO style-mounting pad. Actuator mounting clamps shall be a V-bolt with a toothed V-clamp creating a cold weld, positive grip effect. Single point, bolt or single screw actuator type fastening techniques or direct-coupled actuators requiring field assembly of the universal clamp is not acceptable.
2. Actuators shall be two position as required and be factory or field selectable. Actuators shall have visual position indicators and shall operate in sequence with other devices if required.
3. Actuator shall have an operating range of minus 22 to 122 degrees F.
4. Actuators shall be capable of operating on 120 or 230 VAC and Class 1 Div 1 wiring as directed by the application.
5. Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation. End switches to deactivate the actuator at the end of rotation or magnetic clutches are not acceptable.
6. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW mounting orientation. Spring return models >60 in-lb will be capable of mounting on shafts up to 1.05-in diameter. Spring return actuators with more than 60 in-lb of torque shall have a manual override metal crank. Upon loss of control signal, a proportional actuator shall fail open or closed based on the minimum control signal. Actuator spring shall close damper upon power failure.

7. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Dampers requiring greater torque or higher close off may be assembled with multiple low torque actuators. Dual mounted actuators using additional anti-rotation strap mechanical linkages or special factory wiring to function are not acceptable. Actuators in a tandem pair must be "off the shelf" standard actuators ready for field wiring.
8. Where special classifications are shown on the electrical drawings damper actuators shall be provided with suitable enclosures.
9. Explosion-proof enclosure shall be suitable for Class I, II and III. A suitable shaft seal must be provided. Housing shall be cast copper fill aluminum with stainless steel fasteners and shall be UL listed. Housing shall be suitable for NEMA 4, 7 and 9.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.
- B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.
- C. Equipment
  1. Install equipment in accordance with manufacturer's recommendation. Provide piping and ductwork connections in accordance with the requirements as specified elsewhere in this Section.
  2. When units are shipped disassembled, field connect all sections together as shown on the Drawings to form single air handling unit. Seal all joints with gaskets and/or sealants.
  3. Do not operate equipment without filters. Do not run equipment with dirty filter pressure drop more than twice clean filter pressure drop. A total of three complete sets of filters shall be provided. The first set is to be installed for start-up, test and balancing. The second set shall be installed after final cleanup and acceptance by the Owner. The third set shall be turned over to the Owner as a spare.
- D. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.
- E. Installation of Ductwork
  1. Fabricate and erect all ductwork where shown on the Drawings, as specified herein and in accordance with SMACNA requirements. Rigidly support and secure ductwork in an approved manner. Install hangers plumb and securely suspended from supplementary steel or inserts in concrete slabs. Sufficiently thread lower ends of hanger rods to allow for

adequate vertical adjustment. Do not use building siding and metal decking to hang ductwork.

2. Wherever ducts are divided, maintain the cross-sectional area. All such changes must be approved and installed as directed by the Engineer or as approved on shop or erection drawings.
3. During installation, close the open ends of ducts to prevent debris and dirt from entering. Install work in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.
4. Provide the unused portion of external louvers (where it is not used as a fresh air intake or exhaust) with a blank-off constructed of 0.0625-in aluminum. Provide blank-off panels with aluminum reinforcing angles to prevent buckling and secured to the exterior wall with aluminum angles and rustproof fasteners on not more than 12-in centers. Provide caulking completely around the outside edge of the angle and the aluminum.
5. Install automatic dampers when supplied by other trades.
6. Cross-break sheet metal in accordance with SMACNA duct construction standard. Apply cross-breaking to the sheet metal between the standing seams or reinforcing angles. The center of the cross-break shall be of the required height to assure each panel section being rigid.
7. Cross-break steamlined ducts on top only and adequately brace internally.
8. Beading as specified in SMACNA will be acceptable in lieu of cross-breaking.
9. The Drawings of the air ducts and air risers show the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made, these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.
10. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, maintain the cross-sectional area. All of these changes, however, must be approved and ducts installed as directed by the Engineer or as approved on shop or erection drawings.
11. The taper of all transformations shall be not more than 15 degrees.
12. Secure casing to curbs according to SMACNA Duct Construction Standards.
13. Provide baffle plates as required to prevent stratification and to provide proper operation of controls.
14. Where ducts are constructed of materials other than galvanized steel the reinforcing members shall be of the same material as the ductwork.
15. For PVC ductwork where reinforcing members of material other than PVC are required, totally encase the reinforcing member in PVC.

16. The use of button punching or snap locks on ductwork constructed of aluminum shall not be permitted.

F. Hangers

1. The use of wire to hang flexible ductwork shall not be permitted.
2. Ductwork shall not come in contact with any of the ceiling construction or any other equipment in the ceiling cavity.

G. Sealing of Ductwork

1. General -- Unless, otherwise indicated, seal all ductwork joints and seams using sealant in accordance with the instructions of the sealant manufacturer and this Section. All transverse seams, joints and fitting connections, both shop and field assembled, shall be sealed in accordance with this Section. Not more than one longitudinal seam shall be unsealed in each section of duct.
2. Application of Sealant - Thoroughly clean all seams, joints, etc, of dirt, oil, grease, or other coatings which might interfere with the adhesion of the duct sealant before the sealant is applied.
3. Uncured sealant may be forced into the slotted side of the seam or joint before shop or field assembly, and the joint or seam completed while the sealant is still uncured. Excess sealant shall be removed from both the inside and outside of the duct before it sets.
4. Duct Tape - Use of duct tape alone for sealing ductwork is prohibited. Duct tape may be used primarily for the purpose of retaining the uncured duct sealant in seams and joints until it has cured. Duct tape shall not be applied to the inside of any duct nor shall it be applied to standing type joints at any time. All duct tape used shall be compatible with the sealant.
5. Sealant shall be either in liquid form or a mastic with a maximum flame spread of 25 and a maximum rate of fuel contributed and smoke developed of 50 when tested in accordance with ASTM E84, NFPA 255 and UL 723.
6. Sealing systems shall be suitable for the environment. The following schedule is to be used to select the sealant.
  - a. Indoor, dry galvanized round and rectangular duct is to be sealed with Iron Grip 601 or equal.
  - b. Indoor, dry, stainless steel, aluminum and PVC coated is to be sealed with FTA 20 adhesive and DT-Tape gypsum or equal.
  - c. All other areas unless otherwise noted are to be sealed with FTA 50 adhesive and DT-Tape gypsum or equal.
  - d. All sealers listed or manufactured by Hardcast Inc. and are to define the type of sealer. Other equal sealants are acceptable.

H. Ductwork Fittings and Accessory Items

1. Duct Elbows - Rectangular ductwork where full radius elbows cannot be installed, provide abrupt elbows equipped with shop-installed hollow, air foil turning vanes.

2. Dampers

- a. Install manual volume control dampers wherever it may be necessary to regulate air volume for system air balancing and where shown on the Drawings.
- b. Install splitter dampers, where shown on the Drawings, to regulate air volume for system air balancing. Splitter dampers shall be single blade, end pivoted type, manual adjustment and position locking arrangement.
- c. Factory-fabricated volume extractors shall be used at all supply air diffusers.
- d. An access door, of ample size to permit maintenance and resetting of damper blades, shall be installed at each opposed blade damper, splitter damper and volume extractor so located for easy access to the damper blades.

I. Grilles, Registers and Diffusers

1. The location of diffusers, registers and grilles shall be as shown on the Reflected Ceiling Plans. Where diffusers, registers and grilles are not located in the ceiling, there are no Reflected Ceiling Plans provided, the location shall be as shown on the ductwork drawings. The exact location of these devices shall be determined in the field in cooperation with the other trades.
2. Install all devices in an approved manner in accordance with the manufacturer's recommendation.

J. Duct Supports Through Floors

1. Where vertical ducts pass through floor openings, rigidly attach supporting angles to the ducts and anchor with expansion bolts to the floor or curb. Angles shall be of the same material as the duct for metal duct and stainless steel for non metallic ducts, placed on the two long sides of the duct extending 3-in over edge of opening, and shall not be less than the sizes recommended by SMACNA. Remaining open areas shall be filled in with a plate of the same material as the angles.

K. Ductwork at Masonry

1. Where ducts connect to, or terminate at masonry openings, or along the edges of floors where concrete curbs are not being provided, place a continuous 2-1/2-in by 2-1/2-in by 3/16-in aluminum angle of the same material as the duct around the ductwork. Then bolt the angle to the construction and make airtight to same by applying caulking compound on the angle before it is drawn down tight to construction.

L. Quality of Ductwork Installation

1. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear, correct by removing, replacing or reinforcing the work. Sound levels shall not exceed the minimum requirement as specified in ASHRAE 1980 Systems Volume, page 35.16, Table 23. No discreet tones will be allowed.
2. The maximum allowable leakage of low pressure system shall be 5 percent of air volume.

M. Test Ports

1. Where shown on the Drawings and where required for testing and balancing, provide instrument insertion ports. Size and location of ports shall be coordinated with the Contractor performing air balancing. Seal ports with plastic snap lock plugs. When the ductwork will be insulated, extend the port to the face of the insulation and seal the vapor barrier to the port. When the ductwork is lined, extend the port into the duct to the inner surface of the duct liner.
2. In round ductwork provide 2 ports 90 degrees on centers. In rectangular ductwork provide ports as required by AABC or NEBB for a full traverse measurement.
3. As a minimum, ports shall be provided in the following connections:
  - a. All duct mains.
  - b. All duct branches unless all connections are diffusers, registers, or grilles and the total can be calculated by summing the readings for all of the connections.
  - c. All connections to tanks or hoods where there is no other access for taking a measurement.
4. A main duct is defined as one of the following:
  - a. A duct serving five or more outlets.
  - b. A duct serving two or more branch ducts.
  - c. A duct emanating from a fan or plenum.
  - d. All remaining ducts are considered branch ducts.

### 3.02 FIELD TESTING

#### A. Testing

1. General - If required by the Engineer, tests shall be made during the progress of the work to demonstrate the strength, durability and fitness of the installation. Furnish all instruments, ladders, lubricants, test equipment and personnel required for the tests; including manufacturer's representatives for testing and start-up of all Contractor supplied equipment. Before testing, all systems shall be cleaned as specified. Submit four printed copies and one electronic copy of records of all tests, measurements, settings of throttling devices and nameplate data to the Engineer. Information shall be in Excel spread sheet format.
2. Final Tests - Perform tests of all systems as required by the Engineer prior to final acceptance of the systems for the purpose of demonstrating satisfactory functional and operating efficiency as well as adjustment. During this period, check the setting of all automatic controls and take sufficient measurements to ensure that conditions are correct and that capacities are adequate to meet the specified requirements. Systems will not be considered complete until all tests have been concluded to the satisfaction of the Engineer and all other parties having jurisdiction. In event of leakage or defects, repeat tests until all faults are corrected. Perform the general operating tests under as near design conditions as possible.
3. Coordination of the test shall be the responsibility of the balancing sub-contractor. Access to the site, availability of service representatives, and tenant acquiescence will be considered in the determination of both the testing schedule and the witnessed recheck of the balancing.

### 3.03 BALANCING

- A. Furnish the necessary labor, materials, instruments, transportation and devices required and test, adjust and balance the total heating-ventilating-cooling systems. Each as specified and detailed herein, or as required to cause the systems to perform in accordance with the intent of the Drawings and this Section. Systems to be tested, adjusted and balanced include air and all other systems installed by the HVAC Contractor.
- B. Testing, balancing and operation of the systems shall be performed by competent and experienced personnel, having formerly done similar work and whose qualifications and performance shall be subject to the approval of the Engineer. Test and balance air system and submit testing and balancing reports to the Engineer for review and approval. Re-balance when required by the Engineer, incorporating all changes and certify the systems have been tested and balanced to meet specified requirements.
- C. The tests shall demonstrate the specified capacities and operation of equipment and materials comprising the systems. Such tests other than as described herein, which are deemed necessary by the Engineer to indicate the fulfillment of the Contract, shall be made.
- D. When the work includes modifications to existing systems, the entire system including existing portions shall be rebalanced. Where capacities of existing components are not shown as changed, the original capacities shall be used for balancing.
- E. Systems serving odorous areas shall be balanced for both flow and pressure as defined herein.
- F. Data required by this Section shall receive complete approval before final payment is made.
- G. If, in the opinion of the Engineer, the Contractor has not, will not, or cannot comply with the testing, balancing and adjusting requirements of this Section, he may advise the Owner to employ a qualified firm to perform such work at Contractor's sole expense.
- H. Membership in the AABC or NEBB for air and water testing is required. The testing balancing contractor shall not be affiliated with the on-site contractors.
- I. The balancing contractor shall be prepared to submit credentials and other evidence of qualifications, and work experience, following receipt of, but prior to award of filed sub-bids.
- J. To perform required professional services, the balancing agency shall have a minimum of two test-and-balance engineers certified by the AABC or NEBB.
- K. This certified test-and-balance engineer shall be responsible for supervision and certification for the total work specified herein.
- L. The balancing agency shall furnish all necessary calibrated instrumentation to adequately perform the specified services. An inventory of all instruments and devices in possession of the balancing agency may be required by the Engineer to determine the balancing agency's performance capability.
- M. A complete schedule of balancing procedures for each of the buildings or systems shall be submitted in sufficient time in advance so that the Engineer might arrange to observe these

procedures as they progress. Before commencing with the balancing of the systems, submit the methods and instruments proposed to be used to adjust and balance the air and water systems.

- N. Fan Characteristics Charts: The HVAC and General Contractors shall provide to the Balancing Organization any required characteristic curve charts for all fans to include air conditioning units and air handling units. Characteristic curve charts shall be not less than 8-1/2-in by 11-in and shall show the static pressure, capacity horsepower and overall efficiency for operating conditions from no load to 130 percent of specified load. The minimum size of the actual fan curve shall be no less than 6-in by 8-in. The use of faxed copies of curves is not acceptable.
- O. The balancing work shall be guaranteed to be accurate and factual data, based on readings in the field. All typewritten data shall be submitted within 14 working days of the performance of the test. Test data shall not be held until final completion, but shall be submitted on an interim basis as soon as the test or appropriate groups of tests are finished.
- P. Furnish gaskets, lubricants and other expendable materials required to be replaced during the execution of this work.
- Q. Fixed-pitched pulleys required for fan adjustments shall be furnished on an exchange basis by the party responsible for the fan installation.
- R. Where test results indicate that air quantities at any system fan are below or in excess of the specified amount, the HVAC and General Contractors, at their own expense, shall change driving pulley ratio or shall make approved changes to obtain the specified or scheduled air quantities.
- S. Testing apparatus: Furnish plugs, caps, stops, valves, pumps, compressors, blowers and similar devices required to perform this work.
  - 1. Furnish anemometers, thermometers, gauges, voltmeters, ammeters, tachometers and similar instruments, not part of the permanent installation, but required to record the performance of the equipment and systems.
  - 2. Testing apparatus, not part of the permanent installation, shall remain the property of the Contractor, but made available to the Engineer.
  - 3. Instruments used for testing shall be certified accurate to within plus or minus 0.10 degrees F for temperature or plus or minus 0.10-in wc for pressure. Calibration of the instruments shall be done within 7 days of testing for this project and henceforth every 30 days thereafter for the duration of the testing period. Certification of calibration shall be submitted to the engineer prior to starting the work.
- T. Testing Reports
  - 1. Forms: Furnish both printed and electronic format test report data on 8-1/2-in by 11-in AABC or NEBB form in accordance with Section (01 30 00) ( 01300). Submit format for recording data and receive approval prior to use.
  - 2. The report shall contain the following general data in a format selected by the balancing agency:
    - a. Project number

- b. Contract number
  - c. Project title
  - d. Project location
  - e. Project architect
  - f. Project mechanical engineer
  - g. Test and balance agency
  - h. Test and balance engineer
  - i. General contractor
  - j. Mechanical subcontractor
  - k. Dates tests were performed
  - l. Certification
3. At a minimum, the report shall include:
- a. Preface. A general discussion of the systems, any abnormalities and problems encountered.
  - b. Instrumentation list. The list of instruments including type, model, manufacturer, serial number and calibration dates.
  - c. System Identification. In each report, the VAV boxes, zones, supply, return and exhaust openings and traverse points shall be numbered and/or lettered to correspond to the numbers and letters used on the report data sheets and on the report diagrams.
4. Furnish both printed and electronic format 11-in by 17-in single line diagrams or 12-in by 18-in half size drawings showing all duct systems indicating all terminal air outlets including diffusers, grilles and registers, perforated plates, nozzles and other types of air supply, exhaust or return outlets. The minimum scale for diagrams showing the measurement points shall be 1/8-in=1-ft-0-in in the final form as submitted. The use of faxed copies of diagrams is not acceptable. Location of test points shown on the diagrams shall be clear and easy to locate on the diagram. The identification mark of the test points shall be the same as is shown on the test report showing the test data. The identification for test points shall include indication of the units served, and shall not have a duplicate in the project. All supply outlets shall be adjusted so that there are no drafts. Grille and register readings may be made by a vane anemometer, but diffuser readings shall be made by a flow hood or a velometer, using the tip recommended by the diffuser manufacturer. Each test sheet shall include the following data:
- a. Job name and address.
  - b. Name of HVAC Contractor.
  - c. Name of balancing organization.
  - d. Instruments used to perform the test.
  - e. Name of test technician or test engineer.
  - f. Fan system and/or zone number.
  - g. Room number or area name.
  - h. Size of outlet.
  - i. Type outlet.
  - j. Manufacturer of outlet.
  - k. The cfm at each outlet on system and corresponding cfm at each outlet as noted on the plans.
  - l. Percent deviation of the measured flow versus the design flow.
  - m. Indication of the branch and terminal that are the open/low that are the basis for balancing the remainder of the system

5. Final balancing shall not begin until system has been installed complete and is capable of normal operation. Provide personnel to assist in rough balance and calibration.
6. All grilles, dampers, fans, and linkages shall be verified to be installed and operating.
7. System shall be capable of operating under control as specified on Drawings and/or contained herein.
8. Verify with straight edge that fan/pump and motor shafts are parallel and that sheaves are in proper alignment.
9. Verify that belts are properly tensioned when unit is operating with no excessive squeal at startup. If not correct, adjust sheaves or motor base accordingly.
10. Start fans, verify that rotation is correct. If rotation is incorrect, coordinate with electrical contractor to switch power leads such that the motor rotates correctly.
11. Check nameplate voltage on motor, compare to scheduled voltage. Notify the Engineer immediately of any discrepancies. Measure and record actual voltage across all power leads. Notify the Engineer of discrepancies immediately.
12. Check motor nameplates full load amps, measure and record amperage across all power leads. If there are marked discrepancies in amperage draws between legs, notify the Engineer immediately.
13. Measure and record fan and motor rpm. Check, that motor rpm agrees with nameplate and scheduled rpm.
14. If, upon commencing the work, the balancing contractor finds that the systems are not ready, or if a dispute occurs as to the readiness of the systems, the balancing agency shall request an inspection to be made by the Engineer. This inspection shall establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for testing and balancing. Should the inspection reveal the notification to have been premature, all costs for the inspection and work previously accomplished by the balancing agency shall be paid for by the General Contractor. Furthermore, such items that are not ready for testing and balancing shall be completed and placed in operational readiness before testing and balancing services shall be recommenced.
15. Leaks, damage and defects discovered or resulting from startup, testing and balancing shall be repaired or replaced to like-new condition with acceptable materials. Tests shall be continued until system operates without adjustments or repairs.
16. Systems shall be balanced to be within the following limits of the capacity shown on the Drawings. Limits shall be applied to both individual components and to the system totals.
  - a. Odorous Exhaust Systems (plus/minus 5 percent)

#### U. HVAC Air Systems

1. Balance the supply return and exhaust air systems in accordance with AABC or NEBB Standards by the use of direct reading instruments such as an "anemotherm" or velometer, which has been properly calibrated.

2. Temporarily add static pressure to the system, to simulate the effect of dirty filters, by blanking off portions of the filter section, covering filter section with cheesecloth or other suitable means. Confirm static has been added with new static pressure reading across fan. Remove cheesecloth, etc, after traverses are complete.
3. The sequence of air balancing shall be as follows:
  - a. First, establish airflow quantity at supply fan by main duct traverse.
  - b. Next, establish airflow quantities in main ducts and branches.
  - c. Finally, establish airflow quantities at outlets, using proportional balancing among branch outlets. All multiple opening systems shall be left with at least one "open low" inlet or outlet, to which all other system openings shall be proportionally balanced. The "open low(s)" on each system shall be indicated in the report.
  - d. After all outlets are adjusted to within the tolerances specified elsewhere in this Section, re-measure all system outlets, and re-traverse all branch and main ducts to establish final "as balanced" flows.
  - e. All main air ducts shall be traversed, using a Pitot tube and manometer. The manometer shall be calibrated to read two significant figures in all velocity pressure ranges. The static pressure reading at the traverse point shall be recorded for each successive traverse.
    - 1) A main duct is defined as either of the following:
      - a) A duct serving five or more outlets.
      - b) A duct serving two or more branch ducts.
      - c) A duct emanating from a fan or plenum.
    - 2) All other ducts are branch ducts.
    - 3) The intent of this operation is to measure by traverse, the total air quantity handled by the fan and to verify the distribution of air to zones and to adjust system pressure to minimum level required to satisfy the farthest air outlet.
  - f. Adjust fan speeds if results of system capacity tests are not within tolerances specified and repeat Paragraphs 3.04A4c, d and e above, as required.
  - g. Mark all final balancing damper positions with a permanent marker.
  - h. For systems which modulate between different flow modes (e.g., minimum outside air to 100 percent outdoor air or 100 percent return air to 100 percent exhaust) measure and report system flow under both extremes of modulation and check for excessive system flow deviation above design, when system is modulating between its end points.
  - i. Furnish both printed and electronic format data tabulating the following:
    - 1) Opening number, type, size and design flow rate.
    - 2) Quantity of air in cfm at each air outlet and inlet.
    - 3) Dry bulb temperature in each room.
    - 4) Dry bulb temperature of the supply air.
    - 5) Outdoor dry and wet bulb temperature at the time the above tests are conducted. (Wet bulb temperature only required for AC systems)
  - j. Furnish both printed and electronic format data taken at each air moving device, to include fans, packaged units and air handling units, tabulating the following:
    - 1) Manufacturers, model number and serial number of units.
    - 2) All design and manufacturer's rated data.
    - 3) Total quantity of supply air in cfm.
    - 4) Total quantity of return air in cfm.
    - 5) Total quantity of exhaust or relief air in cfm.
    - 6) Total quantity of outside air in cfm.
    - 7) Outlet velocity - fpm.

- 8) The rpm of each fan or blower.
  - 9) Maximum tip speed - fpm.
  - 10) The rpm of each motor.
  - 11) Voltage and ampere input of each motor (one reading for each phase leg on 3 phase motors).
  - 12) Pressure in inches w.g. at inlet of each fan or blower.
  - 13) Pressure in inches w.g. at discharge of each fan or blower.
  - 14) Pressure drops across system components such as louvers,
  - 15) Submit the actual fan operating point on a copy of the fan shop drawing showing operating curve. List the following data from all fan motors installed.
  - 16) Manufacturer model and size.
  - 17) Motor horsepower, service factor and rpm.
  - 18) Volts, phases, cycles and full load amps.
  - 19) Equipment locations.
4. Odorous Areas - Meter Pit
- a. In odorous areas the following additional procedures shall be used in addition to those all ready described.
  - b. Odorous areas shall be those areas that are exhausted to odor control system, odor control dispersion stacks, or specifically noted as odorous areas.
  - c. Balance the exhaust system to the flows shown on the Drawings. Balance the space to maintain a 0.05 -in w.g. positive pressure relative to the surrounding areas by adjusting the supply air to the space. If the final supply air quantity is below the flow specified, use this flow and pro-rate it for the various supply air devices, on an equal percentage basis.
  - d. Balancing shall be done with all doors to the area closed and all interrelated systems operating.
  - e. After completion of the system balancing the space negative pressures shall be rechecked. If the negative pressures have been reduced, the systems shall be rebalanced to provide the specified negative pressures. This process shall be repeated until the negative pressures are maintained.
  - f. In addition to the data required above, the following shall be included for odor control systems.
    - 1) Required pro-rating of supply systems if any.
    - 2) Differential pressure between the odorous space and all adjacent spaces and the outdoors.]
- V. Where systems are provided with standby equipment, the system shall be balanced for operation in standby as well as normal operation.
- W. Final Acceptance
1. At the time of final inspection, the balancing agency shall recheck, in the presence of the Engineer, specific and random selections of data recorded in the certified test-and-balance report.
  2. Points and areas for recheck shall be selected by the Engineer.
  3. Measurements and test procedures shall be the same as the original test and balance.

4. Selections for recheck, specific plus random, shall not normally exceed 15 percent of the total number tabulated in the report, except where special air systems require a complete recheck for safety reasons.
5. If the specific rechecks are more than 5 percent deviation from the report or specified flows, all of the systems, that require specific recheck, shall be rebalanced. If 5 percent or 5 of the random checks, which ever is less, exceeds a 10 percent deviation from the specified flows, the report shall be rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, a new certified test-and-balance report submitted, and a new inspection test made, all at no additional cost to the Owner.

#### 3.04 START-UP AND TEMPORARY OPERATION

- A. Properly maintain and service all equipment and systems until the particular equipment or the system has been accepted by the Owner.

#### 3.05 BALANCING OF ROTATING EQUIPMENT

- A. All machines shall be balanced both statically and dynamically by the manufacturer within the limits of best commercial practices. The term machine, as used above, is to be considered as any piece of equipment, which contains rotating components. All machines furnished shall have operating speed not exceeding 80 percent of the first critical speed.

#### 3.06 CLEANING

- A. Leave all ductwork and equipment in a thoroughly cleaned condition.
- B. Maintain all ductwork, fans, coils, air filters, outlets and other parts of the ductwork systems in a clean condition during installation.
- C. Clean complete ductwork systems prior to testing and air balancing. Secure cheese cloth over all openings of the ductwork system for entrapment of dirt during the cleaning operation.

END OF SECTION

SECTION 16020  
ELECTRICAL

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials and equipment required to install complete and make operational, electrical and process instrumentation systems as specified, as shown on the Drawings.
- B. The work shall include furnishing and installing the following:
  - 1. Relocation and reconnection of electrical service from the Power Company as indicated on drawings.
  - 2. Conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions of these Specifications.
  - 3. Conduit, wiring and terminations for all field-mounted instruments furnished and mounted under other Divisions of these Specifications, including process instrumentation primary elements, transmitters, local indicators and control panels. Lightning and surge protection equipment wiring at process instrumentation transmitters. Install vendor furnished cables specified under other Divisions of these Specifications.
  - 4. Conduit, wiring and terminations for variable frequency drives furnished and mounted under other Divisions of these Specifications.
  - 5. Mount variable frequency drives furnished under other sections of these specifications.
  - 6. Power wiring for all ventilating equipment furnished under other Divisions of these Specifications
  - 7. Furnish and install precast handhole..
  - 8. Furnish and install .handhole frame and cover.
  - 9. Grounding System
  - 10. Underground System
- C. Excavation, bedding material, forms, concrete and backfill for underground raceways; forms and concrete for electrical equipment furnished under Division 16. The work shall be in accordance with Divisions 2 and 3.

1.02 RELATED WORK

- A. Excavation and backfilling, including gravel or sand bedding for underground electrical work is included in Division 2.

- B. Cast in place concrete work, including concrete encasements for electrical duct banks, equipment pads, light pole bases and reinforcing steel, is included in Division 3.
- C. Except for directly controlled, single phase, all interlocking and termination wiring within the motor starter/motor control centers, and ventilating equipment (duct switches, P-E switches, dampers, etc) will be furnished and installed under Division 15, unless otherwise indicated on the Drawings.
- D. Refer to the Structural plans for room dimensions.
- E. Refer to HVAC Drawings for the exact location of mechanical and instrumentation equipment.

#### 1.03 SUBMITTALS

- A. Submit, in accordance with MAG Uniform Standard Specification - Section 105, shop drawings and product data showing materials of construction and details of installation for:
  - 1. Shop drawings, showing sizes of members, method of assembly, anchorage and connection to other members.
- B. Check shop drawings for accuracy and contract requirements prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to Specifications and Drawings. This statement shall also list all exceptions to the Specifications and Drawings. Shop drawings not so checked and noted shall be returned.
- C. The Engineer's check shall be for conformance with the design concept of the project and compliance with the Specifications and Drawings. Errors and omissions on approved shop drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by the Specifications and Drawings.
- D. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.
- E. 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."
- F. Operation and Maintenance Data
  - 1. Submit operations and maintenance data for equipment furnished under this Division. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc, to instruct operating and maintenance personnel unfamiliar with such equipment.

#### 1.04 CONTRACT PERFORMANCE REQUIREMENTS

- A. Electric equipment, materials and installation shall comply with the latest edition of the National Electrical Code (NEC) and with the latest edition of the following codes and standards:
  - 1. National Electrical Safety Code (NESC)
  - 2. Occupational Safety and Health Administration (OSHA)

3. National Fire Protection Association (NFPA)
  4. National Electrical Manufacturers Association (NEMA)
  5. American National Standards Institute (ANSI)
  6. Insulated Cable Engineers Association (ICEA)
  7. Instrument Society of America (ISA)
  8. Underwriters Laboratories (UL)
  9. Factory Mutual (FM)
  10. National Electrical Testing Association (NETA)
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

#### 1.05 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

#### 1.06 ENCLOSURE TYPES

- A. Unless otherwise specified electrical enclosures shall have the following ratings:

1. NEMA 1 for dry, non-process indoor above grade locations.
2. NEMA 3R for outdoor non-corrosive or hazardous areas.
3. NEMA 7 for areas rated "Class I Div. 1 Group D."

#### 1.07 SERVICE AND METERING

- A. The power company serving this project is Salt River Project (SRP). Service will be obtained at 120/240-Volts, 1-Phase, 3-Wire, 60 Hz from a pole mounted transformer.

#### 1.08 HAZARDOUS AREAS

- A. Equipment, materials and installation in areas designated as hazardous shall comply with National Electrical Code Articles 500, 501, 502 and 503.
- B. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.

#### 1.09 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.

#### 1.10 TESTS AND SETTINGS

- A. Test systems and equipment furnished under Division 16 and repair or replace all defective work and equipment. Refer to the individual equipment sections for additional specific testing requirements.
- B. Make adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.
- C. In addition to the specific testing requirements listed in the individual sections, the following minimum tests and settings shall be performed.
  1. Mechanical inspection, testing and settings of circuit breakers, disconnect switches, protection relays, motor starters, overload relays, control circuits and equipment for proper operation.
  2. Check the full load current draw of each motor. Where power factor correction capacitors are provided the capacitor shall be in the circuit at the time of the measurement. Check ampere rating of thermal overloads for motors and submit a typed record to the Engineer of the same, including MCC cubicle location and driven load designation, motor service factor, horsepower, and Code letter. If incorrect thermal overloads are installed replace same with the correct size overload.
  3. Check power and control power fuse ratings. Replace fuses if they are found to be of the incorrect size.

4. Check settings of the motor circuit protectors. Adjust settings to lowest setting that will allow the motor to be started when under load conditions.
  5. Check motor nameplates for correct phase and voltage. Check bearings for proper lubrication.
  6. Check rotation of motors prior to testing the driven load. Disconnect the driven equipment if damage could occur due to wrong rotation. If the rotation is for the driven equipment is not correct, disconnect the motor lead connections at the motor terminal box and reconnect for proper rotation.
  7. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by control schematic and wiring diagrams.
  8. Inspect each piece of equipment in areas designated as HAZARDOUS to insure that equipment of proper rating is installed.
  9. Verify all terminations at transformers, equipment, panels and enclosures by producing a 1, 2, 3 rotation on a phase sequenced motor when connected to "A," "B" and "C" phases.
  10. Test the grounding system using the three point fall in potential method.
  11. Test all 600 Volt wire insulation with a meg-ohm meter after installation. Make tests at not less than 500V. Submit a written test report of the results to the Engineer.
  12. Assist in the testing of the standby generator and automatic transfer switch. A licensed electrician shall be standing throughout the test perform make adjustments to or test the equipment furnished under this Division of the specifications and to open electrical enclosures.
- D. Testing shall be scheduled and coordinated with the Construction Manager at least two weeks in advance. Provide qualified test personnel, instruments and test equipment.

#### 1.11 SIZE OF EQUIPMENT

- A. Investigate each space in the structure through which equipment 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 insure that the tilting does not impair the functional integrity of the equipment.

#### 1.12 RECORD DRAWINGS

- A. As the work progresses, legibly record all field changes on a set of project contract drawings, hereinafter called the "record drawings."
- B. Record drawings shall accurately show the installed condition of the following items:
  1. One-line Diagram(s).

2. Raceways and pullboxes.
  3. Conductor sizes and conduit fills.
  4. Panel Schedule(s).
  5. Control Wiring Diagram(s).
  6. Lighting Fixture Schedule(s).
  7. Lighting fixture, receptacle and switch outlet locations.
  8. Underground raceway and duct bank routing.
  9. Plan view, sizes and locations of distribution transformers and panelboards.
- C. Submit a schedule of control wiring raceways and wire numbers, including the following information:
1. Circuit origin, destination and wire numbers.
  2. Field wiring terminal strip names and numbers.
- D. As an alternate, point-to-point connection diagrams showing the same information may be submitted in place of the schedule of control wiring raceways and wire numbers.
- E. Submit the record drawings and the schedule of control wiring raceways and wire numbers (or the point-to-point connection diagram) to the Owner.

#### 1.13 EQUIPMENT INTERCONNECTIONS

- A. Review shop drawings of equipment furnished under other Divisions of this Specification and prepare coordinated wiring interconnection diagrams or wiring tables. Submit copies of wiring diagrams or tables with Record Drawings.
- B. Furnish and install all equipment interconnections.

#### 1.14 MATERIALS AND EQUIPMENT

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

#### 1.15 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.

#### 1.16 INTERPRETATION OF DRAWINGS

- A. Unless specifically stated to the contrary, the Drawings are not intended to 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. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.
- 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. Unless otherwise indicated install branch circuit conduits exposed in process/industrial type spaces and concealed in finished spaces.
- 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 necessary 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. It is the intent of these Specifications that the Electrical Systems shall be suitable in every way for the service required. All materials and all work that may be implied as being incidental to the work of this Section shall be furnished at no additional cost to the Owner.

#### PART 2 PRODUCTS

2.01 CONDUITS AND FITTING

A. Rigid Steel Conduit

1. Rigid steel conduit interior and exterior shall be hot-dipped galvanized and be as manufactured by the Allied Tube and Conduit Corp.; Wheatland Tube Co.; Triangle PWC Inc. or equal.

B. PVC Coated Rigid Steel Conduit

1. PVC coated rigid steel conduit shall have a minimum 0.040-in thick, polyvinyl chloride coating permanently bonded to hot-dipped galvanized steel conduit and an internal chemically cured urethane or enamel coating. The ends of all couplings, fittings, etc, shall have a minimum of one pipe diameter in length of PVC overlap. PVC conduit and fittings shall be manufactured by Occidental Coating Company; "Plasti-Bond Red" as manufactured by Robroy Industries; Triangle PWC Inc. or equal.

C. Rigid Aluminum Conduit

1. Rigid aluminum conduit shall be 6063 alloy and shall be as manufactured by New Jersey Aluminum Corp.; AFC Co.; VAW of America, Inc. or equal.

D. Intermediate Metal Conduit

1. Intermediate metal conduit shall be hot-dipped or electro-galvanized steel as manufactured by Allied Tube and Conduit Corp.; Triangle PWC Inc.; Wheatland Tube Co. or equal.

E. Rigid Nonmetallic Conduit

1. PVC conduit shall be rigid polyvinyl chloride schedule 40 and 80 as manufactured by Carlon; An Indian Head Co.; Kraloy Products Co., Inc.; Highland Plastics Inc. or equal.

F. Liquidtight Flexible Metal Conduit, Couplings and Fittings

1. Liquidtight flexible metal conduit shall be Sealtite, Type UA, manufactured by the Anaconda Metal Hose Div.; Anaconda American Brass Co.; American Flexible Conduit Co., Inc.; Universal Metal Hose Co. or equal.
2. Fittings used with liquidtight flexible metal conduit shall be of the screw-in type as manufactured by the Thomas & Betts Co.; Crouse-Hinds Co. or equal.

G. Flexible Couplings

1. Flexible couplings shall be type ECGJH as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; Killark Electric Manufacturing Co. or equal.

H. Boxes and Fittings

1. Pressed steel switch and outlet boxes shall be hot-dipped galvanized as manufactured by the Raco Manufacturing Co.; Adalet Co.; O.Z. Manufacturing Co. or equal.

2. For use in NEMA 1 areas, terminal boxes, junction boxes, pull boxes etc, shall be galvanized sheet steel with continuously welded seams. 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. Covers shall be gasketed and fastened with stainless steel screws. 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. Boxes shall be as manufactured by Hoffman Engineering Co.; Lee Products Co.; Keystone/Rees, Inc. or equal.
3. NEMA 4 terminal boxes, junction boxes, pull boxes, etc, shall be sheet 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 have a continuous gasket on all four sides and be fastened with stainless steel clamps. Terminal boxes shall be furnished with hinged doors, terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20 Amp, 600 Volt. Boxes shall be as manufactured by Hoffman Engineering Co.; Lee Products Co.; Keystone/Rees, Inc. or equal.
4. NEMA 4X terminal boxes, junction boxes and pull boxes shall be fiberglass reinforced plastic with stainless steel hardware and covers having a continuous gasket on all four sides. 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. Boxes shall be as manufactured by Hoffman Engineering Co.; Lee Products Co.; Keystone/Rees, Inc. or equal.
5. Explosion-proof boxes shall be designed for Class 1, Group D, Division 1 hazardous locations. They shall be cast iron with cadmium-zinc or hot-dipped galvanized finish, stainless steel or hot-dipped galvanized bolts; Type EJB as manufactured by the Crouse-Hinds Company; Appleton Electric Co.; The Pyle-National Co. or equal.
6. All boxes and fittings used with PVC coated conduit shall be furnished with a PVC coating bonded to the metal, the same thickness as used on the coated steel conduit. The ends of couplings and fittings shall have a minimum of one pipe diameter PVC overlap to cover threads and provide a seal.
7. Cast or malleable iron device boxes shall be Type FD. All cast or malleable iron boxes and fittings shall have cadmium-zinc finish with cast covers and stainless steel screws as manufactured by the Crouse-Hinds Co. or equal.
8. Cast aluminum device boxes shall be Type FD. All cast aluminum boxes and fittings shall be copper-free aluminum with cast aluminum covers and stainless steel screws as manufactured by the Killark Electric Co.; Crouse-Hinds Co.; L. E. Mason Co. or equal.
9. Steel elbows and couplings shall be hot-dipped galvanized. Elbows and couplings used with PVC coated conduit shall be furnished with a PVC coating bonded to the steel, the same thickness as used on the coated steel conduit.
10. Conduit hubs shall be as manufactured by Myers Electric Products, Inc. or equal.

11. Conduit wall and floor seals for sleeved openings shall be type CSMI as manufactured by the O.Z./Gedney Co. or equal.
12. Explosion proof fittings shall be as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; O.Z./Gedney Co. or equal.
13. Conduit sealing bushings shall be O.Z./Gedney Type CSB or equal.
14. Combination expansion-deflection fittings embedded in concrete shall be Type XD as manufactured by Crouse-Hinds Co.; Type AXDX as manufactured by O.Z./Gedney Co. Type DF as manufactured by Appleton Electric Co. or equal.
15. Combination expansion-deflection fittings installed exposed shall be Type XD as manufactured by Crouse-Hinds Co.; Type AXDX as manufactured by O.Z./Gedney Co. Type DF as manufactured by Appleton Electric Co. or equal.

I. Conduit Mounting Equipment

1. In dry indoor areas, hangers, rods, backplates, beam clamps, channel, etc. shall be galvanized iron or steel.
2. PVC coated steel channel with stainless steel hardware shall be used in areas designated "WET" and "CORROSIVE" on the Drawings and in outdoor locations. Fiberglass channel shall be resistant to the chemicals present in the area in which it is used.

J. Wall and Floor Slab Opening Seals

1. Wall and floor slab openings shall be sealed with "FLAME-SAFE" as manufactured by the Thomas & Betts Corp.; Pro Set Systems; Neer Mfg. Co.; Specified Technologies, Inc. or equal.

K. Cold Galvanizing Compound

1. Cold galvanizing compound shall be as manufactured by ZRC Products Company, a division of Norfolk Corp. or equal.

2.02 WIRE, CABLE AND ACCESSORIES

- 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 for lighting, receptacles and other circuits not exceeding 150 Volts to ground shall be NEC Type THHN/THWN as manufactured by Okonite Co.; Southwire Co.; Pirelli Corp., or equal.
- E. Wire for circuits over 150 Volts to ground shall be NEC type THHN/THWN for sizes up to No. 4/0 AWG and Type RHW for sizes greater than No. 4/0 AWG as manufactured by Okonite Co.; Southwire Co., or equal.

- F. Wire for control, status and alarm circuits shall be No.14 AWG NEC type THHN/THWN, stranded as manufactured by the Okonite Co.; Carol Cable Co. Inc. West; Pirelli Cable Corp. or equal.
- G. Multi-conductor control and power cables shall have stranded conductors with type THHN/THWN insulated, nylon conductor covering, and an overall PVC jacket covering the individual wires. Cable shall be TC rated meeting UL 1277 and IEEE 383 Standards. Cable shall be flame resistant, non-propagating and suitable for installation in a Class I, Division II hazardous location and for direct burial in earth. Power and control cables shall be furnished with a green ground conductor. Power cables shall be furnished with a white neutral conductor where required to serve phase to neutral loads. Cable shall be as manufactured by the Okonite Co.; Southwire Co.; General Cable Co., or equal.
- H. Wire for process instrumentation signals (i.e., 1-5 VDC, 4-20 mA), 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: PVC with 300 Volt, 105 degrees C rating
    - c. Shield: 100 percent mylar tape with drain wire
    - d. Jacket: PVC with UL Subject 13, UL 1581, and manufacturer's identification
    - e. Max overall diameter: 0.262-in
    - f. Miscellaneous: UL listed for underground wet location use
    - g. Manufacturers: Belden No. 1030 or equal
  - 2. Three conductor (triad) cable:
    - a. Conductors: 3- No.16 stranded and twisted on 2-in lay
    - b. Insulation: PVC with 300 Volt, 105 degrees C rating
    - c. Shield: 100 percent mylar tape with drain wire
    - d. Jacket: PVC with UL Subject 13, UL 1581 and manufacturer's identification
    - e. Max overall diameter: 0.276-in
    - f. Miscellaneous: UL listed for underground wet location use
    - g. Manufacturers: Belden No. 1031 or equal
  - 3. Multiple pair cables (where shown on the Drawings):
    - a. Conductor: multiple 2- No.22 stranded and twisted on a 2-in lay
    - b. Insulation: PVC with 300 Volt, 105 degrees C rating
    - c. Shield: Individual pairs shielded with 100 percent mylar tape and drain wire
    - d. Jacket: PVC with UL Subject 13, UL 1581 manufacturer's identification
    - e. Miscellaneous: UL listed for underground wet location use
    - f. Manufacturers: Belden No. 9330, 9331, 9332, 9333, 9334, 9335, 9336, 9337 or equal
- I. Splices for power wiring shall be compression type connectors insulated with a heat shrink boot or outer covering and epoxy filling. Splice kits shall be as manufactured by Raychem; Ideal Industries; 3M Co. or equal.
- J. 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 or equal.

- K. Termination connectors for control wiring shall be of the locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.
- L. Splices for control wiring shall be insulated compression type connectors of the expanded vinyl insulated parallel or pigtail type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.
- M. Termination connectors for shielded instrumentation wiring shall be of the locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.
- N. Wire markers shall be "Omni-Grip" as manufactured by the W.H. Brady Co.; Thomas & Betts Co.; 3M Co. or equal.
- O. 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. or equal.

## 2.03 WIRING DEVICES

- 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 of the following types and manufacturer:
  - 1. Single pole, 20 Amp, 120/277 Volt - Arrow-Hart, Catalog No. 1991, or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
  - 2. Double pole, 20 Amp, 120/277 Volt - Arrow-Hart, Catalog No. 1992, or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
  - 3. Three way, 20 Amp, 120/277 Volt - Arrow-Hart, Catalog No. 1993, or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
  - 4. Four way, 20 Amp, 120/277 Volt - Arrow-Hart, Catalog No. 1994, or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
  - 5. Explosion-proof single pole factory sealed switches shall be for 20 Amps, 120/277 Volts, mounted in copper free aluminum or malleable iron cast boxes and be similar and equal to Crouse-Hinds EDS Series, or equal by Appleton Electric Co. or Killark.
- B. Receptacles shall be heavy duty, specification grade of the following types and manufacturer or equal. Receptacles shall conform to Federal Specification WC596-F.
  - 1. Duplex, 20 Amp, 125 Volt, 2P, 3W; Arrow-Hart, Catalog No. 5362, or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc.
  - 2. Weatherproof/corrosion resistant single, 20 Amp, 125 Volt, 2P, 3W, with cover; Crouse-Hinds Co., Catalog No. WLRS-5-20, or equal by Appleton Electric.
  - 3. Weatherproof/corrosion resistant duplex, 20 Amp, 125 Volt, 2P, 3W, with cover; Crouse-Hinds Co., Catalog No. WLRD-5-20 or equal by Appleton Electric.

4. Ground fault interrupter, duplex, 20 Amp, 125 Volt, 2P, 3W, GFCI feed thru type with "test" and "reset" buttons. Arrow-Hart, Catalog No. GF5342 or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
5. Single, "power lock," 20 Amp, 125 Volt, 2P, 3W; Arrow-Hart, Catalog No. 23030 and plug Arrow-Hart, Catalog No. 23035N or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
6. Single, 20 Amp, 250 Volts, 2P, 3W; Arrow-Hart, Catalog No. 5861 or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
7. Single twist-lock, 20 Amp, 250 Volts, 2P, 3W; Arrow-Hart, Catalog No. 6210; plug: Arrow-Hart, Catalog No. 6212 or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
8. Single twist-lock, 30 Amp, 250 Volts, 2P, 3W; Arrow-Hart, Catalog No. 6340; plug: Arrow-Hart, Catalog No. 6342 or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.
9. Explosion-proof single, 20 Amp, 125 Amp, 2P, 3W; Appleton Electric, Catalog No. CPCI-2350 and plug, Appleton Electric, Catalog No. CPP-2033 or equal by Crouse-Hinds; Harvey Hubbell Inc.
10. Explosion-proof duplex, 20 Amp, 125 Volt, 2P, 3W; Appleton Electric, Catalog No. CPC2-2350 and plug, Appleton Electric, Catalog No. CPP-2023 or equal by Crouse-Hinds; Harvey Hubbell, Inc.

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 to 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, or equal.
3. Oversized plates shall be installed where standard plates do not fully cover the wall opening.
4. Device plates for switches mounted outdoors or indicated as weatherproof shall be gasketed, cast aluminum with provisions for padlocking switches "On" and "Off," Crouse Hinds, No. DS185, or equal.
5. Multiple surface mounted devices shall be ganged in a single, common box and provided with an adapter, if necessary, to allow mounting of single gang device plates on multigang cast boxes.

6. Engraved device plates shall be provided where required.
7. Weatherproof, gasketed cover for GFI receptacle mounted in a FS/FD box shall be Arrow-Hart, Catalog No. 4501-FS or equal by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.

D. Three Phase Power Receptacles

1. Three phase power receptacles and plugs shall be rated for the voltage and current ratings of the connected load or as specified.
2. Receptacles and plug housings shall be constructed of stainless steel listed to UL 498 for watertight construction. Hardware shall be stainless steel.
3. Performance
  - a. Maximum working voltage: 600 Volts RMS.
  - b. Dielectric withstand voltage: 3000 Volts.
  - c. Full load break capability at rated current.
  - d. 5000 connect/disconnect cycles at rated voltage and current.
4. Furnish and install one mating plug with each receptacle.
5. Provide the following features:
  - a. Color coded by voltage.
  - b. One piece housing/angled backbox
  - c. Shrouded pins
  - d. Self closing gasketed cover.
  - e. Watertight cable entrances/stress relief grips.
  - f. Mating keys.
6. Acceptable manufacturers:
  - a. Hubbell (North American Rated Series II)
  - b. General Electric
  - c. Arrow-Hart

E. Interlocked Three Phase Power Receptacles

1. Interlocked three phase power receptacles shall include a combination receptacle and a mechanically interlocked disconnect switch. The two units shall be interlocked to prevent removal or insertion of the plug unless the switch is in the OFF position.
2. Provide a matching plug for every unit furnished.
3. Switch, power receptacle and mating plug shall be constructed of stainless steel.
4. Assemble shall be listed to UL 498 for watertight-construction.
5. Hardware shall be stainless steel.
6. Performance:
  - a. Maximum working voltage: 600 Volts RMS.

- b. Dielectric withstand voltage: 3000 Volts.
  - c. Full load break capability at rated current.
  - d. 5000 connect/disconnect cycles at rated voltage and current.
7. Provide the following features:
    - a. Color coded by voltage.
    - b. One piece housing/angled backbox
    - c. Shrouded pins
    - d. Self closing gasketed cover.
    - e. Watertight cable entrances/stress relief grips.
    - f. Mating keys.
  8. The disconnect switch shall be unfused with ratings as herein before specified. Provide lockout provisions on the disconnect switch handle.
  9. Acceptable manufacturers:
    - a. Crouse-Hinds
    - b. Appleton
    - c. Killark
    - d. Hubbell

## 2.04 MISCELLANEOUS EQUIPMENT

### 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.
2. NEMA 7 enclosures shall be cast aluminum.
3. Switches shall be as manufactured by the Square D Co.; Cutler Hammer Co.; General Electric Company; Siemens Company or equal.

### B. Control Relays

1. Control relays shall be heavy duty machine tool type, with 10 Amps, 300 Volt convertible contacts. Number of contacts and coil voltage shall be as shown on the Drawings. General use relays shall be General Electric Co., Catalog No. CR120B or equal by Square D Co. or Allen-Bradley Co. Latching relays shall be General Electric Co., CR120BL, equal by Square D Co. or Allen-Bradley Co.
2. Time delay relays shall be pneumatic, 600 Volt, 20 Amp contacts, with calibrated knob operated adjustment. On delay and off delay types and timing ranges shall be as shown on the Drawings. Relays shall be Agastat, Model 7012 or 7022 or equal.

### C. Polyethylene Warning Tape

1. Warning tape shall be red polyethylene film, 6-in minimum width.
2. Warning tape shall be W.H. Brady Co., Catalog No. 91296 or equal.

D. Circuit Breakers

1. Panelboards shall be equipped with circuit breakers.
2. Circuit breakers shall be molded case, bolt-in type.
3. Each circuit breaker used in 120/240 Volt panelboard shall have an interrupting capacity of not less than 10,000 amperes, RMS symmetrical.
4. Circuit breakers shall be as manufactured by the panelboard manufacturer.

2.05 UNDERGROUND SYSTEM

- A. Excavation and backfilling, including gravel and sand bedding, are included in Division 2.
- B. All trenching and surface restoration shall be as specified in Division 2, but the responsibility of furnishing and installing the material shall be that of this Section.
- C. Handholes shall be precast concrete, heavy-duty type, designed for a Class H-20 wheel load and conform to ASTM C478. Precast units shall be as manufactured by Chase Precast Corp.; American Precast Co. or equal and constructed to dimensions as shown on the Drawings.
- D. Handhole frames and covers shall be cast iron, heavy duty type for Class H-20 wheel loading.

2.06 GROUNDING

- A. 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 or equal.
- B. Grounding conduit hubs shall be malleable iron type similar to Thomas & Betts Co.; Cat No. 3940 (3/4-in conduit size) by Burndy; O.Z./Gedney Co. or equal, and of the correct size for the conduit.
- C. Waterpipe ground clamps shall be cast bronze saddle type, similar to Thomas & Betts Co. Cat. No. 2 (1/2-in, 3/4-in, or 1-in size) or equal by Burndy; O.Z./Gedney Co. or equal, and of the correct size for the pipe.
- D. Buried grounding connections shall be by Cadweld process, or equal exothermic welding system.

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 necessary 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.
- D. Seal all openings, sleeves, penetration and slots.

### 3.02 INSTALLATION

- A. Any work not installed according to the Specifications shall be subject to change as directed by the Engineer. No extra compensation will be allowed for making these changes.
- B. Electrical equipment shall be protected at all times against mechanical injury or damage by water. Electrical equipment shall not be stored outdoors. Electrical equipment shall be stored in dry permanent shelters. Do not install electrical equipment in its permanent location until structures are weather-tight. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and tested as directed by the Engineer, or shall be replaced at no additional cost at the Engineer's discretion.
- C. Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion.
- D. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer.
- E. Coordinate the conduit installation with other trades and the actual supplied equipment.
- F. Install each 3 phase circuit in separate conduit.
- G. Unless otherwise approved by the Engineer, conduit installed interior to the building shall be installed exposed; conduit installed exterior to the building shall be concealed.
- H. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
- I. Exact locations of electrical equipment 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.

### 3.03 BOXES AND FITTINGS

- A. Except where otherwise specified, all wiring shall be in rigid steel conduit.
- B. Rigid steel conduit shall be used at all locations (underground and within structures) as raceways for shielded process instrumentation wiring, shielded control wiring, and I/O wiring.
- C. PVC coated rigid steel conduit shall be used in areas designated "CORROSIVE."
- D. PVC conduit shall be used for concrete encased underground duct banks.

- E. Aluminum conduit shall be used for exposed conduit runs outdoors, in areas designated as "WET" or "Class 1, Div. 1."
- F. All boxes shall be metal.
- G. Exposed switch, receptacle and lighting outlet boxes and conduit fittings shall be cast or malleable iron, except that cast aluminum shall be used with aluminum conduit.
- H. Concealed switch, receptacle and lighting outlet boxes shall be pressed steel.
- I. Terminal boxes, junction boxes and pull boxes shall have NEMA ratings suitable for the location in which they are installed.
- J. Conduit wall seals shall be used where underground conduits penetrate walls.
- K. Conduit sealing bushings shall be used to seal conduit ends exposed to the weather.
- L. 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 or directed.
- M. No wire shall be pulled until the conduit system is complete in all details.
- N. The ends of all conduits shall be tightly plugged to exclude dust and moisture during construction.
- O. Conduit supports, other than for underground raceways, shall be spaced at intervals of 8-ft or less.
- P. Conduit hangers shall be attached to structural steel by means of beam or channel clamps. Where attached to concrete surfaces, concrete inserts of the spot type shall be provided.
- Q. All conduits shall be run at right angles to and parallel with the surrounding wall and shall conform to the form of the ceiling. No diagonal runs will be allowed. Bends in parallel conduit runs shall be concentric. All conduits shall be run perfectly straight and true.
- R. Conduit terminating in pressed steel boxes shall have double locknuts and insulated bushings.
- S. Conduit terminating in NEMA 3R, 4, 4X and 12 enclosures shall be terminated with Myers type conduit hubs.
- T. Conduits containing equipment grounding conductors and terminating in sheet steel boxes shall have insulated throat grounding bushings.
- U. Conduits shall be installed using threaded fittings.
- V. Liquidtight 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.
- W. Flexible couplings shall be used in hazardous locations for all motor terminations and other equipment where vibration is present.

- X. Aluminum fittings and boxes shall be used with aluminum conduit. Aluminum conduit shall not be imbedded in concrete. Aluminum conduit shall be isolated from other metals with plastic sleeves or plastic-coated hangers. Strap wrenches shall be used for tightening aluminum conduit.
- Y. Where conduits pass through openings in walls or floor slabs, the remaining openings shall be sealed against the passage of flame and smoke.
- Z. PVC conduit to non-metallic box connections shall be made with PVC socket to male thread terminal adapters with neoprene O-ring and PVC round edge bushings.
- AA. Conduit ends exposed to the weather shall be sealed with conduit sealing bushings.
- AB. Conduit sealing and drain fittings shall be installed in areas designated as NEMA 7.
- AC. 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.
- AD. 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 N.E.C. Article 370.
- AE. Miscellaneous steel for the support of fixtures, boxes, transformers, starters, contactors, panels and conduit shall be furnished and installed.
- AF. Steel channels, flat iron and channel iron 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.
- AG. Conduits passing from heated to unheated spaces, exterior spaces, refrigerated spaces, cold air plenums, etc, shall be sealed with "Duxseal" as manufactured by Manville or seal fitting to prevent the accumulation of condensation.
- AH. Rigid galvanized steel conduits which have been field cut and threaded shall be painted with cold galvanizing compounds.
- AI. Conduit expansion and deflection fittings shall be installed on all conduits crossing building expansion joint. Where conduits are installed outdoors provide expansion and deflection fittings on all conduits crossing expansion joints or at 200 foot intervals which ever is the least dimension.

#### 3.04 WIRE, CABLE AND ACCESSORIES

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

C. 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, and other accessible intermediate locations as well as at each termination.

D. The following coding shall be used:

System	Wire	Color
240/120 Volts 1-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

E. Power conductors: 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. Aluminum conductors (where specified) shall employ terminations and splices specifically designed for aluminum conductors.

F. 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.

G. 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.

H. Except where permitted by the Engineer no splices will be allowed in manholes, handholes or other below grade located boxes.

I. Splices shall not be made in push button control stations, control devices (i.e., pressure switches, flow switches, etc), conduit bodies, etc.

J. 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.

- K. Terminal blocks shall be provided at all instrument cable junction and all circuits shall be identified at such junctions.
- L. Shielded instrumentation wire, shall be run without splices between instruments, terminal boxes, or panels.
- M. Shields shall be grounded 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.

### 3.05 WIRING DEVICES

- A. Switch and receptacles outlets shall be installed flush with the finished wall surfaces in areas with stud frame and gypboard construction, in dry areas with cement block construction or when raceways are concealed.
- B. Do not install flush mounted devices in areas designated DAMP, WET or WET/CORROSIVE. Provide surface mounted devices in these areas.
- C. Provide weatherproof devices covers in areas designated WET or WET/CORROSIVE.

### 3.06 PANELBOARDS

- A. Connect panelboard branch circuit loads so that the load is distributed as equally as possible between the phase busses.
- B. Type circuit directories giving location and nature of load served. Install circuit directories in each panelboard.

### 3.07 UNDERGROUND SYSTEM

- A. Install raceways to drain away from buildings.
- B. Reinforce raceway banks when conduits pass over newly excavated pipes.
- C. The minimum cover for raceway banks shall be 24-in unless otherwise permitted by the Engineer.
- D. Swab all raceways clean before installing cable.
- E. Plug spare raceways and seal them watertight at all manholes, buildings and structures.
- F. Seal the ends of raceways and make watertight at all handholes, buildings and structures.

### 3.08 GROUNDING

- 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, disassemble 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.
- D. Ground wire connections to structural steel columns shall be made with long barrel type one-hole heavy duty copper compression lugs, bolted through 1/2-in maximum diameter holes drilled in the column web, with stainless steel hex head cap screws and nuts.
- E. 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.
- F. Seal exposed connections between different metals with No-Oxide Paint Grade A or equal.
- G. Lay all underground grounding conductors slack and, where exposed to mechanical injury, protect by pipes or other substantial guards. If guards are iron pipe, or other magnetic material, electrically connect conductors to both ends of the guard. Make connections as specified herein.
- H. Care shall be taken to ensure good ground continuity, in particular between the conduit system and equipment frames and enclosures. Where necessary, jumper wires shall be installed.
- I. All grounding type receptacles shall be grounded to the outlet boxes with a No. 12 THW green conductor connected to the ground terminal of the receptacle and fastened to the outlet box by means of a grounding screw.
- J. Test the grounding system. 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.
- K. Testing shall be performed before energizing the distribution system.
- L. Notify the Engineer immediately if the resistance to ground for any building or system is greater than five ohms.

END OF SECTION

SECTION 16950  
ELECTRICAL SYSTEM TESTING AND SETTINGS  
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SECTION 16950  
ELECTRICAL SYSTEM TESTING AND SETTINGS

PART 1 GENERAL

1.01 STATUTORY REQUIREMENTS

1.02 SCOPE OF WORK SMALL PROJECTS

- A. The Contractor shall engage the services of the equipment manufacturer' as required for the purpose of performing inspections and tests as herein specified.
- B. The Contractor/manufacturer shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.
- C. It is the purpose of these tests to assure that all tested electrical equipment, both Contractor- and Owner-supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications. The tests and inspections shall determine suitability for energizing equipment.
- D. Test systems and equipment furnished under Division 16 and repair or replace all defective work and equipment at no additional cost to the Owner. Refer to the individual equipment sections for additional specific testing requirements.
- E. Make adjustments to the systems furnished under Division 16 and instruct the Owner's personnel in the proper operation of the systems.
- F. In addition to the specific testing requirements listed in the individual Sections, perform the additional testing, inspections and adjust settings as specified herein.
- G. Testing shall be scheduled and coordinated with the Construction Manager at least 2 weeks in advance.
- H. Provide qualified test personnel, instruments and test equipment.
- I. Provide a test report verifying compliance with the testing requirements included under Division 16.
- J. Before proceeding with the energization of equipment, notify the Construction Manager to schedule the start-up of the equipment.

1.03 RELATED WORK

- A. Electric motors are provided with the driven equipment under Divisions 11, 15 and are specified in the individual equipment specifications and sections 01171.
- B. Variable Frequency Drive units are provided with the driven equipment under Divisions 11, 15 and are specified in the individual equipment specifications and Sections 01174.

#### 1.04 SUBMITTALS

##### A. Test Report

1. The test report shall include the following:
  - a. Summary of project
  - b. Listing of equipment tested
  - c. Test results
  - d. Recommendations
2. Furnish copies of the complete report to the owner/engineer's representative as directed in the contract documents.

B. The report shall include a Table of Content and a data sheet for each component tested. The Table of Content shall identify each component by a unique number. The Number shall appear on the technical data sheet for identification. Submit cable test results, grounding test results, circuit breaker, motor circuit protector, and protective device settings, fuse type and rating for each piece of equipment. Test report shall be submitted in a three ring binder. Three copies shall be furnished.

C. The report shall include a Table of Contents, a technical data sheet for each component (i.e., cable, circuit breaker, transformer, relay, etc.) tested. The Table of Content shall include the name of each component, location, the major piece of equipment the component is located within, and a sheet number on which the technical information is presented. Each data sheet shall include a unique sheet number, the name of the component under test, the major piece of equipment in which the component is located and the weather conditions at the time of the test including the temperature and relative humidity at the time of the test. The firm doing the testing shall include, in the report, their opinion whether or not the equipment being tested complies with the specification and recommended measures to correct the deficiency. Any discrepancies shall be noted in the concluding summary of the report. Test report forms shall be in compliance with NETA standards. Three complete copies shall be provided. Reports shall be signed by the person in responsible charge of the field testing, an officer of the firm performing the tests and an officer of the Electrical Contracting Firm.

D. The reports shall be submitted to the Engineer for review, comment and record purposes. Each report shall include a Table of Content, a technical data sheet, for each component (i.e., cable, circuit breaker, transformer, relay, etc.) tested. The Table of Content shall include the name of each component, the major piece equipment the component is located within, and a sheet number on which the technical information is presented. Each data sheet shall include a unique sheet number, the name of the component under test, The major piece of equipment in which the component is located, the weather conditions at the time of the test (i.e., temperature, humidity, sunny, rain, etc) the tester's observation and findings, discrepancies, any remedial work performed or act to resolve problems, technical parameters obtained during the tests, as left settings of all devices, and a statement indicating the equipment is ready to be energized. The report shall contain a statement indicating the equipment was tested in accordance with the procedures outlined in the latest edition of The International Testing Association Acceptance Testing Specifications.

1.05 APPLICABLE CODES, STANDARDS, AND REFERENCES

- A. All inspections and tests shall be in accordance with the following codes and standards except as provided otherwise herein:
  - 1. National Electrical Manufacturer's Association - NEMA
  - 2. ASTM International - ASTM
  - 3. Institute of Electrical and Electronic Engineers - IEEE
  - 4. InterNational Electrical Testing Association - NETA Acceptance Testing Specifications (ATS) – Latest Revision
- B. All inspections and tests shall utilize the following references:
  - 1. Project design specifications
  - 2. Project design drawings
  - 3. Manufacturer's instruction manuals applicable to each particular apparatus
  - 4. Project list of equipment to be inspected and tested

1.06 QUALITY ASSURANCE

- A. Qualifications of testing firm
  - 1. The testing firm shall be a corporately- and financially-independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing firm.
  - 2. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.
  - 3. The testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or be a Full Member company of the InterNational Electrical Testing Association.
  - 4. The lead, on-site, technical person shall be currently certified by the InterNational Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.
  - 5. The testing firm shall utilize engineers and technicians who are regularly employed by the firm for testing services. Resumes of key staff proposed for the project shall be submitted to the Construction Manager for review.
  - 6. The testing firm shall submit proof of the above qualifications with bid documents, when requested.

7. The terms used here within, such as test agency, test Engineer, testing laboratory, or Contractor's test company shall be construed to mean the testing firm.

#### 1.07 DIVISION OF RESPONSIBILITY

- A. The Contractor shall perform routine insulation-resistance, continuity, and rotation tests for all distribution and utilization equipment prior to and in addition to tests performed by the testing firm specified herein.
- B. The Contractor shall supply a suitable and stable source of electrical power to each test site. The testing firm shall specify the specific power requirements.
- C. The Contractor shall notify the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.
- D. The project electrical engineer is responsible for obtaining and approving a short-circuit analysis and coordination study prepared by an independent testing firm or consulting engineer.
- E. The project electrical engineer shall supply a short-circuit analysis and coordination study, a protective device setting sheet, a complete set of electrical plans, specifications, and any pertinent change orders to the testing firm prior to commencement of testing.
- F. The testing firm shall notify the Owner/Engineer's representative prior to commencement of any testing.
- G. Any system, material, or workmanship which is found defective on the basis of acceptance tests shall be reported to the owner/engineer's representative.
- H. The testing firm shall maintain a written record of all tests and, upon completion of project, shall assemble and certify a final test report.
- I. Safety and Precautions
  1. Safety practices shall include, but are not limited to, the following requirements:
    - a. Occupational Safety and Health Act (OSHA)
    - b. Accident Prevention Manual for Industrial Operations, National Safety Council (NSC)
    - c. Applicable state and local safety operating procedures
    - d. Owner's safety practices (Lockout/Tagout)
    - e. National Fire Protection Association - NFPA 70E
    - f. National Fire Protection Association – NFPA 79
    - g. American National Standards for Personnel Protection
  2. All tests shall be performed with apparatus de-energized. Exceptions must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.
  3. The testing firm shall have a designated safety representative on the project to supervise the testing operations with respect to safety.

#### 1.08 TEST EQUIPMENT REQUIREMENTS

- A. Suitability of Test Equipment

1. All test equipment shall be in good mechanical and electrical condition.
2. Selection of metering equipment should be based on a knowledge of the waveform of the variable being measured. Digital multimeters may be average or RMS sensing and may include or exclude the dc component. When the variable contains harmonics or dc offset and, in general, any deviation from a pure sine wave, average sensing and average measuring RMS scaled meters may be misleading. Use of RMS measuring meters is recommended.
3. Field test metering used to check power system meter calibration must have an accuracy higher than that of the instrument being checked.
4. Accuracy of metering in test equipment shall be appropriate for the test being performed.
5. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and tested equipment.

B. Test Instrument Standards

1. All equipment used for testing and calibration procedures shall exhibit the following characteristics:
  - a. Maintained in good visual and mechanical condition
  - b. Maintained in safe operating condition
2. Test equipment should have operating accuracy equal to, or better than, the following limits:
  - a. Portable multimeters should be true RMS measuring.
  - b. Multimeters should have the following accuracy limits, or better:
    - 1) AC voltage ranges: .75% +/-3 last single digits @ 60 Hz
    - 2) AC current ranges: .90% +/-3 last single digits @ 60 Hz, including adapters, transducers
    - 3) DC voltage ranges: .25% +/-1 last single digit
    - 4) DC current ranges: .75% +/-1 last single digit
    - 5) Resistance ranges: .50% +/-1 last single digit
    - 6) Frequency range: .10% +/-1 last single digit @ 60 Hz
  - c. Clamp-on ammeters: ac current +/-3% of range +/-1 last single digit @ 60 Hz
  - d. Dissipation/power factor field equipment
    - 1) +/-0.1% power factor for power factor values up to 2.0%
    - 2) 5% of the reading for power factor values above 2.0%
  - e. Low-range dc resistance equipment: 1.0% of reading, +/-2 last single digits
  - f. Transformer turns-ratio test equipment: 0.5% or better @ 60 Hz
  - g. Ground electrode test equipment: +/-2% of range
  - h. Insulation test sets: 0-1000V dc +/-20% of reading at mid-scale
  - i. Electrical load survey equipment
    - 1) +/-5% total error, including sensors
    - 2) 1% resolution
    - 3) Current transformers +/-2% of range @ 60 Hz
    - 4) Voltage transformers +/-0.5% of range @ 60 Hz
  - j. Liquid dielectric strength test equipment: +/-2% of scale
  - k. Infrared scanning equipment: sensitivity of 20c
  - l. Phase shifting equipment: +/-1.0o over entire range

- m. High-current test equipment: +/-2% of range
- n. DC high potential test equipment: +/-2% of full scale
- o. AC high potential test equipment (60 Hz): +/-2% of full scale

C. Test Instrument Calibration

1. The testing firm shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.
3. Instruments shall be calibrated in accordance with the following frequency schedule:
  - a. Field instruments: 6 months maximum
  - b. Laboratory instruments: 12 months
  - c. Leased specialty equipment: 12 months (Where accuracy is guaranteed by lessor)
  - d. Dated calibration labels shall be visible on all test equipment.
  - e. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date and available upon request.
  - f. Up-to-date instrument calibration instructions and procedures shall be maintained for each test instrument.
  - g. Calibrating standard shall be of higher accuracy than that of the instrument tested.

PART 2 PRODUCTS

2.01 NOT USED

PART 3 EXECUTION

3.01 PREPARATION

- A. Testing shall be scheduled and coordinated with the Construction Manager at least 2 weeks in advance.

3.02 ACCEPTANCE TESTING

- A. Provide acceptance testing for all equipment provided under Division 16 in accordance with the individual specification sections.
- B. Provide acceptance testing for all motors provided under Divisions 11 and 15.

3.03 ACCEPTANCE TESTING FOR SMALL PROJECTS

- A. Tests all electrical equipment, both Contractor- and Owner-supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications prior to energizing equipment.
- B. Test systems and equipment furnished under Division 16 and repair or replace all defective work and equipment at no additional cost to the Owner. Refer to the individual equipment sections for additional specific testing requirements.

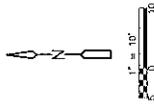
- C. Make adjustments to the systems furnished under Division 16 and instruct the Owner's personnel in the proper operation of the systems.
- D. Provided mechanical inspection of equipment and operational testing of control circuits to confirm proper operation of equipment.
- E. Check and record the full load current draw of each motor. Where power factor correction capacitors are provided the capacitor shall be in the circuit at the time of the measurement. Check ampere rating of thermal overloads for motors and submit a typed record to the Engineer, if using ambient compensated thermal overloads, submit the ambient temperature used at the time of the test. Include MCC cubicle location and driven load designation, motor service factor, horsepower, and Code letter. If incorrect thermal overloads are installed replace with the correct size overload.
- F. Check power and control power fuse ratings for correct size and type. Replace fuses if they are found to be of the incorrect size/ratings.
- G. Check settings of the motor circuit protectors. Adjust settings to lowest setting that will allow the motor to be started when under load conditions.
- H. Check motor nameplates for correct phase and voltage.
- I. Check rotation of motors prior to testing the driven load. Disconnect the driven equipment if damage could occur due to wrong rotation. If the rotation of the motor shaft is not correct, for the driven equipment, change the motor connections at the motor terminal box.
- J. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by control schematic and wiring diagrams.
- K. Inspect each piece of equipment in areas designated as HAZARDOUS to ensure that equipment of proper rating is installed. In the case where HAZARDOUS rated equipment is installed outdoors or in "WET" locations, verify that equipment furnished is also rated for use in WET locations and that conduit and equipment drains are provided. If equipment is not properly rated advise the Engineer.
- L. Verify all terminations at transformers, equipment, panels and enclosures are connected to the proper terminals by producing a 1, 2, 3 rotation on a phase sequenced motor when connected to "A," "B" and "C" phases.
- M. Verify all circuit breaker ratings are as required by the Contract Documents or as amended during shop drawing review. Advise the Engineer of discrepancies and make changes as directed by the Engineer.
- N. Verify proper operation of automatic and manual transfer switches, accessories devices and associated motor interlocks provided to either delay or prevent motor starting after transfer. Verify that the upstream protective device for each automatic and manual transfer switch is of the proper type and rating to achieve the specified short-circuit withstand rating. If a specific upstream protective device is required to obtain the proper short circuit withstand rating, verify that the proper signage is installed on the upstream protective device and on the automatic/manual transfer switch enclosures indicating the proper replacement parts. If signage

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is not installed on both the upstream protective device and the transfer switch advise the Construction Manager and provide the signage as specified in the transfer switch specification section..

END OF SECTION



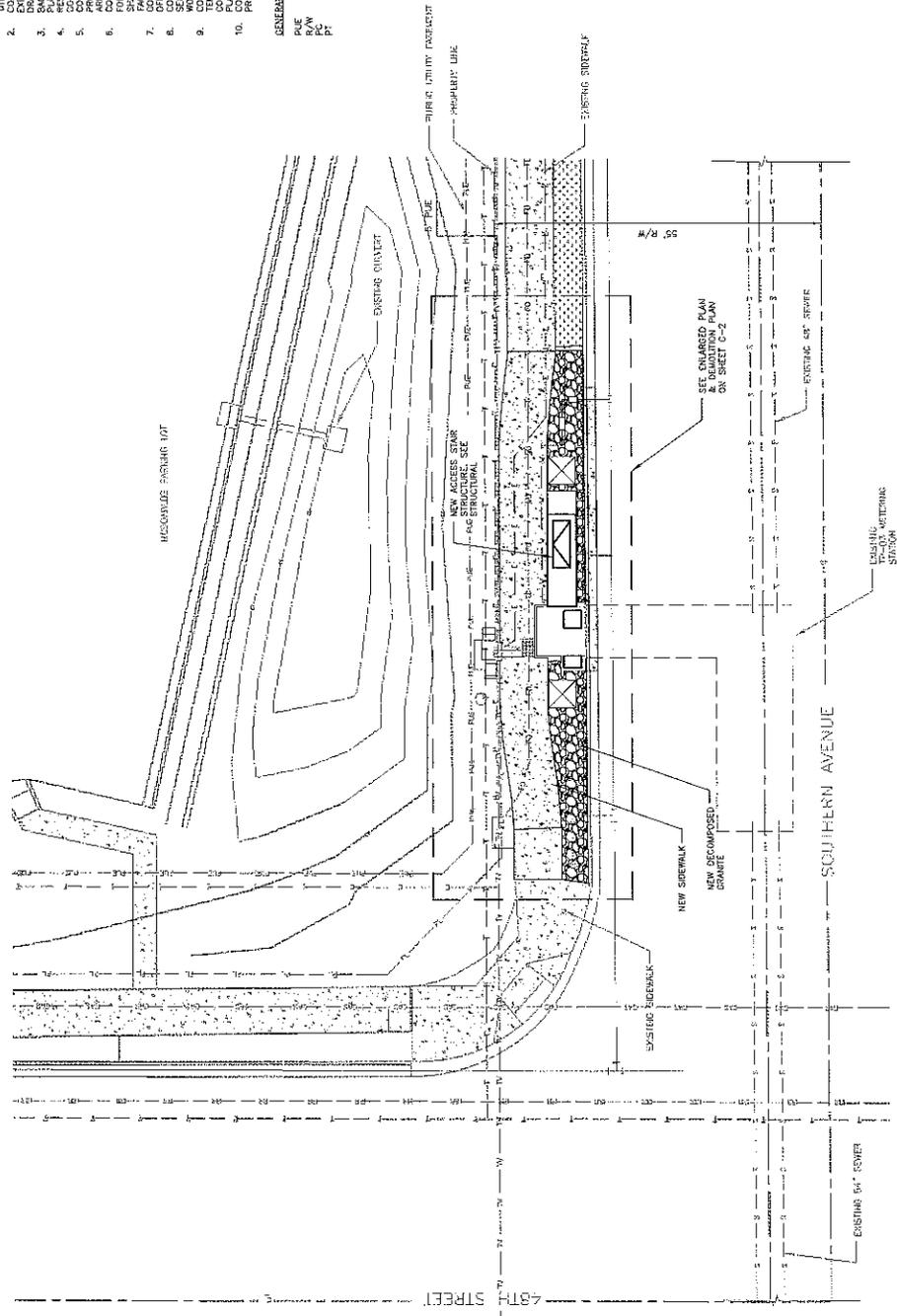


- NOTES:**
1. CONTRACTOR SHALL VERIFY ALL EXISTING UTILITIES PRIOR TO CONSTRUCTION.
  2. CONTRACTOR SHALL PROTECT IN PLACE ALL EXISTING UTILITIES UNLESS OTHERWISE NOTED IN BACKGROUND IS BASED ON MEDONALD'S SITE SURVEY AND SHALL BE RESPONSIBLE TO RECONSTRUCT ALL EXISTING UTILITIES TO ORIGINAL CONDITION INCLUDING REGRADING SYSTEM, CONDUIT, AND/OR OTHER UTILITIES.
  3. CONTRACTOR SHALL PROVIDE HIS OWN SECURITY FOR HIS WORK AREA AND USE STORED MATERIALS AND TOOLS FOR HIS PERSONNEL. CONTRACTOR'S PERSONNEL SHALL NOT USE THE OWNER'S OR COMMERCIAL PROPERTY.
  4. CONTRACTOR SHALL PROVIDE STAGING AREA SEQUENCING WITH OWNER PRIOR TO STARTING CONSTRUCTION.
  5. CONTRACTOR SHALL NOT IMPEDER TRAFFIC. IF TEMPORARY RE-ROUTING OF TRAFFIC IS REQUIRED, CONTRACTOR SHALL SUBMIT AND OBTAIN APPROVED PLANS TO OWNER PRIOR TO STARTING WORK. CONTRACTOR SHALL MAINTAIN ALL DRIVEWAYS BACK TO PRE-CONSTRUCTION GRADE.

**GENERAL ABBREVIATIONS:**

- PUE PUBLIC UTILITY EASEMENT
- R/W RIGHT OF WAY
- PC POINT OF CURVATURE
- PT POINT OF TANGENT

- LEGEND**
- CENTER LINE
  - - - - - PROPERTY LINE
  - - - - - PUBLIC UTILITY EASEMENT (PUE)
  - - - - - EXISTING IRRIGATION LINE
  - - - - - EXISTING TELEPHONE LINE
  - - - - - EXISTING TELEVISION LINE
  - - - - - EXISTING FIBER OPTIC LINE
  - - - - - EXISTING SEWER LINE
  - - - - - EXISTING WATER LINE
  - - - - - EXISTING GAS LINE
  - - - - - EXISTING ELECTRICAL LINE
  - - - - - NEW ELECTRICAL LINE
  - - - - - NEW WATER LINE
  - - - - - EXISTING GROUND
  - - - - - EXISTING SIDEWALK
  - - - - - NEW SIDEWALK
  - - - - - DEMOLITION
  - - - - - DECOMPOSED GRANITE



**SITE PLAN**  
SCALE: 1"=10'



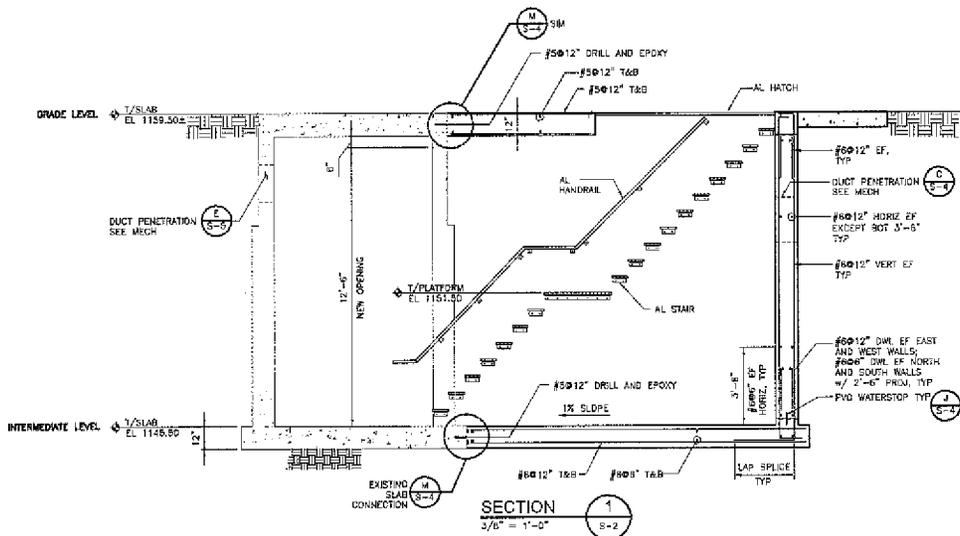
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DATE: 08/27/2013	
DRAWN BY: [Name]	
CHECKED BY: [Name]	
SCALE: 1"=10'	
PROJECT NAME: [Name]	
SHEET NO. C-1	
DATE: 08/27/2013	
DRAWN BY: [Name]	
CHECKED BY: [Name]	
SCALE: 1"=10'	

FOR MORE INFORMATION VISIT US AT  
**802-263-1100**  
 WWW.GDMSMITH.COM  
 CALL OR VISIT US TODAY

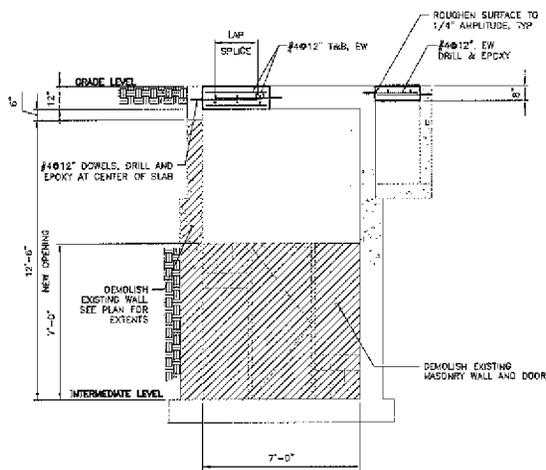




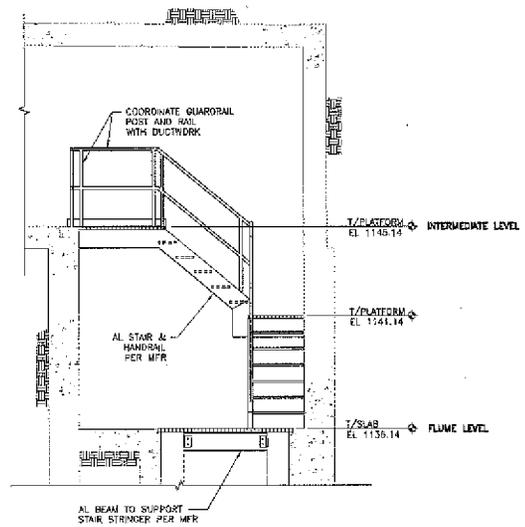




SECTION 1  
3/8" = 1'-0"



SECTION 2  
3/8" = 1'-0"



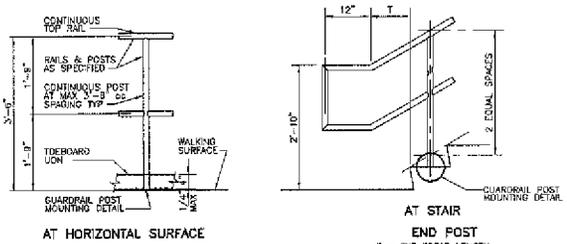
SECTION 3  
3/8" = 1'-0"



TWO WEEKS DATE BEFORE YOU DO  
FINAL FOR THE SUBMITTER  
602-283-1100  
BANK STATE SYSTEM  
CALL COLLECT



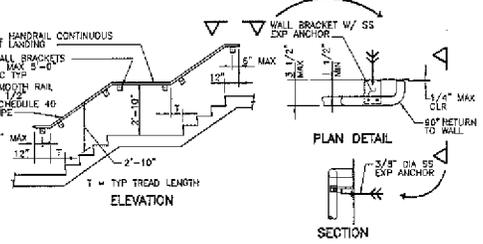
NO.		REVISION	DATE	BY
<b>CDM Smith</b>				
3333 East Camelback Road Suite 300 Phoenix, AZ 85024 TEL: (602) 281-9999				
CDMSMITH PROJECT NO. 1228-02X-00				
DEPARTMENT OF PUBLIC WORKS CITY OF TEMPE DIVISION OF ENGINEERING				
P.O. BOX 5000 TEMPE, ARIZONA 85280				
DATE	MARCH 2013	PROJECT	STREET	
DESIGNED	JLB	CHECKED	PPB	
DESCRIPTION		METER STRUCTURE SECTIONS		
CHECKED	PPB	SCALE	AS NOTED	
				S-3
				SHEET 5 OF 16



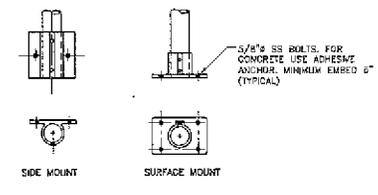
AT HORIZONTAL SURFACE  
AT STAIR  
T = TYP TREAD LENGTH

1. TOEBOARD SHALL BE PROVIDED UNLESS SPECIFICALLY NOTED OTHERWISE ON PLANS OR IN SPEC. TOEBOARD NOT REQUIRED WHEN CONCRETE CURBS 4" OR HIGHER ARE PROVIDED.

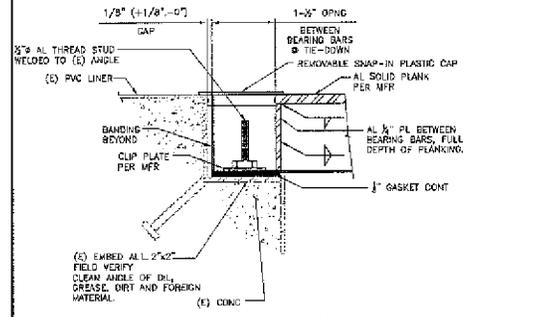
TWO RAIL TOP MOUNTED GUARDRAIL WITH TOEBOARD  
DETAIL A



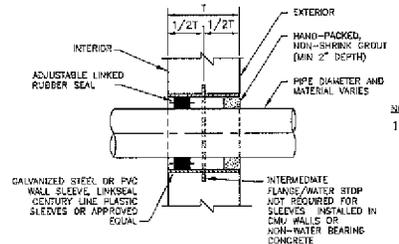
WALL MOUNTED HANDRAIL  
DETAIL B



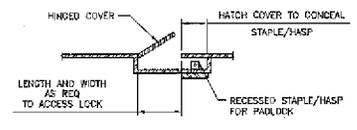
STANDARD GUARDRAIL POST MOUNTING  
DETAIL C



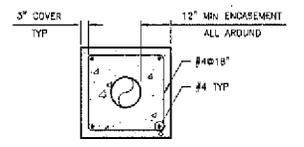
AL PLANKING TIE - DOWN  
DETAIL D



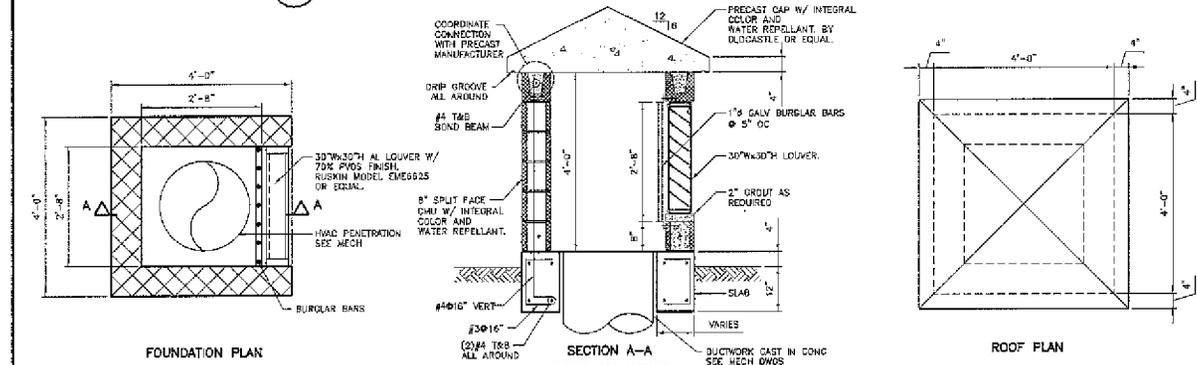
LINK SEAL WALL PENETRATION  
DETAIL E



RECESSED LOCK  
DETAIL F



DUCT ENCASUREMENT DETAILS  
DETAIL H



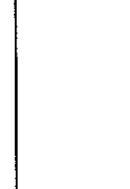
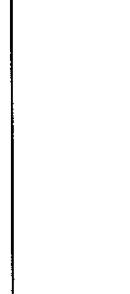
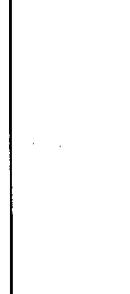
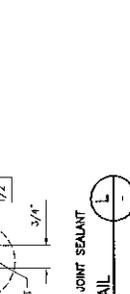
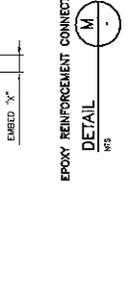
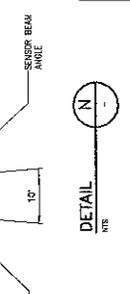
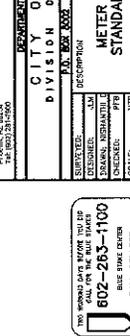
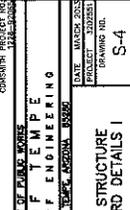
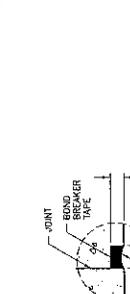
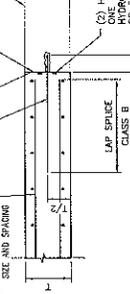
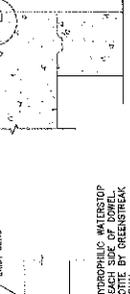
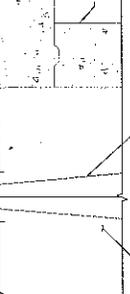
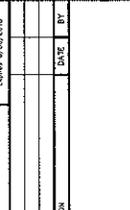
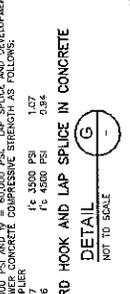
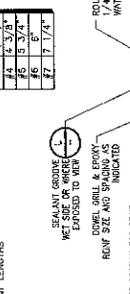
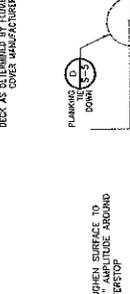
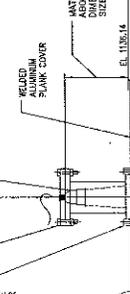
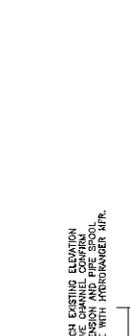
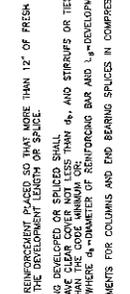
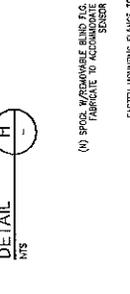
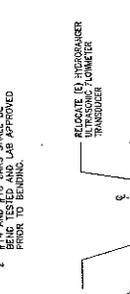
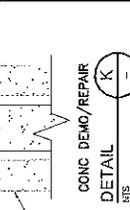
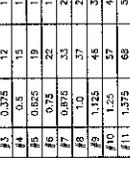
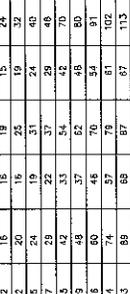
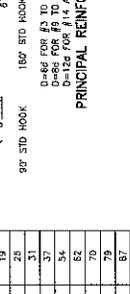
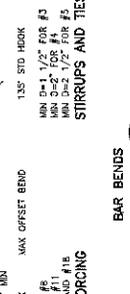
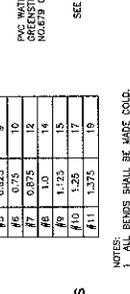
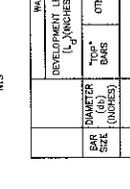
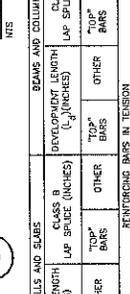
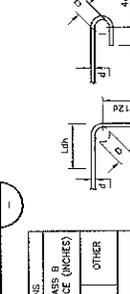
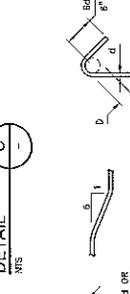
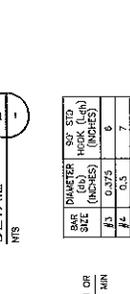
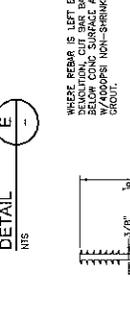
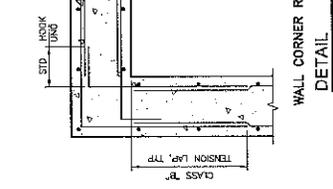
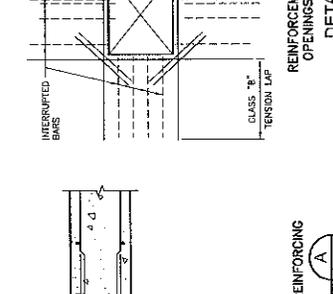
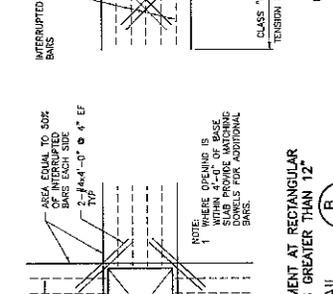
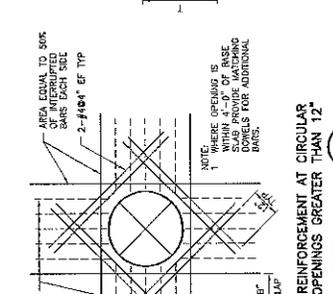
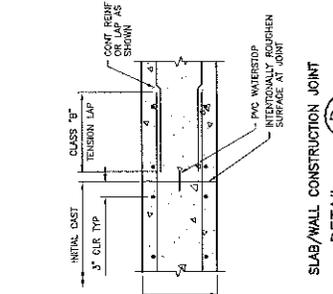
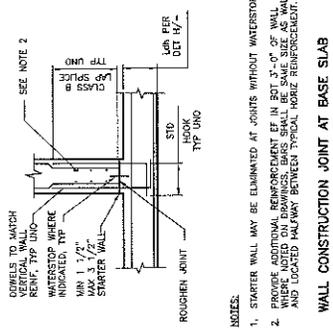
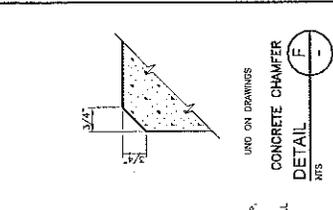
LOUVER STRUCTURE  
DETAIL G

- LOUVER STRUCTURE NOTES:**
1. COLORS TO BE SELECTED BY OWNER.
  2. INTEGRAL WATER REPELLANT: LIQUID POLYMERIC INTEGRAL WATER-REPELLANT ADMIXTURE THAT DOES NOT REDUCE FLEXURAL BOND STRENGTH.
  3. PRODUCTS:
    - 1) ACM CHEMISTRIES: BANDED.
    - 2) S&P ANTIMICROBIALS: TRIOCEL PLUS.
    - 3) GRADE CONSTRUCTION PRODUCTS, W. R. GRADE & CO. - CONCRETE DRY-BLOCK.
    - 4) OR EQUAL.

FOR WORKS DATA BEFORE YOU GO  
CALL FOR THE BLUE BOOK  
**802-263-1100**  
BUSINESS CENTER  
CALL COLLECT



NO.	REVISION	DATE	BY
<b>CDM Smith</b>			
DEPARTMENT OF PUBLIC WORKS <b>CITY OF TEMPE</b> DIVISION OF ENGINEERING P.O. BOX 6026 TEMPE, ARIZONA 85286			
DESCRIPTION: METER STRUCTURE STANDARD DETAILS II		DATE: MARCH 2023	PROJECT: 2302851
DRAWING NO.: S-5		DRAWING VIA:	
SCALE: NTC		SHEET 8 OF 15	



SEE NOTE 2

CONCRETE CHAMFER

DETAIL F

REINFORCING

WALL CONSTRUCTION JOINT AT BASE SLAB

DETAIL E

REINFORCING

SLAB/WALL CONSTRUCTION JOINT

DETAIL D

REINFORCING

REINFORCEMENT AT CIRCULAR OPENINGS GREATER THAN 12"

DETAIL C

REINFORCING

REINFORCEMENT AT RECTANGULAR OPENINGS GREATER THAN 12"

DETAIL B

REINFORCING

WALL CORNER REINFORCING

DETAIL A

REINFORCING

CONCRETE DEMO/REPAIR

DETAIL K

REINFORCING

6" PVC JOINT WATERSTOP

DETAIL J

REINFORCING

STIRRUPS AND TIES

DETAIL H

REINFORCING

BAR BENDS

DETAIL G

REINFORCING

STANDARD HOOK AND LAP SPLICE IN CONCRETE

DETAIL I

REINFORCING

EPOXY REINFORCEMENT CONNECTIONS

DETAIL M

REINFORCING

JOINT SEALANT

DETAIL L

REINFORCING

NOTES:  
1. STARTER WALL MAY BE ELIMINATED AT JOINTS WITHOUT WATERSTOP.  
2. PROVIDE ADDITIONAL REINFORCEMENT OF AN 8" x 3" x 3" OF WALL WHERE NOTED ON DRAWINGS. BARS SHALL BE SAME SIZE AS WALL AND LOCATED HALFWAY BETWEEN TYPICAL HORIZONTAL REINFORCEMENT.

WHERE REBAR IS LEFT EXPOSED AFTER DEMOLITION OF BASE WALL, PROTECT WITH 1/2" THICK NON-SHRINK, NON-METALLIC GROUT.

WHERE REBAR IS LEFT EXPOSED AFTER DEMOLITION OF BASE WALL, PROTECT WITH 1/2" THICK NON-SHRINK, NON-METALLIC GROUT.

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BAR SIZE (INCHES)	DEVELOPMENT LENGTH (L <sub>d</sub> ) (INCHES)	CLASS B LAP SPLICE (INCHES)	CLASS B TOP BARS	CLASS B OTHER BARS	CLASS B OTHER BARS	CLASS B OTHER BARS
#3	12	18	18	18	18	18
#4	16	24	24	24	24	24
#5	20	30	30	30	30	30
#6	24	36	36	36	36	36
#7	28	42	42	42	42	42
#8	32	48	48	48	48	48
#9	36	54	54	54	54	54
#10	40	60	60	60	60	60
#11	44	66	66	66	66	66

BAR SIZE (INCHES)	DEVELOPMENT LENGTH (L <sub>d</sub> ) (INCHES)	CLASS B LAP SPLICE (INCHES)	CLASS B TOP BARS	CLASS B OTHER BARS	CLASS B OTHER BARS	CLASS B OTHER BARS
#3	12	18	18	18	18	18
#4	16	24	24	24	24	24
#5	20	30	30	30	30	30
#6	24	36	36	36	36	36
#7	28	42	42	42	42	42
#8	32	48	48	48	48	48
#9	36	54	54	54	54	54
#10	40	60	60	60	60	60
#11	44	66	66	66	66	66

BAR SIZE (INCHES)	DEVELOPMENT LENGTH (L <sub>d</sub> ) (INCHES)	CLASS B LAP SPLICE (INCHES)	CLASS B TOP BARS	CLASS B OTHER BARS	CLASS B OTHER BARS	CLASS B OTHER BARS
#3	12	18	18	18	18	18
#4	16	24	24	24	24	24
#5	20	30	30	30	30	30
#6	24	36	36	36	36	36
#7	28	42	42	42	42	42
#8	32	48	48	48	48	48
#9	36	54	54	54	54	54
#10	40	60	60	60	60	60
#11	44	66	66	66	66	66

BAR SIZE (INCHES)	DEVELOPMENT LENGTH (L <sub>d</sub> ) (INCHES)	CLASS B LAP SPLICE (INCHES)	CLASS B TOP BARS	CLASS B OTHER BARS	CLASS B OTHER BARS	CLASS B OTHER BARS
#3	12	18	18	18	18	18
#4	16	24	24	24	24	24
#5	20	30	30	30	30	30
#6	24	36	36	36	36	36
#7	28	42	42	42	42	42
#8	32	48	48	48	48	48
#9	36	54	54	54	54	54
#10	40	60	60	60	60	60
#11	44	66	66	66	66	66

BAR SIZE (INCHES)	DEVELOPMENT LENGTH (L <sub>d</sub> ) (INCHES)	CLASS B LAP SPLICE (INCHES)	CLASS B TOP BARS	CLASS B OTHER BARS	CLASS B OTHER BARS	CLASS B OTHER BARS
#3	12	18	18	18	18	18
#4	16	24	24	24	24	24
#5	20	30	30	30	30	30
#6	24	36	36	36	36	36
#7	28	42	42	42	42	42
#8	32	48	48	48	48	48
#9	36	54	54	54	54	54
#10	40	60	60	60	60	60
#11	44	66	66	66	66	66

BAR SIZE (INCHES)	DEVELOPMENT LENGTH (L <sub>d</sub> ) (INCHES)	CLASS B LAP SPLICE (INCHES)	CLASS B TOP BARS	CLASS B OTHER BARS	CLASS B OTHER BARS	CLASS B OTHER BARS
#3	12	18	18	18	18	18
#4	16	24	24	24	24	24
#5	20	30	30	30	30	30
#6	24	36	36	36	36	36
#7	28	42	42	42	42	42
#8	32	48	48	48	48	48
#9	36	54	54	54	54	54
#10	40	60	60	60	60	60
#11	44	66	66	66	66	66

BAR SIZE (INCHES)	DEVELOPMENT LENGTH (L <sub>d</sub> ) (INCHES)	CLASS B LAP SPLICE (INCHES)	CLASS B TOP BARS	CLASS B OTHER BARS	CLASS B OTHER BARS	CLASS B OTHER BARS
#3	12	18	18	18	18	18
#4	16	24	24	24	24	24
#5	20	30	30	30	30	30
#6	24	36	36	36	36	36
#7	28	42	42	42	42	42
#8	32	48	48	48	48	48
#9	36	54	54	54	54	54
#10	40	60	60	60	60	60
#11	44	66	66	66	66	66

NOTES:  
1. TOP BARS ARE REINFORCED WITH DEVELOPMENT LENGTH OF 12" OF FRESH CONCRETE IS TO BE MAINTAINED BELOW THE DEVELOPMENT LENGTH OF SPLICE.

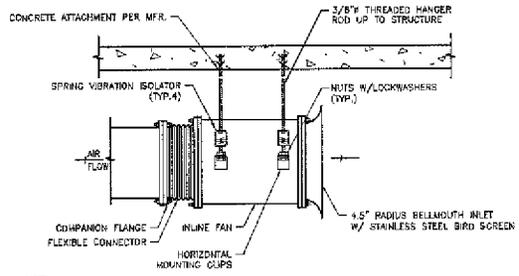
2. CLASS B TOP BARS ARE REIN





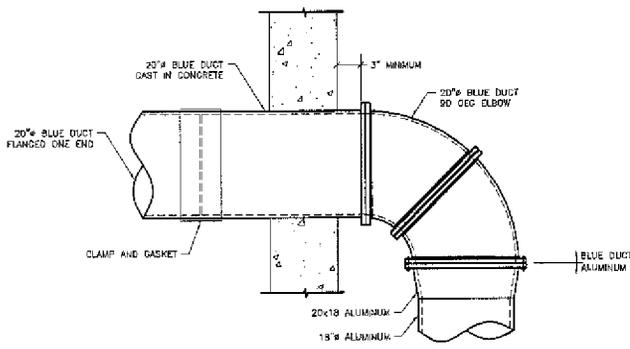
TAG	SERVICE	FAN TYPE	CFM		ELECTRICAL			BASIS OF DESIGN	NOTES
			HIGH	LOW	WHP	BRP	HPV		
SAF-01	METER STRUCTURE EXHAUST AIR FAN	VANEAXIAL	1,250	875	0.70	0.50	0.35	115V/1 240V/3/60	APPROVED VW 18W7 OR EQUAL 1, 2, 3, 5
EAF-01	METER STRUCTURE EXHAUST AIR FAN	VANEAXIAL	1,250	875	0.70	0.50	0.35	115V/1 240V/3/60	APPROVED VW 18W7 OR EQUAL 1, 2, 4, B

- NOTES:
- FAN SHALL BE ALUMINUM CONSTRUCTION WITH FULLY ENCLOSED MOTOR.
  - FAN SHALL HAVE CLASS 1 DIV 1 RATING.
  - FAN SHALL BE DELIMS MOUNTED W/ HORIZONTAL SIDE TABS AND ISOLATION DAMPERS. SEE DETAIL A.
  - FAN SHALL BE MOUNTED TO WALL BRACE W/ VERTICAL SIDE TABS AND ISOLATION DAMPERS. SEE DETAIL B.
  - FAN SHALL HAVE 4.5 INCH RADIUS BELLMOUTH INLET AND FLEXIBLE CONNECTOR W/ COMPANION FLANGE ON OUTLET.
  - FAN SHALL HAVE FLEXIBLE CONNECTORS W/ COMPANION FLANGES ON INLET AND OUTLET.

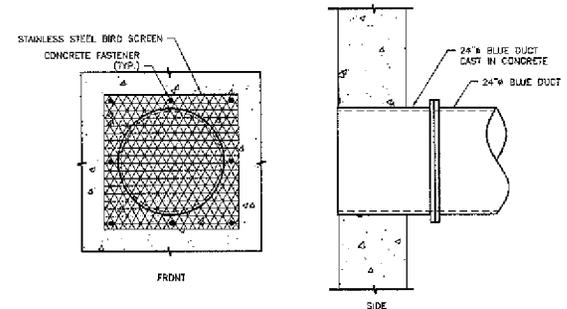


SAF-01 SUPPORT  
DETAIL A  
NTS M-2

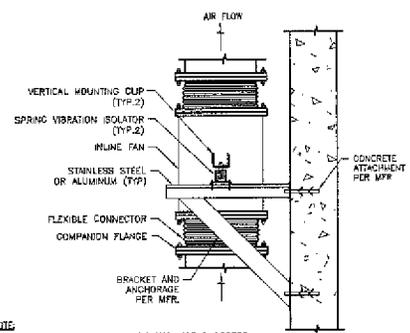
NOTE:  
PROVIDE ACCESS PANEL FOR FAN AND MOTOR ACCESS.  
PROVIDE ADEQUATE SERVICE SPACE AROUND FAN FOR FAN REMOVAL AND MAINTENANCE.



EXHAUST WALL PENETRATION  
DETAIL B  
NTS M-2

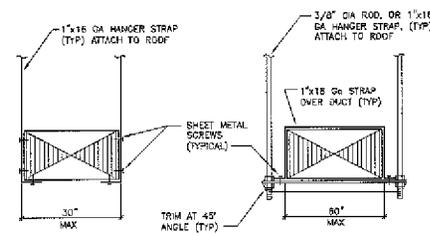


INTAKE WALL PENETRATION  
DETAIL C  
NTS M-2



EAF-01 SUPPORT  
DETAIL D  
NTS M-2

NOTE:  
PROVIDE ACCESS PANEL FOR FAN AND MOTOR ACCESS.  
PROVIDE ADEQUATE SERVICE SPACE AROUND FAN FOR FAN REMOVAL AND MAINTENANCE.



RECTANGULAR DUCT HANGER  
TYPICAL DUCT HANGERS  
DETAIL E  
NTS

NOTE:  
ALL HANGER ROD AND HARDWARE SHALL BE STAINLESS STEEL.

NO WORKING CHANGES WILL BE MADE. CALL FOR THE BLUE LINES.  
602-263-1100  
RUC STINK CENTER  
CALL COLLECT



NO.		REVISION	DATE	BY
<b>CDM Smith</b>				
4400 EAST CENTRAL EXPRESS WAY SUITE 100 PHOENIX, AZ 85024 TEL: (602) 263-1100				
DEPARTMENT OF PUBLIC WORKS <b>CITY OF TEMPE</b> DIVISION OF ENGINEERING P.O. BOX 20000 TEMPE, ARIZONA 85280				
SURVEYED: N/A DESIGNED: CDM DRAWN: MFM CHECKED: CDM SCALE: AS NOTED	DESCRIPTION: <b>HVAC SCHEDULE AND DETAILS</b>			DATE: MARCH 2015 PROJECT: 03020101 DRAWING NO.: <b>M-3</b>
CDMSMITH PROJECT NO. 1772-00260				SMT: 11 OF 16

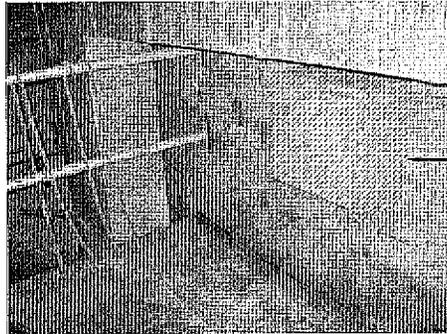








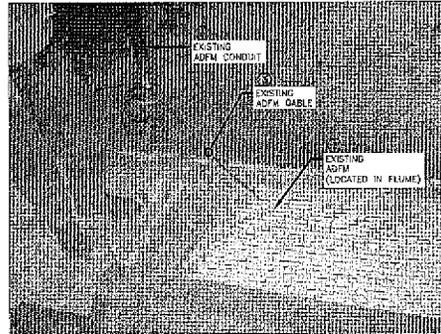




① EXISTING INSTRUMENT PANEL

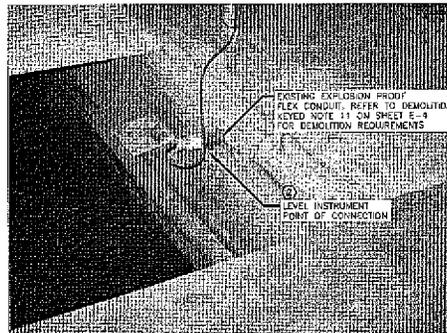
EXISTING INSTRUMENT CABINET DEMOLITION

DETAIL (G) E-4  
NTS



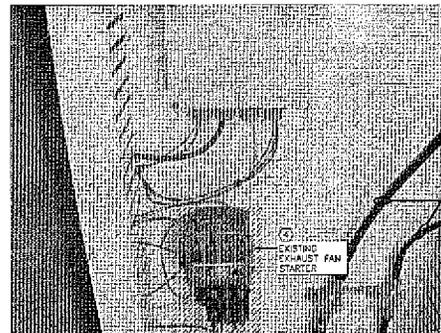
EXISTING FLOW INSTRUMENT CONNECTION POINT DEMOLITION

DETAIL (I) E-4  
NTS



EXISTING LEVEL INSTRUMENT CONNECTION POINT DEMOLITION

DETAIL (H) E-4  
NTS



EXISTING EXHAUST FAN STARTER (LOCATED IN EXISTING RTU CABINET) DEMOLITION

DETAIL (J) E-4  
NTS

**ELECTRICAL DEMOLITION NOTES:**

1. ITEMS SHOWN HATCHED ARE IDENTIFIED FOR DEMOLITION UNLESS OTHERWISE STATED IN THE DRAWINGS.
2. SURVEY THE EXISTING ELECTRICAL SYSTEMS AND EQUIPMENT IDENTIFIED FOR REMOVAL WITH OWNER AND REPRESENTATIVES FROM OTHER TRADES PRIOR TO PERFORMING ANY DEMOLITION WORK.
3. CONTRACTOR SHALL DISCONNECT ELECTRICAL CIRCUITS IDENTIFIED FOR DEMOLITION TO ALLOW FOR SAFE AND COMPLETE REMOVAL OF THE DESIGNATED EQUIPMENT.
4. PATCH ALL SURFACES AFFECTED DURING DEMOLITION IN A FLUSH, SMOOTH AND APPROVED MANNER.
5. MAINTAIN ALL CONDUIT SEALS BETWEEN CLASSIFIED AND UNCLASSIFIED AREAS.

**DEMOLITION KEYED NOTES:**

- ① DEMOLISH EXISTING INSTRUMENT PANEL (EMPTY). DEMOLISH ASSOCIATED CONDUIT AND WIRE BACK TO SOURCE.
- ② DISCONNECT LEVEL INSTRUMENT AT EXPLOSION PROOF FLEX CONDUIT LOCATED IN FLUME. PROTECT LEVEL INSTRUMENT AND CABLE FOR RELOCATION TO NEW POINT OF CONNECTION. REFER TO DEMOLITION KEYED NOTE 11 ON SHEET E-4 FOR FURTHER DEMOLITION DETAILS. REFER TO ELECTRICAL POWER PLAN ON SHEET E-6 FOR NEW WORK.
- ③ UPON COMPLETION OF NEW ADVANCED DOPPLER FLOW METER (ADFM) CONDUIT AND CABLE NEW WORK PER KEYED NOTES 1 AND 10 ON SHEET E-6, CONTRACTOR SHALL DEMOLISH ALL EXISTING ADFM CONDUIT, CABLE AND SEAL CONDUIT BODIES WITHIN THE METER STATION VAULT. REFER TO KEYED NOTE 13 ON SHEET E-6 FOR TERMINATION POINT OF CONDUIT. DEMOLITION CONTRACTOR SHALL SEAL ALL KNOCKOUTS AND CONDUIT PENETRATIONS ASSOCIATED WITH EXISTING ADFM CONDUIT REMOVAL IN ACCORDANCE WITH NEC REQUIREMENTS FOR A CLASS 1, DIV 1 HAZARDOUS LOCATION. REFER TO DEMOLITION KEYED NOTES 12 & 13 ON SHEET E-4 FOR FURTHER DEMOLITION DETAILS. REFER TO ELECTRICAL POWER PLAN ON SHEET E-6 FOR EXTENSION OF NEW CONDUIT AND ADFM CABLE TO NEW LOCATION.
- ④ DEMOLISH EXISTING EXHAUST FAN STARTER, OVERLOADS AND CONDUCTORS. RELOCATE EXISTING LIGHTNING ARRESTOR CABLE AS REQUIRED FOR INSTALLATION OF NEW EXHAUST AND SUPPLY FAN VFD'S, CONTACTORS AND RELAYS IN NEW WORK PHASE.

HATCHED AREAS DENOTES EQUIPMENT TO BE DEMOLISHED.

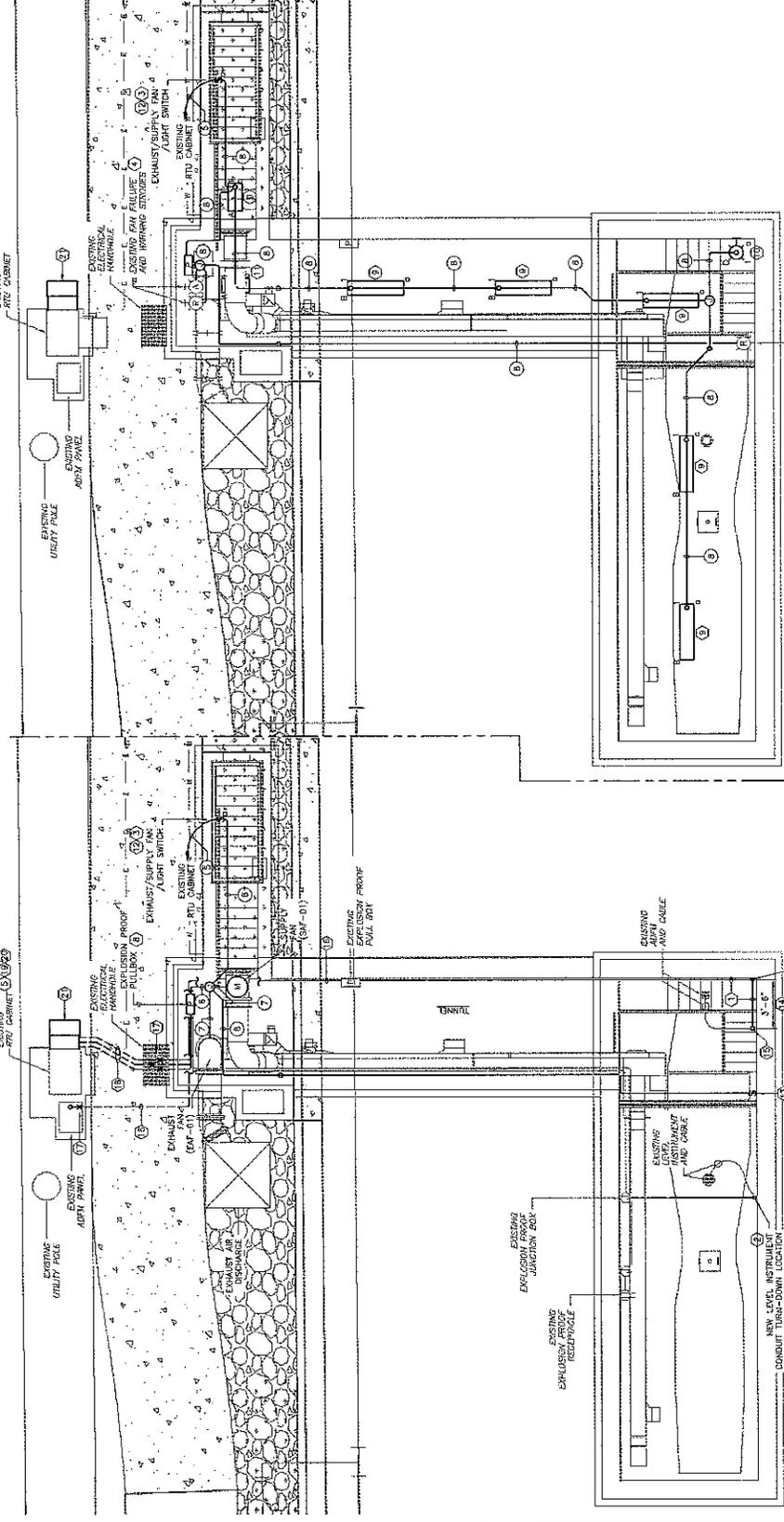


EXPIRES 12/31/19

NO.	REVISION	DATE	BY
<b>CDM Smith</b>			
4330 EAST CHANDLER STREET, SUITE 300 PHOENIX, AZ 85044 TEL: 602-954-7800			
CDM SMITH PROJECT NO. 1255-02884			
DEPARTMENT OF PUBLIC WORKS <b>CITY OF TEMPE</b> DIVISION OF ENGINEERING 300 N. BOY LANE, TEMPE, ARIZONA 85283			
DESIGNED: TSM	DESCRIPTION:	DATE: MARCH 2015	PROJECT: 1252884
DRAWN: JCL			DRAWING NO. E-5
CHECKED: BRY			SCH. 17 OF 18
SCALE: NTS			

NO WORKING DAYS BEFORE YOU GO AWAY FROM THE WORK SITES  
**602-263-1100**  
HAVE STATE DEPT. CALL COLLECT

- ELECTRICAL GENERAL NOTES**
1. CONTRACTOR SHALL COORDINATE NEW ELECTRICAL WORK WITH ALL OTHER ASSOCIATED DISCIPLINES.
  2. CONTRACTOR SHALL SEAL-OFF ALL CONDUITS LOCATED WITHIN HAZARDOUS LOCATION AREAS PER NEC.
  3. JUNCTION BOXES, PULL BOXES AND SWITCHES LOCATED WITHIN HAZARDOUS LOCATIONS SHALL BE NEMA 7 EXPLOSION PROOF.
  4. IF A TERMINATION IS REQUIRED BY VENDOR PERMANENTLY LOCATED WITHIN HAZARDOUS LOCATION AREAS PER NEC, THE TERMINATION SHALL BE NEMA 7 EXPLOSION PROOF.
  5. CONDUIT ENDINGS SHALL BE DISCONTINUED AT THE FIELD.
  6. CONTRACTOR SHALL FIELD IDENTIFY ALL PANELS AND COORDINATE WITH OWNER PRIOR TO BEGINNING ANY ELECTRICAL WORK.
  7. REFER TO SHEET E-3 FOR CONDUIT AND WIRE SCHEDULE.



**ELECTRICAL LIGHTING PLAN**  
1/4" = 1'-0"

**ELECTRICAL POWER PLAN**  
1/4" = 1'-0"

- ELECTRICAL KEYED NOTES:**
1. CONTRACTOR SHALL PROVIDE THE FOLLOWING NEW WORK PRIOR TO DEMOLITION OF EXISTING EQUIPMENT:
    - a. CABLE: PROVIDE NEW CONDUIT AND NEW ADIM MANUFACTURER'S CABLE WITHOUT SPLICE FROM EXISTING ADIM PANEL TO EXISTING EXPLOSION PROOF SUFFICIENT ASYM CHILL TO LOCATIONS REFER TO KEYED NOTE 1 ON THIS SHEET FOR FURTHER DETAILS.
    - b. CAS AND SEAL ARISING FROM MANUFACTURER'S CABLE PER NEC REQUIREMENTS FOR HAZARDOUS LOCATION AREAS.
    - c. CONTRACTOR SHALL PROVIDE THE FOLLOWING NEW WORK PRIOR TO DEMOLITION OF EXISTING EQUIPMENT:
      - i. CAS AND SEAL ARISING FROM MANUFACTURER'S CABLE PER NEC REQUIREMENTS FOR HAZARDOUS LOCATION AREAS.
      - ii. CONTRACTOR SHALL PROVIDE THE FOLLOWING NEW WORK PRIOR TO DEMOLITION OF EXISTING EQUIPMENT:
        - j. PROVIDE NEW SEAL CONDUIT BODIES AT LOCATIONS SHOWN EXISTING.
        - k. RELOCATED EXISTING SERVICE EXHAUST/PANELBOARD AND ELECTRICAL PULL BOX.
  2. PROVIDE NEW CONDUIT AND EXPLOSION PROOF JUNCTION BOXES TO LOCATION SHOWN ON SHEET.
  3. PROVIDE NEW CONDUIT AND EXPLOSION PROOF JUNCTION BOXES TO LOCATION SHOWN ON SHEET.
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  17. PROVIDE NEW CONDUIT AND EXPLOSION PROOF JUNCTION BOXES TO LOCATION SHOWN ON SHEET.

**CITY OF TEMPE**  
DIVISION OF ENGINEERING

**CDM Smith**  
PROJECT NO. 802-263-1100  
DATE: JANUARY 2013  
SCALE: E-6

**ELECTRICAL POWER AND LIGHTING PLANS**

PROJECT NO. 802-263-1100  
DATE: JANUARY 2013  
SCALE: E-6

CONTRACTOR SHALL COORDINATE NEW ELECTRICAL WORK WITH ALL OTHER ASSOCIATED DISCIPLINES.

CONTRACTOR SHALL COORDINATE NEW ELECTRICAL WORK WITH ALL OTHER ASSOCIATED DISCIPLINES.

CONTRACTOR SHALL SEAL-OFF ALL CONDUITS LOCATED WITHIN HAZARDOUS LOCATION AREAS PER NEC.

JUNCTION BOXES, PULL BOXES AND SWITCHES LOCATED WITHIN HAZARDOUS LOCATIONS SHALL BE NEMA 7 EXPLOSION PROOF.

IF A TERMINATION IS REQUIRED BY VENDOR PERMANENTLY LOCATED WITHIN HAZARDOUS LOCATION AREAS PER NEC, THE TERMINATION SHALL BE NEMA 7 EXPLOSION PROOF.

CONDUIT ENDINGS SHALL BE DISCONTINUED AT THE FIELD.

CONTRACTOR SHALL FIELD IDENTIFY ALL PANELS AND COORDINATE WITH OWNER PRIOR TO BEGINNING ANY ELECTRICAL WORK.

REFER TO SHEET E-3 FOR CONDUIT AND WIRE SCHEDULE.

CONTRACTOR SHALL PROVIDE THE FOLLOWING NEW WORK PRIOR TO DEMOLITION OF EXISTING EQUIPMENT:

CABLE: PROVIDE NEW CONDUIT AND NEW ADIM MANUFACTURER'S CABLE WITHOUT SPLICE FROM EXISTING ADIM PANEL TO EXISTING EXPLOSION PROOF SUFFICIENT ASYM CHILL TO LOCATIONS REFER TO KEYED NOTE 1 ON THIS SHEET FOR FURTHER DETAILS.

CAS AND SEAL ARISING FROM MANUFACTURER'S CABLE PER NEC REQUIREMENTS FOR HAZARDOUS LOCATION AREAS.

CONTRACTOR SHALL PROVIDE THE FOLLOWING NEW WORK PRIOR TO DEMOLITION OF EXISTING EQUIPMENT:

CAS AND SEAL ARISING FROM MANUFACTURER'S CABLE PER NEC REQUIREMENTS FOR HAZARDOUS LOCATION AREAS.

**City of Tempe**

**TP-03 Metering Station Improvements**

**Project No. 3202551**

**Work Order Directive**

04-17-13

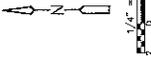
Attached drawing M-2 shows color mark-ups of changes required for HVAC and Plumbing

Attached drawing C-2 shows changes to the new site plan. Revised plan clouded.

Attached sketch SK-1, SK-2 and SK-3 provide details for intake and exhaust structure

The following work order directive includes the following changes:

- Civil changes include:
  - Sidewalk alignment
  - Location and stationing of sidewalk and exhaust/intake structures.
  - Deletion of exhaust structure and addition of modifications to existing intake structure
  - Deletion of intake louver structure and addition of intake vault structure.
  - Extending length of gutter repair
  - New 4" PVC drain line between intake structure and exhaust structure.
- Structural changes include:
  - Replace intake louver structure with intake vault structure per attached sketch SK-1 & SK-2.
  - Eliminate exhaust louver structure and modified existing intake per sketch SK-3.
  - Eliminate the new concrete infill slab over the existing intake from drawings.
  - Eliminate detail G/S-5 from drawings.
  - Eliminate new slab over existing intake and infill existing intake wall. See sketch SK-3 for new wall infill.
  - Core two openings for 4" drain line and linked rubber seal.
- Building Mechanical changes include:
  - Provide 4" PVC drain line from intake vault to exhaust vault.
  - Revise ductwork fittings as required. See M-2 for additional information.
  - Revise exhaust and intake buried ductwork to 18" nominal diameter.

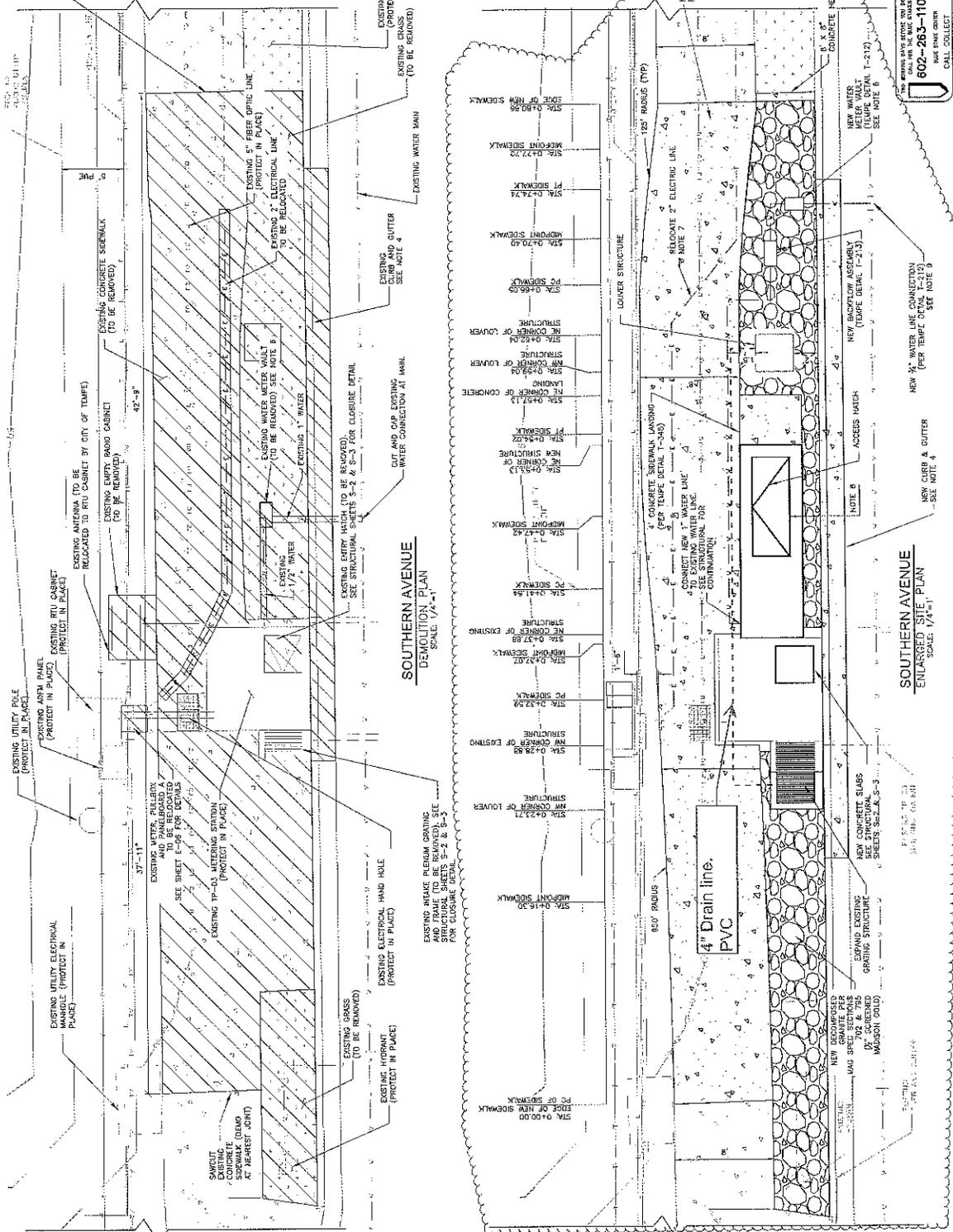


REMOVE EXISTING  
CONCRETE (BEAD AT NEAREST  
JOINT)

- NOTES:**
- CONTRACTOR SHALL FIELD VERIFY ALL EXISTING UTILITIES WITHIN THE LIMITS OF CONSTRUCTION. EXISTING UTILITIES UNLESS OTHERWISE NOTED IN DRAWING.
  - ALL DISTURBED LANDSCAPE TO ORIGINAL CONDITION INCLUDING IRRIGATION SYSTEM, GRASS, TREES AND SHRUBS TO BE REINSTALLED. GUTTER PER AS SHOWN (TO BE REMOVED).
  - WHERE EXISTING CURB AND GUTTER IS DISTURBED EXISTING SPRINKLERS TO BE RELOCATED IN FIELD BY CONTRACTOR. CONTRACTOR SHALL FIELD VERIFY LOCATION OF SPRINKLERS PRIOR TO CONSTRUCTION.
  - WATER MAIN TO BE RELOCATED BY CITY. WATER CONTRACTOR SHALL COORDINATE RELOCATED CURB AND GUTTER WITH WATER MAIN WITH CITY. WATER MAIN SHALL BE 2" DIAMETER FROM BACK OF CURB. CONTRACTOR SHALL VERIFY MAIN WITH WITNESS LINE 7AP.
  - WITNESS LINE 7AP.

**LEGEND:**

- CENTER LINE
- PROPERTY LINE
- PUBLIC UTILITY EASEMENT (PUE)
- EXISTING IRRIGATION LINE
- EXISTING TELEPHONE LINE
- EXISTING TELEVISION LINE
- EXISTING FIBER OPTIC LINE
- EXISTING SEWER LINE
- EXISTING WATER LINE
- EXISTING GAS LINE
- EXISTING ELECTRICAL LINE
- NEW ELECTRICAL LINE
- NEW WATER LINE
- EXISTING HYDRANT
- EXISTING SIDEWALK
- NEW SIDEWALK
- DEMOLITION
- DECOMPOSED GRANITE



**SOUTHERN AVENUE  
DEMOLITION PLAN**  
SCALE: 1/4"=1'-1"

**SOUTHERN AVENUE  
ENLARGED SITE PLAN**  
SCALE: 1/4"=1'-1"



10000 N. CENTRAL EXPRESSWAY, SUITE 1000  
PHOENIX, AZ 85020  
TEL: 602-998-8800  
WWW.CDMSMITH.COM

**CITY OF TEMPE  
DIVISION OF ENGINEERING**

**ENLARGED SITE PLAN  
& DEMOLITION PLAN**

PROJECT NO. 2015-0000000000  
DRAWING NO. C-2  
SHEET 3 OF 13

THE ENGINEER HAS REVIEWED THIS PLAN AND SHALL BE RESPONSIBLE FOR THE ACCURACY OF THE INFORMATION SHOWN HEREON.  
602-263-1100  
CALL COLLECT

NEW 1/2" WATER MAIN CONNECTION (PER TEMP DETAIL T-212) SEE NOTE 9

NEW CURB & GUTTER SEE NOTE 4

NEW BACKFLOW ASSEMBLY (TEMP DETAIL T-213) SEE NOTE 6

NEW CONCRETE SLABS SEE STRUCTURE SHEETS S-2, S-3

NEW GRANITE PEDS AND SPILL SECTIONS BY SCREENED GRANITE STRUCTURE (MARRON GOLD)

NEW 4\"/>

NEW 1/2\"/>

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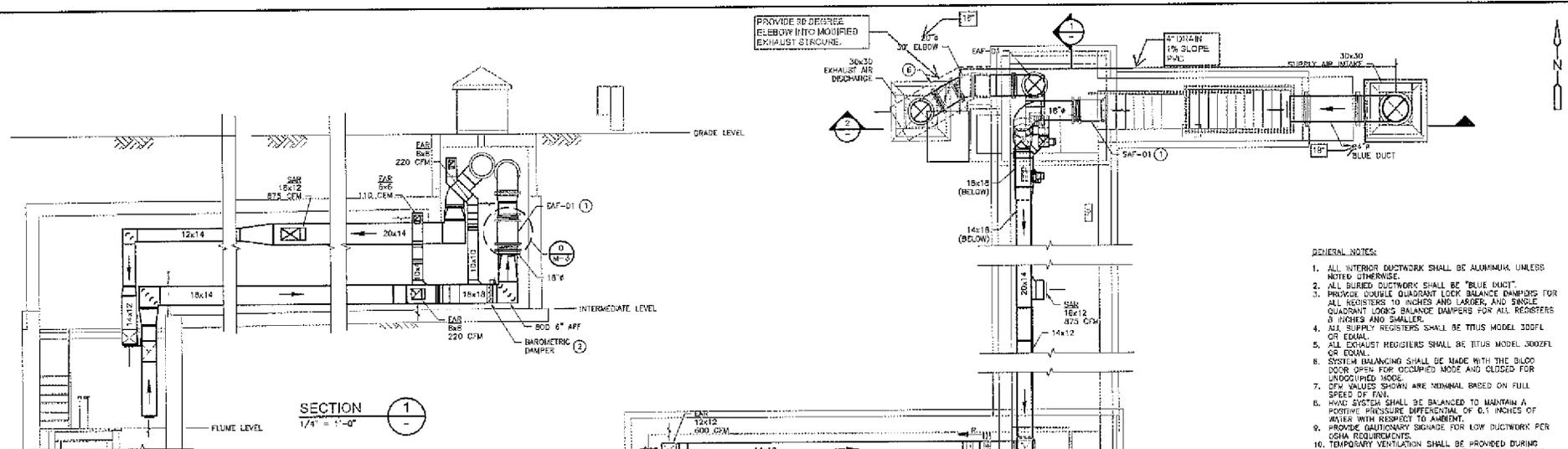
NEW CURB & GUTTER SEE NOTE 4

NEW BACKFLOW ASSEMBLY (TEMP DETAIL T-213) SEE NOTE 6

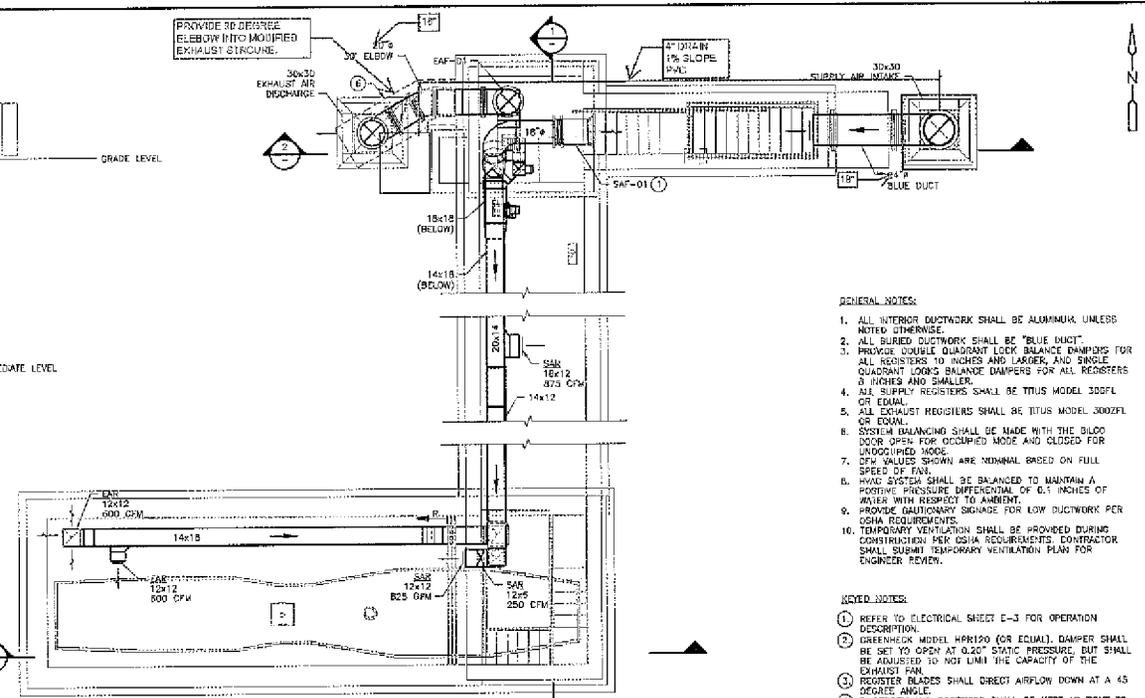
NEW CONCRETE SLABS SEE STRUCTURE SHEETS S-2, S-3

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NEW 4\"/>



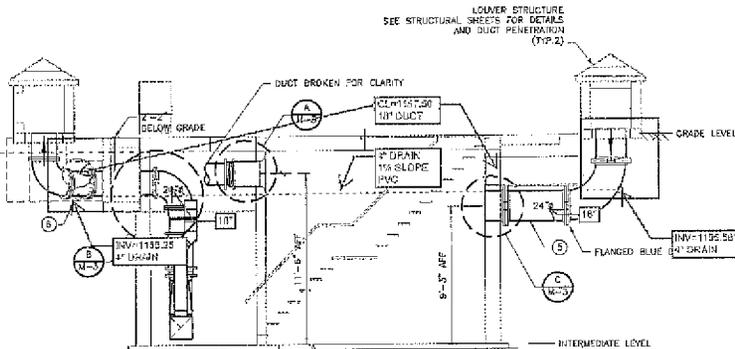
SECTION 1  
1/4" = 1'-0"



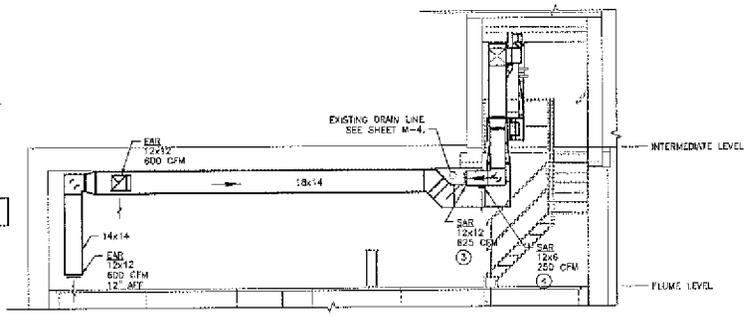
PLAN  
1/4" = 1'-0"

- GENERAL NOTES:
1. ALL INTERIOR DUCTWORK SHALL BE ALUMINUM, UNLESS NOTED OTHERWISE.
  2. ALL BURIED DUCTWORK SHALL BE "BLUE DUCT".
  3. PROVIDE DOUBLE QUADRANT LOCK BALANCE DAMPERS FOR ALL REGISTERS 10 INCHES AND LARGER, AND SINGLE QUADRANT LOCK BALANCE DAMPERS FOR ALL REGISTERS 8 INCHES AND SMALLER.
  4. ALL SUPPLY REGISTERS SHALL BE TITUS MODEL 300FL OR EQUAL.
  5. ALL EXHAUST REGISTERS SHALL BE TITUS MODEL 300EFL OR EQUAL.
  6. SYSTEM BALANCING SHALL BE MADE WITH THE BILCO DOOR OPEN FOR OCCUPIED MODE AND CLOSED FOR UNOCCUPIED MODE.
  7. DFM VALUES SHOWN ARE NOMINAL BASED ON FULL SPEED OF FAN.
  8. HVAC SYSTEM SHALL BE BALANCED TO MAINTAIN A POSITIVE PRESSURE DIFFERENTIAL OF 0.1 INCHES OF WATER WITH RESPECT TO AMBIENT.
  9. PROVIDE CAUTIONARY SIGNAGE FOR LOW DUCTWORK PER OSHA REQUIREMENTS.
  10. TEMPORARY VENTILATION SHALL BE PROVIDED DURING CONSTRUCTION PER OSHA REQUIREMENTS. CONTRACTOR SHALL SUBMIT TEMPORARY VENTILATION PLAN FOR ENGINEER REVIEW.

- KEYED NOTES:
1. REFER TO ELECTRICAL SHEET E-3 FOR OPERATION DESCRIPTION.
  2. GREENHECK MODEL HP1010 (OR EQUAL). DAMPER SHALL BE SET TO OPEN AT 0.2" STATIC PRESSURE, BUT SHALL BE ADJUSTED TO NOT EXCEED THE CAPACITY OF THE EXHAUST FAN.
  3. REGISTER BLADES SHALL DIRECT AIRFLOW DOWN AT A 45 DEGREE ANGLE.
  4. DUCTWORK AND REGISTERS SHALL BE KEPT AS TIGHT TO THE CEILING AS POSSIBLE, AND SHALL NOT BE LOWER THAN 8'-0" ABOVE FINISHED FLOOR.
  5. DUCT SHALL BE SLOPED 1/8" PER FOOT TO DRAIN TOWARD THE MECH STRUCTURE.
  6. DUCT TO BE ENCASED IN CONCRETE. SEE STRUCTURAL DETAIL H ON SHEET S-5.



SECTION 2  
1/4" = 1'-0"

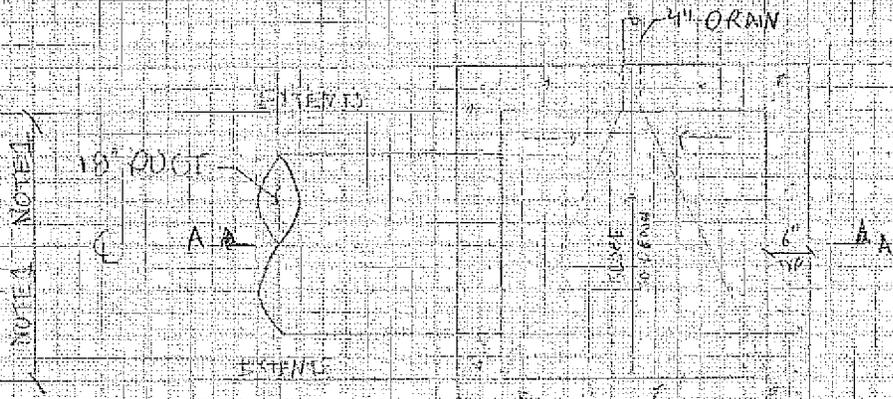
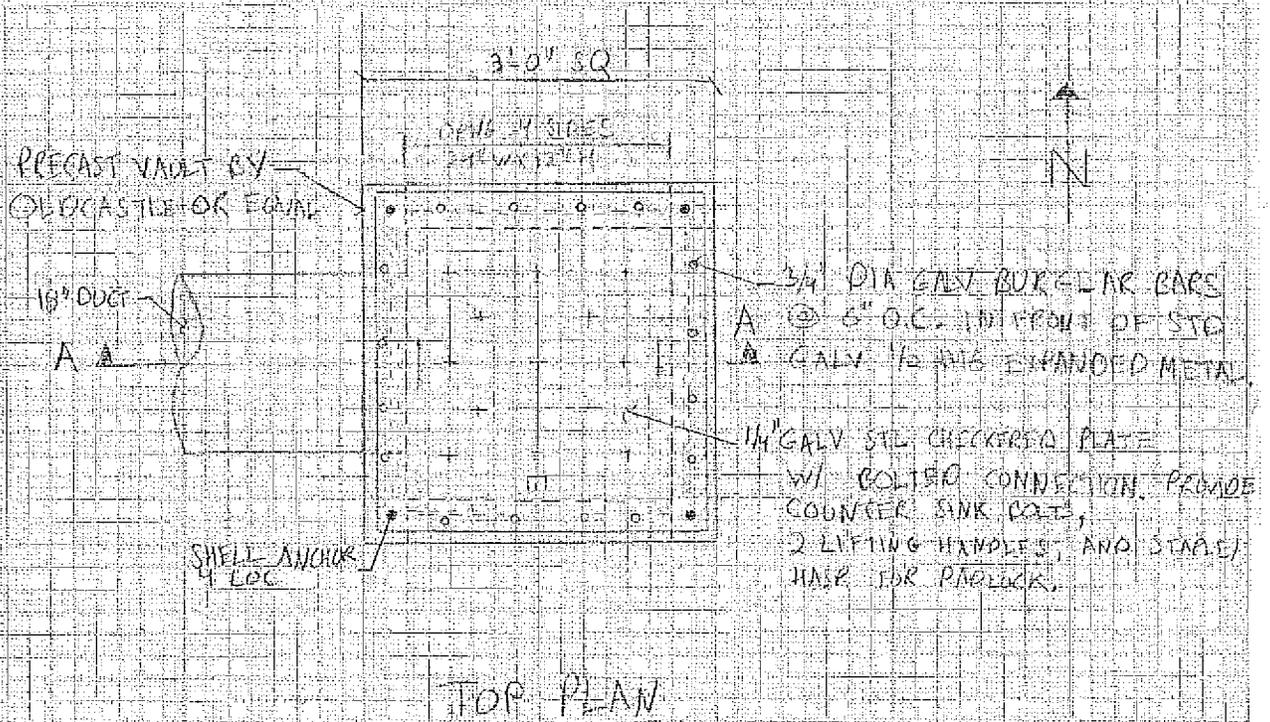


SECTION 3  
1/4" = 1'-0"



NO WORKING DAYS BEFORE THE BIG DALL FOR THE BIG DALL  
**602-263-1100**  
 DALL FROM CENTER  
 CALL COLLECT

NO.	REVISION	DATE	BY
DEPARTMENT OF PUBLIC WORKS <b>CITY OF TEMPE</b> DIVISION OF ENGINEERING P.O. BOX 5000, TEMPE, ARIZONA 85280			
SURVEYED: 3/24 DESIGNED: CJS DRAWN: MSH CHECKED: CJS SCALE: AS NOTED		CDM Smith PROJECT NO. 1225-02266 PROJECT: 1225021 DRAWING NO. <b>M-2</b> SHEET 16 OF 18	

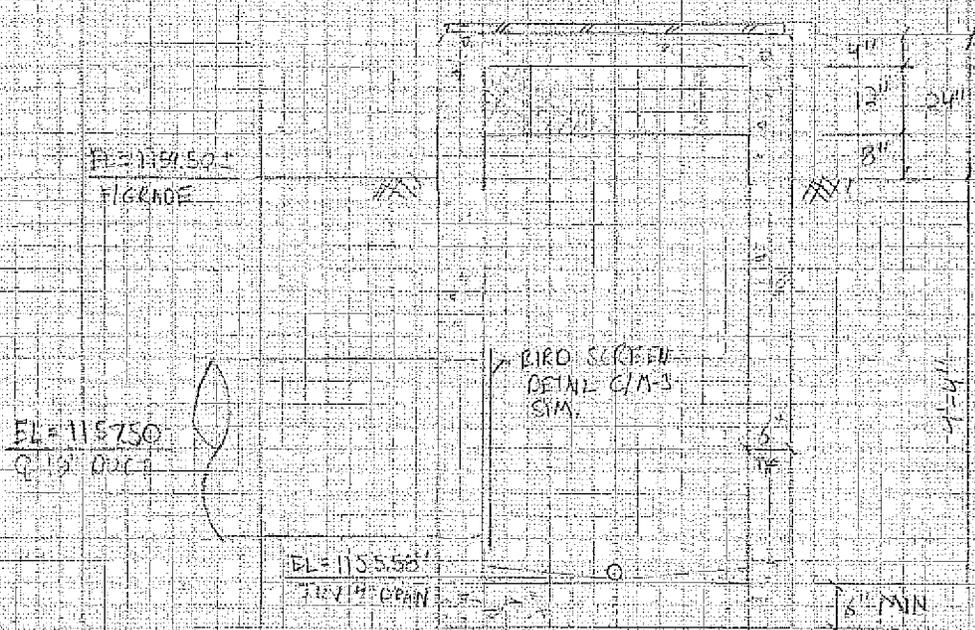


NOTES  
 1. COORDINATE LOCATION OF PENETRATION W/ CIVIL.

FOUNDATION PLAN

INTAKE STRUCTURE PLANS

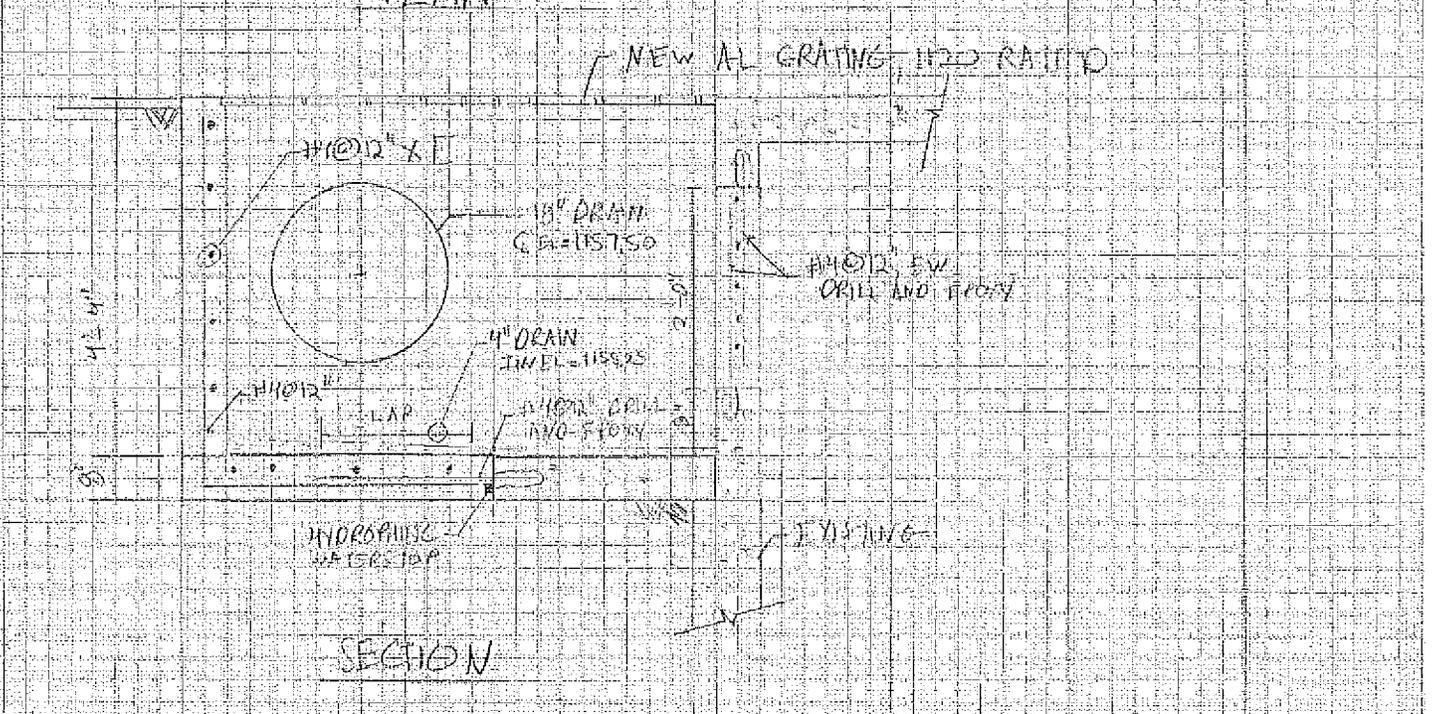
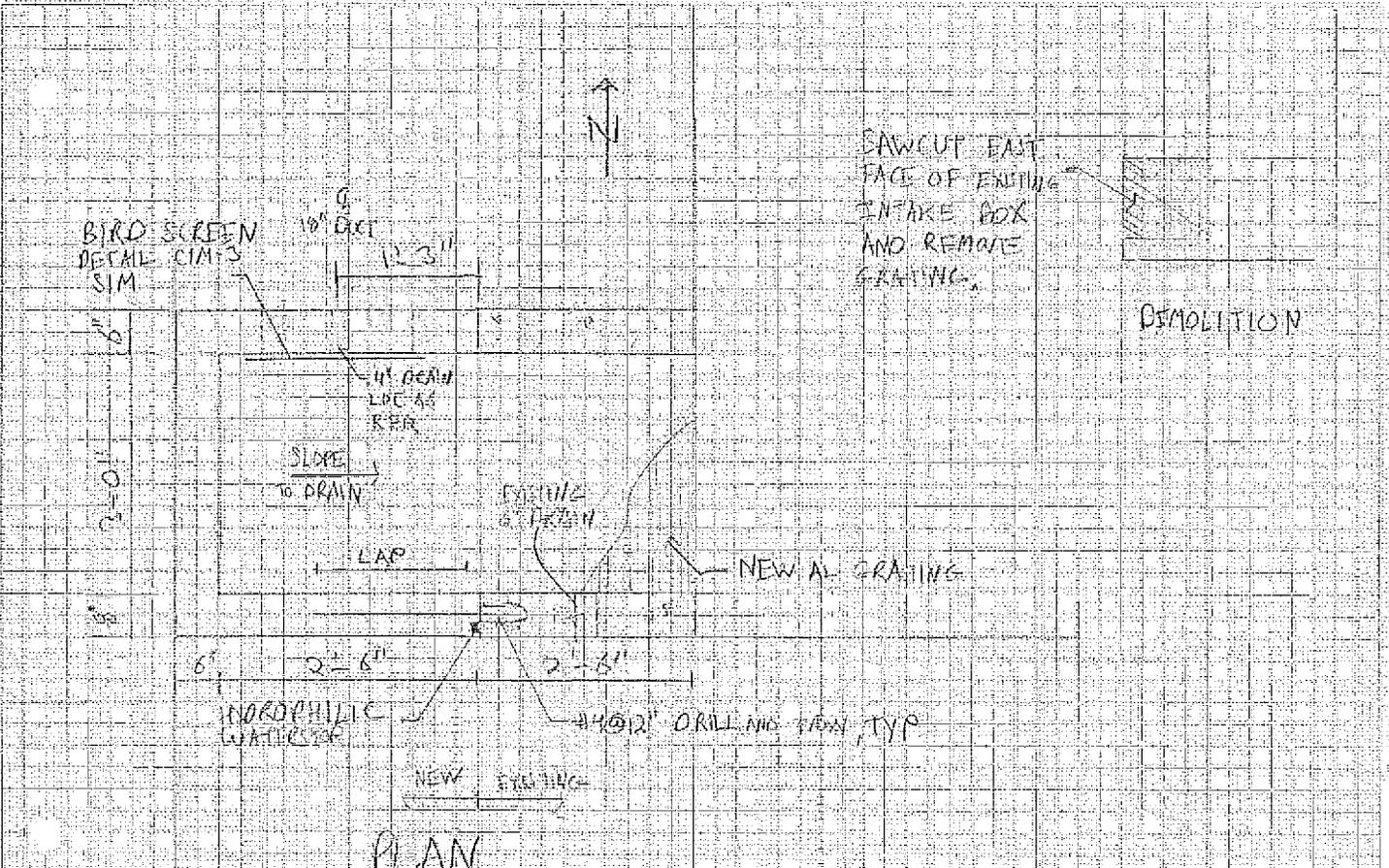
SKETCH  
 SK-1



SECTION A-A

INTAKE STRUCTURE SECTION

SKETCH  
SK-2



EXHAUST STRUCTURE MODIFICATIONS

SKETCH  
SK-3