

~~~~~ **PROJECT NOTE** ~~~~~

ARCHITECT OF RECORD/ENGINEER OF RECORD IS RESPONSIBLE FOR REVIEWING THIS SPECIFICATION SECTION IN DETAIL FOR COORDINATION WITH THE PROJECT SCOPE OF WORK.

ALL "PROJECT NOTE" TEXT IS TO BE REMOVED FOLLOWING REVIEW OF THE CONTENT OF EACH NOTE BY THE ARCHITECT OF RECORD/ENGINEER OF RECORD.

EDIT THE DOCUMENT FOOTER TO INCLUDE THE PROJECT NAME AND NUMBER.

EDIT THE DOCUMENT HEADER TO INDICATE THE ARCHITECT OF RECORD PROJECT ISSUE" DATE. THE "CPS CONTROL" DATE SHOULD NOT BE EDITED.

ANY MODIFICATIONS TO THE TECHNICAL STANDARDS IN THIS SECTION - INCLUDING THE REMOVAL OR ADDITION OF MANUFACTURERS - MUST BE APPROVED BY CPS. REQUESTS FOR MODIFICATION ARE TO BE SUBMITTED TO THE DESIGN MANAGER DURING THE DESIGN PHASE FOR REVIEW AND APPROVAL.

~~~ **END OF PROJECT NOTE** ~~~~

SECTION 26 29 23

VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Variable-frequency controllers (VFC).

1.02 REFERENCE STANDARDS

- A. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink); 2020.
- B. IEEE 519 - IEEE Standard for Harmonic Control in Electric Power Systems; 2022.
- C. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2008 (Reaffirmed 2020).
- D. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems; 2022.
- E. NEMA ICS 7 - Industrial Control and Systems: Adjustable-Speed Drives; 2020.
- F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- G. NEMA MG 1 - Motors and Generators; 2021.
- H. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems; 2021.
- I. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. Shop Drawings:

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1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current rating of integrated unit.
 - d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

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CPS HAS EXPERIENCED SIGNIFICANT FAILURE WITH VFDS OVER THE YEARS. EOR SHALL INCLUDE ON DESIGN DRAWINGS, THE ONE LINE ELECTRICAL DIAGRAM, DETAILED ENOUGH FOR VFD MANUFACTURER TO PROVIDE AN IEEE 519 CALCULATION. 519 CALCULATIONS SHALL IDENTIFY ALL HARMONIC MITIGATION/POWER QUALITY CORRECTION REQUIRED FOR EACH VFD.

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3. Provide IEEE 519 calculation identifying all required harmonic mitigation/power quality correction required for each project VFD.
- D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- E. Qualification Data: For manufacturer and testing agency.
- F. Field Quality-Control Test Reports: Submit reports documenting the activities performed. These reports are to be submitted two weeks after startup is completed.
- G. Training Reports: Submit reports on training documenting dates and attendance.
- H. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.
- I. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.

1.04 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Award the work to a single firm that specializes in the production of variable frequency drives, with not less than 5 years experience in the production of variable frequency drives similar in design and performance to those required for the Project, and whose work has resulted in a history of successful in-service performance. The manufacturer shall have sufficient production capacity, and have organized quality control and testing procedures, to be capable of producing the equipment required for the Project without causing a delay in the Work. The manufacturer shall maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- C. Products: Listed, classified, and labeled as suitable for the purpose intended.

- D. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing.
- E. Source Limitations: Obtain all VFCs required for the Project through one source from a single manufacturer.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- G. Regulatory Requirements: Comply with the Chicago Building Code, including requirements for components and installation.
- H. Comply with IEEE 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."

1.05 COORDINATION

- A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances, including clearances required for maintenance, and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Deliver setting templates in time to allow casting of anchor-bolt inserts into bases.
- C. Coordinate features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- D. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.06 COORDINATION WITH ENERGY MANAGEMENT SYSTEM

- A. General: The equipment specified in this Section is required to be interfaced with the Energy Management System (EMS) as specified in Division 23 Section "Building Automation System." Provide all devices, hardware, programming, startup and commissioning required to establish the interface. Provide equipment with a BACnet IP interface. If a BACnet IP interface is not an option BACnet MS/TP is acceptable.
- B. Coordinate with EMS supplier for their review and acceptance of the communications interface to be provided. Include evidence of the coordination and review process with the required submittals for this Section.
- C. Provide a list of all read/write and read-only points available through the user interface. Provide software, hardware or paperwork that the contractor installing the EMS will require in order to accomplish the interface.
- D. The equipment supplier is solely responsible for the proper performance of their equipment provided the correct information is provided through the communications interface.
- E. Provide a prefunctional checklist, startup checklist and demonstration report to the Engineer, Commissioning Agent, or Board Authorized Representative for acceptance of system.
- F. Provide a startup technician on-site during the establishment of the interface. Coordinate this activity with the EMS installer.
- G. BACNet IP compliant manufacturer-provided controls

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1. Provide any information necessary to allow the BACNet compliant device to be directly connected to the existing network, and send/receive information to the system installed under Division 23 sections.
2. The EMS shall then read and present the information made available by the equipment manufacturer, and transmit information receivable by the equipment manufacturer. This shall be accomplished by user configuration of point information, but shall not require recompiling or downloading of control programs.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store VFCs in manufacturer's original protective packaging, with original labels detailing contents intact. Store VFCs indoors, off of ground, under cover, in clean, dry location with uniform temperature and humidity to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

1.08 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer's Warranty: Manufacturer agrees to repair or replace components or equipment that fail in materials or workmanship within the specified warranty period. Manufacturer's warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer in providing on-site service and repair or replacement.
 1. Warranty Period: Five years from the date of Preliminary Acceptance.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Design - Environmental: Equipment shall be rated for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
 1. Temperature Range, Ambient: 32 deg F to 105 deg F.
 2. Relative Humidity: Less than 90 percent (noncondensing).
 3. Altitude: Not exceeding 3300 feet.
 4. Conditions: Winter: -10 deg F DB; Summer: 95 deg F DB / 75 deg F WB.
- B. Noise: The VFC shall not produce motor noise in excess of the manufacturers published noise standards for 60 Hz operation.

2.02 MANUFACTURERS

- A. Variable-Frequency Motor Controllers:
 1. ABB: www.new.abb.com
 2. Danfoss: www.danfoss.com
 3. LS Drives:
 4. Yaskawa America, Inc; : www.yaskawa.com

2.03 DESCRIPTION

- A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
 1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.
- B. Enclosures:
 1. Indoor/Dry Application: NEMA 250, Type 1, suitable for equipment application in dry conditions. Suitable for places restricted to persons employed on the premises.

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2. Outdoor/Wet Application: NEMA 3R, suitable for equipment application in places outside or in areas with high humidity or high chance of water contact.
 - C. All PWM AC Variable Frequency Drives of 40 hp and above shall be equipped with harmonic mitigation equipment to prevent power system problems resulting from high levels of reflected harmonic distortion. Provide harmonic mitigation for drives less than 40 hp where required to meet IEEE 519.
 1. The harmonic mitigation equipment shall treat all of the characteristic low frequency harmonics generated by a 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.).
 2. The characteristic harmonics shall be suppressed without the need for individual tuning or the requirement to phase shift against other harmonic sources.
 3. Harmonic mitigation shall be by passive inductor/capacitor network or internal phase shifting transformer. Active electronic components shall not be used.
 4. Power factor shall be 0.98 lagging to 0.95 leading in operating range from full to half load.
 5. To ensure compatibility with engine generators, the harmonic mitigation equipment must never introduce a capacitive reactive power (KVAR) that is greater than 15% of its kVA rating.
 6. The harmonic mitigation equipment shall not resonate with system impedances or attract harmonic currents from other harmonic sources.
 7. The harmonic mitigation equipment in combination with the Variable Frequency Drive shall meet all requirements of IEEE 519 for individual and total harmonic voltage and current distortion. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment.
 8. Provide IEEE 519 calculation identifying all required harmonic mitigation/power quality correction required for each project VFD.
 9. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. These limits shall apply while operating on either utility supply or generator supply when applicable. The harmonic mitigation equipment vendor shall not be responsible for pre-existing voltage distortion caused by other harmonic sources.
 10. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE 519 . For I_{sc}/I_l ratio < 20 , TDD must be less than 5%. For all other I_{sc}/I_l ratios, the TDD must not exceed 8% even when Table 10.3 allows for more relaxed limits. For single-phase applications, the TDD must not exceed 12%.
 11. The full load efficiency of the harmonic mitigation equipment / VFD combination shall be greater than 96%. The harmonic mitigation equipment itself shall have efficiency no less than 99%.
 - D. Design and Rating: Match load type such as fans, blowers, and pumps, and type of connection used between motor and load, such as direct or through a power-transmission connection.
- 2.04 OPERATING REQUIREMENTS
- A. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
 - B. Input ac voltage ranges of 208 V, plus or minus 10 percent or 480 V, plus or minus 10 percent as indicated on equipment schedules.
 - C. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.

- D. Minimum Efficiency: 96 percent at 60 Hz, full load.
- E. Minimum Displacement Primary-Side Power Factor: 96 percent.
- F. Overload Capability: 1.2 times the base load current for 60 seconds; 1.8 times the base load current for 3 seconds.
- G. Starting Torque: 100 percent of rated torque or as indicated.
- H. Speed Regulation: Plus or minus 1 percent.

2.05 COMPONENTS AND FEATURES

- A. Isolated Control Interface: To allow controller to follow control signal over an 11:1 speed range.
 - 1. Electrical Signal: 4 to 20 mA at 24 V OR 0-10VDC.
- B. Internal Adjustability Capabilities:
 - 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3. Acceleration: 2 to a minimum of 22 seconds.
 - 4. Deceleration: 2 to a minimum of 22 seconds.
 - 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- C. Self-Protection and Reliability Features:
 - 1. Input transient protection by means of surge suppressors.
 - 2. Under- and overvoltage trips; inverter over-temperature, overload, and overcurrent trips.
 - 3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 10 performance.
 - 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 - 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 - 6. Loss-of-phase protection.
 - 7. Reverse-phase protection.
 - 8. Short-circuit protection.
 - 9. Motor over temperature fault where motor is equipped with RTD.
- D. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.
- E. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- F. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
- G. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- H. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- I. Input Line Conditioning: dc bus link reactors, isolation transformers, active and passive harmonic filters, and phase shifting transformers.
- J. VFD Output Filtering: Line inductors, output limit filters, sine wave filters, and motor termination filters shall be provided where the motor to drive conductor lengths exceed manufacturer's recommended lengths.

- K. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
 - 1. Power on.
 - 2. Run.
 - 3. Overvoltage.
 - 4. Line fault.
 - 5. Overcurrent.
 - 6. External fault.
- L. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- M. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
 - 1. Output frequency (Hz).
 - 2. Motor speed (rpm).
 - 3. Motor status (running, stop, fault).
 - 4. Motor current (amperes).
 - 5. Motor torque (percent).
 - 6. Fault or alarming status (code).
 - 7. PID feedback signal (percent).
 - 8. DC-link voltage (VDC).
 - 9. Set-point frequency (Hz).
 - 10. Motor output voltage (V).
- N. Control Signal Interface:
 - 1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
 - 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the EMS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
 - 3. Output Signal Interface:
 - a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
 - 4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.

- b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- O. Communications: Provide a BACnet IP interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via EMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- P. Integral Disconnecting Means: NEMA AB 1, molded-case switch with lockable handle.
- Q. Operation and Maintenance Features:
 - 1. Current-Voltage-Frequency Indicating Devices: Mount meters or digital readout device and selector switch flush in controller door and connect to indicate controller output.
 - 2. Manual Bypass: Magnetic contactor arranged to safely transfer the motor from the controller to the power line, or from the line to the controller while the motor is at zero speed. Include VFC-bypass selector switch and indicator lights to indicate mode selection. The operator shall have full control of the bypass starter by operation of the selector switch.
 - 3. Integral Main Disconnect: Circuit breaker connected to shut down all power to both the controller and the bypass. Interlock breaker with cabinet door.
 - 4. Auxiliary Motor Contactors: Electrically interlocked. One contactor connected between the controller output and the motor, controlled by the controller regulator; and one between the bypass power line and the motor, providing across-the-line starting capability in the bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.
 - 5. Isolating Circuit Breaker: Arranged to electrically isolate the variable-speed controller to permit safe trouble-shooting and testing of the controller, both energized and de-energized, while the motor is operating in the bypass mode.
 - 6. Form C output contacts for run and fault conditions.
 - 7. Terminal strip for N.C. safety shutdown contacts.
 - 8. N.C. input for remote start/stop control in Auto mode.
- R. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- S. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- T. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- U. Standard Displayed information, display shall be interchangeable for all VFDs installed:
 - 1. Output frequency (Hz).
 - 2. Set-point frequency (Hz).
 - 3. Motor current (amperes).
 - 4. DC-link voltage (VDC).
 - 5. Motor torque (percent).
 - 6. Motor speed (rpm).
 - 7. Motor output voltage (V).
 - 8. Fault history with analytical data.
- V. Historical Logging Information and Displays:
 - 1. Real-time clock with current time and date.

2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- W. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M.

2.06 FINISH

- A. Finish: Manufacturer's standard paint finish, applied to factory-assembled and -tested VFCs.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that mounting surfaces are ready to accept controllers.
- B. Verify that conditions are satisfactory for installation prior to starting work.
- C. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.
- D. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.
- E. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Harmonic Analysis: Obtain the electrical system one-line diagram from the contract document, provide a harmonic analysis demonstrating that the proposed VFDs (along with harmonic mitigation equipment provided) conform with IEEE 519.

3.03 SELECTION

- A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, minimum clearances between VFDs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.
- B. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.
- C. Select horsepower rating of controllers to suit motor controlled.

3.04 INSTALLATION

- A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- B. Tighten accessible connections and mechanical fasteners after placing controller.
- C. Anchor each VFD assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.
- D. Install VFDs on concrete bases where indicated to be installed on the floor. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- E. VFD's are not to be installed inside air handlers or air plenums due to the potentially high humidity or temperatures.
- F. Install wiring between VFCs and remote devices according to Division 26 sections. Power and control wiring shall not be run in the same conduit, and shall follow manufacturer's recommendations.
- G. Bundle, train, and support wiring in enclosures.
- H. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.
 - I. Install conduit and ground equipment in accordance with Division 26 sections.
- 3.05 ADJUSTING
- A. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.
 - B. Set field-adjustable switches and circuit-breaker trip ranges.
- 3.06 CONTRACTOR STARTUP AND REPORTING
- A. Prepare for acceptance tests as follows:
 1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
 - B. Reports: Prepare written reports certified by testing organization of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made. Harmonic compliance shall be verified with on-site field measurements of both the voltage and current harmonic distortion at the input terminals of the harmonic mitigating equipment with and without the equipment operating. A recording type Fluke 41 or equivalent harmonics analyzer displaying individual and total harmonic currents and voltages must be utilized.
 - C. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
 3. Prepare written reports.
 - D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
 1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- 3.07 DEMONSTRATION AND COMMISSIONING
- A. Engage a factory-authorized service representative to train Board's maintenance personnel to adjust, operate, and maintain air handling units.
 1. Train Board's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the equipment. The training will occur after the startup report has been provided to the Board and the trainer will provide two (2) Installation and Operations manuals for the use of the Board's personnel during training.
 2. Review data in maintenance manuals. Refer to Section 01 78 00 - Closeout Submittals. All required and recommended maintenance will be reviewed as well as operational

troubleshooting. If the IOM does not include a written troubleshooting guide one shall be provided.

3. Schedule training with Board, through Architect/Engineer of Record, with at least seven days' advance notice.
- B. Demonstrate proper operation of equipment to commissioning agent or Board's designated personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Divisions 01 and 23 sections.

END OF SECTION

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