PROJECT MANUAL FOR:
UNIVERSITY OF MISSOURI TEACHING HOSPITAL – NORMAL POWER UPGRADE

PROJECT NUMBER: CP191241

AT
UNIVERSITY OF MISSOURI
COLUMBIA, MISSOURI

FOR:

THE CURATORS OF THE UNIVERSITY OF MISSOURI

PREPARED BY:

Burns & McDonnell Engineering Company, Inc.
Reid DeBaun
9400 Ward Parkway
Kansas City, MO  64114
816-333-9400

DATE:  November 18, 2019

ISSUED FOR BID
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I hereby certify that these Drawings A-001, A-002, A-101 and Specifications Division 04, Division 07, Division 08, and Division 09 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and/or Specifications are as required by and in compliance with Building Codes of the University of Missouri.

Signature: ____________________________

STATE OF MISSOURI
ARCHITECT
MARK ANDREW OQUIST
NUMBER A-201201409

11-11-19
I hereby certify that these Drawings M-001, M-101, M-501, M-502, M-701, M-702, P-001, P-101, F-001, F-101 and Specifications Division 22 and Division 23, excluding section 230940 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and/or Specifications are as required by and in compliance with Building Codes of the University of Missouri.

Signature: ____________________________

I hereby certify that these Drawings E-001, E-101, E-102, E-103, E-104, E-105, E-106, E-107, E-108, E-501, E-502, E-503, E-601, E-701 and Specifications Division 26 and Division 33, excluding sections 260800, 260813, and 260816 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and/or Specifications are as required by and in compliance with Building Codes of the University of Missouri.

Signature: ____________________________
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIVISION 1</strong></td>
<td><strong>GENERAL REQUIREMENTS</strong></td>
</tr>
<tr>
<td>Advertisement for Bids</td>
<td></td>
</tr>
<tr>
<td>1.B</td>
<td>Bidder's Statement of Qualifications</td>
</tr>
<tr>
<td>1.B.2</td>
<td>Supplier Diversity Compliance Evaluation</td>
</tr>
<tr>
<td>1.B.3</td>
<td>Application for Waiver</td>
</tr>
<tr>
<td>1.B.4</td>
<td>Affidavit for Affirmative Action</td>
</tr>
<tr>
<td>1.B.5</td>
<td>Certifying Supplier Diversity Agencies</td>
</tr>
<tr>
<td>1.B.6</td>
<td>Newspapers for Outreach to Diverse Suppliers</td>
</tr>
<tr>
<td>1.B.7</td>
<td>Affidavit of Supplier Diversity Participation</td>
</tr>
<tr>
<td>1.C</td>
<td>Information for Bidders</td>
</tr>
<tr>
<td>1.D</td>
<td>General Conditions</td>
</tr>
<tr>
<td>1.E</td>
<td>Special Conditions</td>
</tr>
<tr>
<td>1.E.1</td>
<td>Healthcare Construction Safety Requirements</td>
</tr>
<tr>
<td>1.E.2</td>
<td>Scheduling Specification</td>
</tr>
<tr>
<td>1.E.5</td>
<td>Shop Drawing and Submittal Log</td>
</tr>
<tr>
<td>1.E.6</td>
<td>Operating Instructions and Service Manual Log</td>
</tr>
<tr>
<td>1.E.7</td>
<td>Closeout Log</td>
</tr>
<tr>
<td>1.E.8</td>
<td>Sustainability Report</td>
</tr>
<tr>
<td>1.F</td>
<td>Index of Drawings</td>
</tr>
<tr>
<td>1.G</td>
<td>Wage Order 26</td>
</tr>
<tr>
<td><strong>01 91 00</strong></td>
<td><strong>General Commissioning Requirements</strong></td>
</tr>
<tr>
<td></td>
<td><strong>(ADDENDUM #1)</strong></td>
</tr>
</tbody>
</table>
DIVISION 2  SITE WORK (NOT USED)
DIVISION 3  CONCRETE (NOT USED)
DIVISION 4  MASONRY
04 22 00  CONCRETE UNIT MASONRY
DIVISION 5  METALS (NOT USED)
DIVISION 6  WOOD AND PLASTICS (NOT USED)
DIVISION 7  THERMAL AND MOISTURE PROTECTION
07 84 13  PENETRATION FIRESTOPPING
DIVISION 8  DOORS, WINDOWS & GLASS
08 11 13  HOLLOW METAL DOORS AND FRAMES
08 71 00  DOOR HARDWARE
DIVISION 9  FINISHES
09 90 00  PROTECTIVE COATINGS
DIVISION 10  SPECIALTIES (NOT USED)
DIVISION 11  EQUIPMENT (NOT USED)
DIVISION 12  FURNISHINGS (NOT USED)
DIVISION 13  SPECIAL CONSTRUCTION (NOT USED)
DIVISION 14  CONVEYING SYSTEMS (NOT USED)
DIVISION 21  FIRE SUPPRESSION (NOT USED)
DIVISION 22  PLUMBING SYSTEMS
22 13 16  SANITARY WASTE AND VENT PIPING
DIVISION 23  MECHANICAL
23 05 13  COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
23 05 19  METERS AND GAGES FOR HVAC PIPING
23 05 23  GENERAL-DUTY VALVES FOR HVAC PIPING
23 05 29  HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
23 05 53  IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
23 05 93  TESTING, ADJUSTING, AND BALANCING
23 07 13  DUCT INSULATION
23 07 19  HVAC PIPING INSULATION
23 09 00  INSTRUMENTATION AND CONTROL FOR HVAC
23 09 40  COMMISSIONING OF MECHANICAL SYSTEMS
23 21 13  HYDRONIC PIPING
23 31 13  METAL DUCTS
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 33 00</td>
<td>AIR DUCT ACCESSORIES</td>
</tr>
<tr>
<td>23 36 00</td>
<td>AIR TERMINAL UNITS</td>
</tr>
<tr>
<td>23 73 13</td>
<td>MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS</td>
</tr>
<tr>
<td>26 05 10</td>
<td>BASIC ELECTRICAL REQUIREMENTS</td>
</tr>
<tr>
<td>26 05 19</td>
<td>LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES</td>
</tr>
<tr>
<td>26 05 26</td>
<td>GROUNDING</td>
</tr>
<tr>
<td>26 05 29</td>
<td>HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 33</td>
<td>RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 53</td>
<td>ELECTRICAL IDENTIFICATION</td>
</tr>
<tr>
<td>26 08 00</td>
<td>ELECTRICAL SYSTEMS COMMISSIONING</td>
</tr>
<tr>
<td>26 08 13</td>
<td>ELECTRICAL SYSTEMS PREFUNCTIONAL CHECKLISTS AND START-UPS</td>
</tr>
<tr>
<td>26 08 16</td>
<td>ELECTRICAL SYSTEMS FUNCTIONAL PERFORMANCE</td>
</tr>
<tr>
<td>26 11 16</td>
<td>SECONDARY UNIT SUBSTATIONS</td>
</tr>
<tr>
<td>26 22 13</td>
<td>TRANSFORMERS (ADDENDUM #1)</td>
</tr>
<tr>
<td>26 24 16</td>
<td>PANELBOARDS (ADDENDUM #1)</td>
</tr>
<tr>
<td>26 27 26</td>
<td>WIRING DEVICES</td>
</tr>
<tr>
<td>26 28 13</td>
<td>FUSES</td>
</tr>
<tr>
<td>26 28 16</td>
<td>CIRCUIT AND MOTOR DISCONNECT SWITCHES</td>
</tr>
<tr>
<td>26 36 00</td>
<td>TRANSFER SWITCHES (ADDENDUM #1)</td>
</tr>
<tr>
<td>26 51 00</td>
<td>LIGHTING</td>
</tr>
<tr>
<td>27</td>
<td>COMMUNICATIONS (NOT USED)</td>
</tr>
<tr>
<td>28</td>
<td>ELECTRONIC SAFETY AND SECURITY (NOT USED)</td>
</tr>
<tr>
<td>31</td>
<td>EARTHWORK (NOT USED)</td>
</tr>
<tr>
<td>32</td>
<td>EXTERIOR IMPROVEMENTS (NOT USED)</td>
</tr>
<tr>
<td>33</td>
<td>UTILITIES</td>
</tr>
<tr>
<td>33 71 49</td>
<td>MEDIUM VOLTAGE CABLES</td>
</tr>
<tr>
<td>33 71 73.33</td>
<td>ELECTRIC METERS</td>
</tr>
</tbody>
</table>

END OF SECTION
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Submittal Number</th>
<th>Date Submitted</th>
<th>Review Status</th>
<th>Date Returned</th>
<th>Remarks</th>
<th>Resubmittal Date</th>
<th>Returned Date</th>
<th>Review Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIVISION 04 - MASONRY</td>
<td>04 22 00 Concrete Unit Masonry</td>
<td>Product Data</td>
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<td>Cold-Weather and Hot-Weather Procedures</td>
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<td>DIVISION 07 - THERMAL AND MOISTURE PROTECTION</td>
<td>07 84 13 Penetration Fire Stopping</td>
<td>Product Data</td>
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<td>Product Test Reports</td>
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<td>DIVISION 08 - OPENINGS</td>
<td>08 11 13 Hollow Metal Doors and Frames</td>
<td>Product Data</td>
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<tr>
<td>DIVISION 09 - FINISHES</td>
<td>09 40 00 Protective Coatings</td>
<td>Schedule of Products and Paint Systems</td>
<td></td>
<td></td>
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<td>Color Charts</td>
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<td>Technical Data Sheets and MSDS</td>
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<td>Contractor Written Certification</td>
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<td>DIVISION 22 - PLUMBING</td>
<td>22 1316 Sanitary Waste and Vent Piping</td>
<td>Product Data</td>
<td></td>
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<tr>
<td>DIVISION 23 - HVAC</td>
<td>23 0519 Meters and Gauges for HVAC</td>
<td>Product Data</td>
<td></td>
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<td>Delegated-Design Submittal</td>
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<td>Welder Performance Qualifications Record</td>
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<td>Test Reports</td>
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<td>26 3400 (ADDENDUM #1)</td>
<td>Transfer Switches (ADDENDUM #1)</td>
<td>Field Quality-Control Test Reports (ADDENDUM #1)</td>
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<td>Medium Voltage Cables</td>
<td>Test &amp; Inspection Reports</td>
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<tr>
<td>33 7173.33</td>
<td>Electricity Metering</td>
<td>In Service Test</td>
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<td></td>
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SECTION 1.F

INDEX OF DRAWINGS

Drawings referred to in and accompanying Project Manual consist of following sheets.

Sheet 1 of 31: COVER – PROJECT INFORMATION, SITE MAP, AND DRAWING INDEX
Sheet 2 of 31: A-001 – ARCHITECTURAL LEGEND
Sheet 3 of 31: A-002 – LIFE SAFETY PLAN
Sheet 4 of 31: A-101 – ARCHITECTURAL PLANS
Sheet 5 of 31: M-001 – MECHANICAL LEGEND
Sheet 6 of 31: M-101 – MECHANICAL PLANS

Sheet 7 of 31: M-200 – DEMOLITION PHOTOS (ADDENDUM #1)
Sheet 8 of 31: M-501 – MECHANICAL DETAILS
Sheet 9 of 31: M-502 – MECHANICAL DETAILS
Sheet 10 of 31: M-701 – MECHANICAL CONTROLS
Sheet 11 of 31: M-702 – MECHANICAL CONTROLS
Sheet 12 of 31: P-001 – PLUMBING LEGEND
Sheet 13 of 31: P-101 – PLUMBING PLANS
Sheet 14 of 31: F-001 – FIRE PROTECTION LEGEND
Sheet 15 of 31: F-101 – FIRE PROTECTION PLANS
Sheet 16 of 31: E-001 – ELECTRICAL LEGEND
Sheet 17 of 31: E-101 – ELECTRICAL POWER PLANS – PHASE 1
Sheet 18 of 31: E-102 – ELECTRICAL POWER PLANS – PHASE 1
Sheet 19 of 31: E-103 – ELECTRICAL POWER PLANS – PHASE 2
Sheet 20 of 31: E-104 – ELECTRICAL POWER PLANS – PHASE 2
Sheet 21 of 31: E-105 – ELECTRICAL POWER PLANS – PHASE 2
Sheet 22 of 31: E-106 – ELECTRICAL POWER PLANS – PHASE 3
Sheet 23 of 31: E-107 – ELECTRICAL POWER PLANS – PHASE 3
Sheet 24 of 31: E-108 – ELECTRICAL POWER PLANS – PHASE 4

Sheet 25 of 31: E-109 – ELECTRICAL POWER PLANS – PHASE 4 (ADDENDUM #1)

Sheet 26 of 31: E-501 – ELECTRICAL ONE-LINE DIAGRAM – PHASE 1
Sheet 27 of 31: E-502 – ELECTRICAL ONE-LINE DIAGRAM – PHASE 2
Sheet 28 of 31: E-503 – ELECTRICAL ONE-LINE DIAGRAM – PHASE 3

Sheet 29 of 31: E-504 – ELECTRICAL ONE-LINE DIAGRAM – PHASE 4 (ADDENDUM #1)

Sheet 30 of 31: E-601 – ELECTRICAL SUBSTATION ELEVATIONS
Sheet 31 of 31: E-701 – ELECTRICAL DETAILS

END OF SECTION
SECTION 01 91 00 – GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Specifications throughout all Divisions of the Project Manual, which pertain to operable equipment and/or building systems, are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY
   A. This Section establishes general and administrative requirements pertaining to commissioning of equipment, devices, and building systems installed on renovation and new construction projects delivered under various contracting methodologies. Technical requirements for commissioning of particular systems and components are established in the Contract Documents.

   B. It is of primary concern that all operable systems installed in the Project perform in accordance with the Contract Documents and the specified Owner's operational needs. During Commissioning, the Contractor systematically demonstrates to the Owner that the operable systems are properly performing in strict accordance with the Contract Documents.

   C. Commissioning requires cooperation and involvement of all parties throughout the construction process. The Contractor shall deliver a successful Commissioning process. Successful Commissioning requires that installation of all building systems complies with Contract Document requirements and that full operational check-out and necessary adjustments are performed prior to Substantial Completion, with the exception of deferred tests approved in advance by Owner.

   D. Commissioning will encompass and coordinate traditionally separate functions of system documentation, Inspection, Prefunctional Checklists and start-up, control system calibration and point-to-point checkout, testing, adjusting, and balancing, Functional Performance Tests, Integrated System Tests, Contractor demonstration to the Owner, and training of Owner’s personnel. This requires assembling all related documentation into one Commissioning Manual. Commissioning is intended to achieve the following specific objectives of the Contract Documents.

      1. Verify and document proper installation and design parameters of equipment, systems, and integrated systems.

      2. Ensure that operating and maintenance and Commissioning documentation requirements are complete.

      3. Provide Owner with functional buildings and systems that meet the Contract Document requirements at Substantial Completion.

1.03 DEFINITIONS
   A. Capitalized terms used in this Section shall have the meanings as set forth in the Contract and as defined below.

   B. Commissioning: A systematic process confirming that building systems have been installed, properly started, and consistently operated in strict accordance with the Contract Documents, that all systems are complete and functioning in accordance with the Contract Documents at Substantial Completion, and that Contractor has provided Owner adequate system documentation and training. Commissioning includes Deferred Tests, as approved by Owner.
C. Commissioning Authority (CxA): Party employed on the Project, by Owner under a Separate Contract, to provide certain commissioning services as defined herein under Commissioning Authority’s Role and Responsibilities. Commissioning Authority does not have authority to alter design or installation procedures without the written approval of Owner and the A/E.

D. Commissioning Plan: A document that provides the structure, schedule, and coordination plan for Commissioning during the construction phase and through the warranty period. The Commissioning Plan will describe the project and systems to be commissioned, Commissioning activities, procedures to follow throughout Commissioning, roles and responsibilities for each participant, and general description of testing and verification methods. The Commissioning Plan must satisfy all Test Requirements set forth in the Contract Documents.

E. Commissioning Team: Working group made up of representative(s) from the A/E, Contractor, Test, Adjust, and Balance Firm, Building Automation System vendor, specialty manufacturers and suppliers, Owner, and Commissioning Authority. Contractor will provide ad-hoc representation of Subcontractors on the Commissioning Team as required for implementation of the Commissioning Plan.

F. Deferred Tests: Functional Performance or Integrated System Tests performed after Substantial Completion, with Owner’s approval, due to seasonal requirements, site conditions, or both, that prohibit the test from being performed prior to Substantial Completion.

G. Deficiency: Condition of a component, piece of equipment, or system that is not in compliance with the Contract Documents.

H. Factory Testing: Testing of equipment at the factory, by factory personnel with an Owner’s representative present, if deemed necessary by Owner.

I. Functional Performance Test: Test of dynamic function and operation of equipment and systems executed by Contractor. Systems shall be tested in various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Functional Performance Tests are executed after start-ups and Prefunctional Checklists are complete.

J. Functional Performance Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configuration and steps required to determine if the system is performing and functioning properly.

K. Integrated System Test: Test of dynamic function and operation of multiple systems. Integrated System Tests are conducted under various modes, such as fire alarm and emergency situations, life safety conditions, power failure, etc. Systems are integrally operated through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Integrated System Tests are executed after Functional Performance Tests are complete and prior to Substantial Completion. Integrated System Tests provide verification that the integrated systems will properly function according to the Contract Documents.

L. Integrated System Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configurations and steps required to determine if the interacting systems are performing and functioning properly.

M. Manual Test: Use of hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing trend data to make the “observation”).

N. Non-Compliance Report (NCR): A tool used to document an item or condition that does not meet the Contract Documents.
O. Prefunctional Checklist: A list of static inspections and material or component tests that verify proper installation of equipment (e.g., belt tension, oil levels, labels affixed, gages in place, sensors calibrated, etc.). The word Prefunctional refers to before Functional tests. Prefunctional Checklists must include the manufacturer’s start-up checklist(s).

P. Start-up: The activities where equipment is initially energized tested and operated. Start-up is completed prior to Functional Performance Tests.

Q. Test, Adjust, and Balance (TAB) Firm: The TAB Firm shall be a part of the Commissioning Team and shall provide services as set forth in the Specifications.

R. Test Requirements: Requirements specifying what systems, modes and functions, etc. must be tested. Test Requirements are not detailed test procedures. Test Requirements and acceptance criteria are specified in the Contract Documents.

S. Training Plan: A detailed plan prepared by the Contractor, and reviewed by the Owner, that outlines the training activities, instructors, time durations, and system requirements in accordance with the Contract Documents and Commissioning Plan.

T. Trending: Data collection of monitoring points using the Building Automation System or dataloggers.

1.04 COORDINATION

A. Commissioning Team:

1. Owner’s Members
   a. Representatives assigned by Owner’s Designated Representative
   b. Commissioning Authority.
   c. A/E.
   d. TAB Agent.

2. Contractor’s Members:
   a. Individuals, each having authority to act on behalf of the entity they represent, explicitly organized to implement all Commissioning activities through coordinated actions.
   b. Representatives of Contractor, including but not limited to, project manager and commissioning coordinator, Subcontractors, installers, and equipment suppliers. Owner must approve Contractor’s commissioning coordinator.

3. Scheduling:
   a. Contractor shall integrate all Commissioning activities into the Baseline Schedule and the Work Progress Schedule. All parties will address scheduling problems and make necessary notifications in a timely manner to expedite all Commissioning activities.
   b. Contractor shall provide the initial schedule of primary Commissioning activities at the pre-commissioning meeting. Prior to the first Start-up or Prefunctional Checklist test occurring, Contractor shall have incorporated and integrated all Commissioning activities into the Baseline Schedule and Work Progress Schedule with appropriately linked predecessors and successors.
1.05 ROLES AND RESPONSIBILITIES

A. Roles and responsibilities of Commissioning Team members are provided in this Section to clarify the commissioning process.

B. Owner’s Role and Responsibilities:

1. Review Specifications containing Commissioning requirements.

2. Provide Owner’s Test Requirements to Commissioning Team.

3. Approve the Contractor’s schedule for completing all Commissioning activities.

4. Participate in Commissioning activities, including the following:
   
a. Commissioning Team meetings.


c. Attendance at Contractor’s training sessions in operation and maintenance of systems and equipment.

d. Observation of Contractor’s demonstration of systems and equipment operation.

5. Commissioning Authority’s Role and Responsibilities.
   
a. Prepare and submit the Commissioning Plan for Owner’s approval.

b. Review and comment on Contractor’s schedule for Commissioning activities.

c. Participate in Contractor-led Pre-Commissioning Meeting.

d. Conduct and document Commissioning Team meetings.

e. Perform site visits as necessary or in conjunction with Commissioning Team meetings to observe component and system installations.

f. Review and comment on Submittals and coordination drawings applicable to systems being commissioned after initial review and comments from A/E.

g. Prepare Prefunctional Checklist. Review and comment on other Contractor-prepared documents, including Operating and Maintenance Manuals and Training Plan.

h. Prior to equipment Start-ups, review the control sequences and coordinate with the Contractor and A/E in order to prepare the Functional Performance Test and Integrated System Test procedures.

i. Witness equipment Start-ups as executed by Contractor.

j. Write Functional Performance Test Procedures and Integrated System Test Procedures for Contractor’s execution of tests.

l. Coordinate resolution of Deficiencies identified during Commissioning, Deferred Tests, and during the warranty period.

m. Review Contractor’s Training Plan.

n. Compile Commissioning documentation for Commissioning and Closeout Manual including test documentation, Deficiency reports and solution results; non-compliance issue tracking; and recommendations on continuous commissioning, best practices, and preventive maintenance.

6. Architect/Engineer’s Role and Responsibilities:
   a. Attend Commissioning Team meetings.
   b. Review and comment on Submittals and coordination drawings applicable to systems being commissioned.
   d. Review and Approve Contractor’s Training Plan.
   e. Review and Approve Test, Adjust, and Balance plan.
   f. Approve technical requirements for correction of Deficiencies identified during Commissioning, Deferred Tests, and during the warranty period.
   g. Review Operating and Maintenance Manuals.

7. Contractor’s Role and Responsibilities:
   a. Contractor shall review and provide comments on documents produced by the Commissioning Authority, and shall accept the Commissioning Plan, Functional Performance Test Procedures, and Integrated System Test Procedures as approved by Owner.
   b. As the Project progresses, add specific checklists, test procedures, schedules, recorded results, action lists, signoff sheets and other documents for the Commissioning and Close-out Manual. Administer updates to the Commissioning and Close-out Manual with the intent that all Commissioning Team members will have up-to-date documentation as the Commissioning progresses.
   c. Provide an individual, subject to Owner’s approval, experienced in construction and Commissioning of building systems to organize, schedule, and execute the Commissioning Plan and the Commissioning process. The Contractor shall assign this individual to act as the Contractor’s Commissioning Coordinator. The Contractor’s Commissioning Coordinator may have additional duties such as MEP Coordinator, but not as Project Manager or Superintendent. Submit qualifications demonstrating the Commissioning Coordinator’s technical expertise and experience to the Owner for approval. In the event that Contractor chooses to subcontract its Commissioning obligations, then Contractor must submit the subcontractor’s qualifications and personnel to Owner for Owner’s approval.
e. Ensure that Commissioning activities are incorporated into the Baseline Schedule and the Work Progress Schedule.

f. Submit inspection and Start-up documentation to Owner in accordance with this Section, and the Commissioning Plan.

g. Furnish copies of all Submittals, manufacturers’ literature, maintenance information, and any other information required for the Commissioning process. Contractor must submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

h. Schedule and conduct pre-installation meetings and pre-commissioning meetings with Subcontractors and equipment suppliers related to Commissioning. Contractor must invite the CxA, A/E and Owner to attend the pre-installation meetings and pre-commissioning meetings.

i. Provide qualified personnel, including Subcontractors as required, to fully perform the testing and operational demonstrations required by the Contract Documents and the Commissioning Plan, including any Deferred Tests or re-testing related to warranty work.

j. Correct Deficiencies identified during any stage of commissioning prior to proceeding as approved by Owner.

k. Provide training to Owner. Coordinate Subcontractor and vendor participation in training sessions.

l. Perform Deferred Tests and make necessary amendments to Operating and Maintenance Manuals and Record Documents for applicable issues identified during the Deferred Tests.

m. Contractor shall be responsible for the following activities, and may contract with a Building Automation System (BAS) vendor for these activities.

1) Coordinate with the Owner’s control group for software programming and hardware operation to exercise sequences of operation and to correct hardware and wiring deficiencies identified during Commissioning. Contractor must provide Record Documents reflecting correction of hardware and wiring deficiencies identified during Commissioning.

2) Attend pre-commissioning meetings and Commissioning meetings including seasonal, post occupancy, or deferred Commissioning meetings and activities as deemed appropriate by Owner.

8. Test, Adjust, and Balance Firm’s Role and Responsibilities (Or, Owner if self-performed), when engaged for the project:

a. Attend pre-commissioning meetings and Commissioning Team meetings including seasonal, post occupancy, or deferred Commissioning meetings and activities as deemed appropriate Owner.

b. Submit Test, Adjust, and Balance Plan and forms describing methodology for performance of Test, Adjust, and Balance procedures specific to this Project to Owner/Engineer of record for review.

c. Cooperate with Contractor and Contractor’s Building Automation System vendor, if any, during Commissioning.
d. Provide instrumentation, computer, software and communication resources necessary to
demonstrate compliance with the Contract Documents and the Commissioning Plan during the
Prefunctional Checklist activities, Functional Performance Tests and Integrated System Tests
of Building Automation System equipment.

e. Re-balance as needed to correct any Deficiencies identified during Commissioning.

f. Review BAS graphics and performance tests for accuracy, note deficiencies.

g. Prepare BAS Training Plans with Commissioning Team and perform training as specified in
Contract Documents and Commissioning Plan.

h. Maintain comprehensive system calibration and checkout records. Submit records to Owner.
i. Set up, capture, analyze, and report trend logs as requested by Owner to substantiate proper
systems operation.

j. Provide T A B data to Contractor and Commissioning Team before Contractor begins
Functional Performance Tests.

1.06 EQUIPMENT DOCUMENTATION REQUIREMENTS

A. Equipment Matrix:

1. Contractor shall submit a complete listing of all equipment, devices, and systems, with certain
information as herein noted, within twenty-one (21) days of issuance of the Notice to Proceed with
Construction and at least seven (7) days prior to submission of the first Application for Payment.
This listing shall be referred to as the Equipment Matrix.

2. Contractor shall coordinate Contractor’s response to this requirement with Contractor’s
preparation of the Baseline Schedule, Work Progress Schedule, Submittal Schedule, Schedule of
Values, and list of all equipment.

a. To the extent practical, Contractor should minimize redundant efforts in favor of a single,
organized approach to all documentation required for Project equipment, systems, and
devices.

3. The Equipment Matrix shall be formatted as a spreadsheet, with capability for printing various
selected data columns to meet documentation requirements at various stages of construction, and
for different purposes as required by various Technical Sections. The Equipment Matrix shall be
updated as the Project progresses and submitted periodically as requested by Owner. Provide
Owner with an electronic version of the final approved Equipment Matrix at or before Project
Close-out.

a. Contractor may elect to combine the Submittal Schedule and Equipment Matrix into one
spreadsheet (with multiple tabbed sheets) that Contractor updates as the Project progresses.

4. The Equipment Matrix shall identify all operable devices and equipment grouped by the
Specification Number under the system they are primarily categorized under. When sorted by the
column for system identification, the resulting printout must identify all system components,
regardless of whether they are mechanical, electrical, or otherwise.

5. Contractor shall continue to update the Equipment Matrix for each device or system. Owner will
assist the Contractor in collecting information on Owner-furnished and Contractor-installed
equipment. The Equipment Matrix shall include the following column headings, as a minimum, for
each device:
a. Equipment Plan Designation: Equipment Naming Convention (equipment acronym and sequential number) from Contract Documents.

b. Specification Section number.

c. Building ID: Shall be obtained from Owner.

d. Location / Room Number: Owner’s Wayfinding Codes from Owner’s Space Management database referring to room number or building location shall be obtained from Owner.

e. Asset Short Description: The asset short description is to be a very short textual description. Type a brief, identifying description for the asset followed by a comma then the “Equipment Plan Designation”. If multiple units, of same type, include equipment ID number from the Construction Documents. This field is limited to 80 characters. Example= Pump, Secondary Chilled Water, SCHWP-01-2B.

f. Product submittal reference number(s).

g. Product submittal approval date.

h. Name of installing Subcontractor.

i. Equipment Manufacturer.

j. Equipment model number.

k. Equipment serial number.

l. Equipment manufacturer’s representative (Vendor).

m. Equipment manufacturer’s representative (Vendor) contact information.

n. Manufacturer’s purchase order number.

o. Asset Cost: Equipment purchase price excluding all auxiliary costs.

p. Start-up Date: Date of initial equipment or device start-up by the Contractor.

q. Prefunctional Checklist completion date.

r. Functional Performance Test completion date.

s. Integrated Systems Test completion date.

t. Substantial Completion date.

u. Manufacturer’s warranty start date.

v. Warranty End Date: The date on which the asset warranty ends. (Default is one year after the Substantial Completion Date unless a longer warranty period is requested or provided.)

6. Owner will furnish the following additional information; allow column headings for this data:

a. Asset Number
PART 2 - EXECUTION

2.01 COMMISSIONING PLAN

A. CxA shall develop and submit draft Commissioning Plan to Owner and A/E for review within ninety (90) days prior to initial installation of materials or equipment that will undergo Start-up and Functional Performance Tests, as directed by Owner.

B. Contractor shall allow in the Work Progress Schedule a minimum of twenty-one (21) days after the receipt by the Owner of the draft Commissioning Plan Submittal for the Owner to submit review comments to the CxA and the Contractor.

C. CxA shall incorporate Owner’s review comments and resubmit the revised Commissioning Plan to Owner within fourteen (14) days of receipt of the review comments.

D. Contractor shall allow in the Work Progress Schedule an additional fourteen (14) days for Owner’s approval of the resubmitted Commissioning Plan that incorporates Owner’s review comments.

2.02 PRE-COMMISSIONING MEETING

A. Upon obtaining Owner’s approval of the Commissioning Plan, Contractor shall schedule a Pre-Commissioning Meeting with all parties involved in Commissioning. This meeting should include the major Subcontractors, specialty manufacturers/suppliers, A/E, Test, Adjust, and Balance Firm, Commissioning Authority, and Owner’s representatives as participants.

B. Contractor shall prepare for the Pre-Commissioning Meeting by creating drafts of the following documents. Commissioning Authority will assist in the creation.

1. Equipment Matrix and the Close-out and Documentation Matrix.

2. Baseline Schedule and Work Progress Schedule incorporating Commissioning activities.

C. CxA shall conduct the Pre-Commissioning Meeting and review all aspects of the Commissioning Plan. All documentation will be discussed and all test procedures and forms reviewed for approval with the Owner. Contractor shall prepare an outline noting responsibilities of the various parties involved in Commissioning for review at this meeting.

D. The Commissioning Plan shall be reviewed with all attendees and the scope of work discussed. Contractor should be prepared to distribute copies of the pertinent sections to the various Subcontractors involved in Commissioning.

E. Contractor shall present Commissioning target dates for the Project. These dates and durations shall be incorporated in the Baseline Schedule and the Work Progress Schedule. The CxA will provide anticipated durations of Commissioning activities.

2.03 REPORTING

A. Contractor shall provide status reports to Owner at frequencies directed by Owner.

B. Contractor shall communicate at least monthly with all members of the Commissioning Team, keeping them apprised of Commissioning progress and scheduling changes.

C. Contractor shall submit Non-Compliance and Deficiency reports to Owner within five (5) days of the date the Non-Compliance or Deficiency is first observed. This includes responses to items noted by the Commissioning Authority.

D. Contractor shall provide final Commissioning documentation to Owner in accordance with Project Close-out Procedures, which will become part of the Commissioning and Close-out Manual.
2.04 TEST EQUIPMENT

A. Contractor shall provide all specialized tools, test equipment and instruments required to execute start-up, checkout, and testing of equipment.

B. All specialized tools, test equipment and instruments required to execute start-up, checkout, and testing of equipment shall be of sufficient quality and accuracy to test and measure system performance within specified tolerances. A testing laboratory must have calibrated test equipment within the previous twelve (12) months. Calibration shall be NIST traceable. Contractor must calibrate test equipment and instruments according to manufacturer’s recommended intervals and whenever the test equipment is dropped or damaged. Calibration tags must be affixed to the test equipment or certificates readily available.

2.05 PRE FUNCTIONAL CHECKLIST

A. CxA shall provide a Prefunctional Checklist for each system to Owner and A/E for review.

1. CxA shall provide a draft version of each individual Prefunctional Checklist at a preinstallation meeting for the system. Based on discussions at a pre-installation meeting and subsequent as-constructed conditions, CxA shall amend and revise each Pre-functional Checklist as appropriate prior to requesting system inspection from the Owner.

2. CxA shall submit the final approved Prefunctional Checklist and all supporting documentation prior to requesting Start-up and Functional Performance Tests.

B. Contractor shall review the installation and Contract Documents for each system and shall provide written confirmation of the following if not included in the Prefunctional Checklist.

1. All required test reports and certifications have been submitted and accepted by Owner. Contractor must provide certification of acceptance from manufacturer’s representative.

2. Evidence that A/E has approved all Submittals for each component device.

3. All valve charts, wiring diagrams, control schematics, electrical panel directories, etc. have been submitted and approved, and that all devices have been installed in accordance with the Contract Documents.

4. All tabulated data has been submitted for each system and for each device.

5. Each component device has been installed in accordance with applicable codes, the Contract Documents, and manufacturer’s written recommendations.

2.06 INITIAL START-UP

A. Start-up of Independent Devices:

1. Prior to Start-up, Contractor shall not energize or activate, or allow to be energized or activated, any operable device until Contractor has verified to Contractor’s own satisfaction that all Contract Document requirements for the operable device have been met and have been documented in the Prefunctional Checklists.

2. Contractor may energize or start-up independent devices for operational check-out and testing only after Contractor and manufacturer’s representative or engineering technician (if required by the Contract Documents) have inspected and accepted the installation. The installation must not vary from provisions of the applicable Specifications and the manufacturer's written recommendations for Start-up.
3. When Start-up of equipment or systems have the potential to impact Owner’s daily operations or when the Contract Documents require the Owner to witness Start-up, Contractor must provide advance notice to Owner in accordance with the procedures outlined in the Contract Documents prior to Start-up. Contractor may not proceed with Start-up without the Owner’s written approval.

B. Start-up of Building Systems:

1. Contractor shall not energize or activate any building system until the following conditions have been met:
   a. Contractor has verified that all wiring and support components for equipment are complete and have been tested in accordance with the technical specifications and the manufacturer's written recommendations.
   b. Contractor has verified that each component device has been checked for proper lubrication, vibration isolation, drive rotation, belt tension, control sequence, or other conditions that may cause damage.
   c. Contractor has verified that all tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer and are in compliance with applicable Contract Documents.
   d. Contractor has received approved building system final inspection reports.
   e. Contractor has provided the Owner and A/E with a written fourteen (14) day notice of intent to start-up the system for operational check-out. The notification procedures outlined in the Contract Documents shall be utilized.

2. Contractor shall perform Start-up under supervision of the responsible manufacturer's representative in accordance with manufacturer's instructions and specification requirements.

3. Contractor shall coordinate and schedule system(s) Start-up in a timely manner so that each component or system can operate for a period of time that is sufficient to evaluate and adjust performance as necessary. All building systems shall be operational and must have been successfully inspected by Owner, through attendance and concurrence with results of the Prefunctional Checklists or as otherwise approved by Owner, prior to the Contractor proceeding with Functional Performance Tests.

4. Contractor shall clearly list outstanding items or initial Start-up and Prefunctional Checklists items not completed successfully. Contractor shall obtain from Subcontractor completed forms documenting any outstanding Deficiency within five (5) days of completion of tests.

5. Contractor shall review completed Deficiency forms to determine if outstanding items prevent execution of the Functional Performance Tests and shall issue any necessary responses to the Commissioning Team.

2.07 REQUEST FOR START-UP AND FUNCTIONAL PERFORMANCE TESTS

A. Contractor shall notify Owner to request: (1) initial energization or operation of equipment and systems; and (2) an inspection of any system or system component for readiness prior to Functional Performance Tests.

1. Request for Start-up. Contractor must certify that: (1) electrical and mechanical connections have been installed and are safe for initial Start-up; (2) Contractor has complied with Owner’s utilities outage notifications; and (3) Start-up will not harm Owner’s daily routine operations.
2. Contractor shall complete the applicable Prefunctional Checklist(s) signed by Contractor and CxA evidencing Contractor’s own thorough inspection of the system and completion of Start-up activities required by the Contract Documents and the Commissioning Plan. Contractor shall submit required supporting documentation, including but not limited to, factory start-up forms, operational testing data, and certifications.

3. Request for Functional Performance Test. Contractor must certify that the Contractor has verified that the installation, Start-up, Prefunctional Checklists, and initial operation of the system or component are in accordance with the Contract Documents and the Commissioning Plan including manufacturer’s instructions, manufacturer’s requirements for maintenance of warranty, and verification that the system is ready for Functional Performance Tests. Contractor must certify that the manufacturer’s representative has verified that the installation, Start-up, and initial operation of the system or component are in accordance with the manufacturer’s published recommendations.

B. Contractor must obtain Owner’s approval prior to proceeding with the Start-up or Functional Performance Test. All construction inspections must be completed. Any and all Deficiencies and all items included in the Non-Compliance Report have been brought into compliance with the Contract Documents.

2.08 FUNCTIONAL PERFORMANCE TESTS

A. Objective and Scope:

1. The objective of a Functional Performance Test is to demonstrate that the entire individual system operates according to the Contract Documents.

2. Contractor shall operate each system through all modes of operation (occupied, unoccupied, warm-up, cool-down, etc.) for specified system responses. Contractor is required to demonstrate to Owner’s satisfaction each operational sequence. Refer to Mechanical and Electrical Specifications.

B. Development of Functional Performance Test Procedures:

1. The purpose of a Functional Performance Test is to verify and document compliance with the stated criteria of acceptance. Commissioning Authority shall develop specific script-type test procedures and associated test forms to verify and document proper operation of each piece of equipment and system.

2. Commissioning Authority shall prepare Functional Performance Test Procedure forms as part of the Commissioning Plan. Once approved by Owner, Contractor shall utilize the forms for all testing activities.

3. Functional Performance Test Procedure forms must include the following:

   a. System and equipment or component name(s).

   b. Equipment location and identification number as identified in the Equipment Matrix.

   c. Unique test identification number and reference to unique Prefunctional Checklist identification numbers for the equipment.

   d. Date and time of test.

   e. Project name.

   f. Participating parties.

   g. Specific sequence of operation or other specified parameters, including performance data being verified.
h. Instructions for setting up a Functional Performance Test.

i. Specific script-type, step-by-step procedures to perform a Functional Performance Test, in a clear, sequential and repeatable format that is customized for the system being tested.

j. A Pass / Fail checkbox (or data entry box as appropriate) for clearly indicating whether or not proper performance of each part of a Functional Performance Test was achieved and space for actual readings.

k. Section for comments.

l. Signatures and date block for participant and Owner approvals.

4. Contractor shall operate, or cause to be operated, each system, device, or equipment item, both intermittently and continuously, for a duration period as indicated in the Specification(s) for each item and/or in accordance with the manufacturer's written recommendations, the Contract Documents and the Commissioning Plan.

5. Contractor shall operate each component device and each building system to the full extent of its capability, from minimum to maximum, and under automatic control and manual control.

6. Contractor and manufacturer's representatives shall supervise and coordinate adjustments and balancing of all devices and systems for proper operation prior to requesting a Functional Performance Test(s).

a. Where final balancing of a system is to be performed by Owner, such as final air balancing, Contractor shall provide all services indicated in the applicable Specifications and under this Section, including the following, prior to Owner’s final balancing.

1) Operational verification of all component devices and the total system, including automatic controls when applicable. Operational verification includes verification that all motors, fans, dampers, and other operable devices are performing in compliance with Specifications throughout their operable range and that all devices are controlled as described in the specified sequence of operation.

2) All tabulated data, motor amperage readings, valve tag verifications, and other data required by the Specifications.

b. Where final balancing of a system or particular components of a system are not specifically indicated to be performed by Owner, Contractor shall provide final balancing and adjustments for operation within specified tolerances prior to Functional Performance Test of such system.

c. Coordination and Scheduling. Members of the Commissioning Team, including Owner, may observe Functional Performance Tests of equipment components and systems. Contractor shall provide written notice to Owner at least ten (10) days prior to Functional Performance Tests of equipment components and systems. Contractor shall notify Owner in advance of any changes to the Functional Performance Test schedule. Owner may require Contractor to reschedule Functional Performance Tests to ensure availability of Owner’s representative(s).

d. Contractor conducts Functional Performance Tests after system Start-up and Prefunctional Checklists are satisfactorily completed and have been approved by Owner. Air balancing and water balancing shall be completed before Functional Performance Tests.

e. Contractor conducts Integrated System Tests after Functional Performance Tests are satisfactorily completed and have been approved by Owner.
INTEGRATED SYSTEM TESTS

A. Objective and Scope:

1. The objective of an Integrated System Test is to demonstrate that each system operates jointly with other systems according to the Contract Documents.

2. Contractor shall operate each system jointly with other systems, through selected modes of operation (fire alarm integration with HVAC, emergency power modes, equipment failures among related systems, etc.) for specified system responses. Contractor is required to demonstrate to Owner’s satisfaction each operational sequence.

B. Development of Integrated System Test Procedures:

1. The purpose of an Integrated System Test is to verify and document compliance with the stated criteria of acceptance. Commissioning Authority shall develop specific script-type test procedures and associated test forms to verify and document proper operation of each piece of equipment and system, jointly and independently of other systems.

2. Commissioning Authority shall prepare Integrated System Test Procedure forms as part of the Commissioning Plan. Once approved by Commissioning Team, Contractor shall utilize the forms for all testing activities.

3. Integrated System Test Procedure forms must include the following.
   a. System and equipment or component name(s).
   b. System and equipment location and identification number as identified in the Equipment Matrix.
   c. Unique test identification number and reference to unique Functional Performance Test identification numbers for the system and equipment.
   d. Date and time of test.
   e. Project name.
   f. Participating parties.
   g. Specific sequence of operation or other specified parameters, including performance data being verified.
   h. Instructions for setting up an Integrated System Test.
   i. Specific script-type, step-by-step procedures to perform an Integrated System Test, in a clear, sequential and repeatable format that is customized for the system being tested.
   j. A Pass / Fail checkbox (or data entry box as appropriate) for clearly indicating whether or not proper performance of each part of an Integrated System Test was achieved and space for actual readings.
   k. Section for comments.
   l. Signatures and date block for participant and Owner approvals.

4. Contractor shall operate, or cause to be operated, each system, device, or equipment item, both intermittently and continuously, for a duration period as indicated in the Specifications for each item and in accordance with the manufacturer's written recommendations, the Contract Documents and the Commissioning Plan.
5. Coordination and Scheduling.
   
a. Members of the Commissioning Team, including Owner may observe Integrated System Tests of equipment components and systems. Contractor shall provide written notice to Owner at least fourteen (14) days prior to Integrated System Tests of equipment components and systems. Contractor shall notify Owner and A/E in advance of any changes to the Integrated System Test schedule. Owner may require Contractor to reschedule Integrated System Tests to ensure availability of Owner’s representative(s).

b. Contractor conducts Integrated System Tests after Functional Performance Tests are satisfactorily completed and have been approved by Owner.

2.10 DOCUMENTATION AND NON-CONFORMANCE

A. Documentation:

   1. Commissioning Authority shall witness and document the results of all Functional Performance Tests and Integrated Systems Tests using specific procedural forms developed for that purpose or an approved electronic database program. Prior to testing, CxA shall submit these forms to the Owner and A/E for review and approval. Contractor will include the completed, filled-out forms in the Commissioning and Close-out Manual.

B. Non-Conformance:

   1. Contractor shall record results of Functional Performance Tests and Integrated System Tests. Commissioning Authority shall report all Deficiencies and non-conformance issues to Commissioning Team in accordance with the procedures outlined in the Commissioning Plan.

   2. At the sole discretion of Owner, Owner may permit Contractor to make corrections of minor Deficiencies observed during a Functional Performance Test or during an Integrated System Test. However, the Contractor must document the Deficiency and resolution on the appropriate report form.

   3. Contractor shall make every effort to expedite testing and minimize unnecessary delays, while not compromising the integrity of a Functional Performance Test or an Integrated Systems Test.

   4. Contractor, A/E and Owner will attempt to resolve Deficiencies in the following manner.

      a. When there is no dispute about a Deficiency and Contractor accepts responsibility for correction.

         1) Commissioning Authority or Contractor documents the Deficiency and the corrective actions, and then proceeds to another test or sequence. A Deficiency report is submitted to Owner. Contractor corrects the Deficiency, completes the statement of correction form certifying that the equipment or system is ready for retesting, and sends the certification to Owner.

         2) Contractor reschedules test with Owner.

      b. When there is a dispute about whether or not the test indicates a Deficiency or the Contractor’s responsibility for correction of the apparent Deficiency.

         1) Commissioning Authority or Contractor documents the apparent Deficiency. A Deficiency report is submitted to Owner, including the apparent Deficiency.
2) Contractor facilitates resolution of the Deficiency and provides recommendations to the Owner. Contractor and Owner may bring other parties into the discussions as needed. Final technical interpretive authority is with the A/E. Final acceptance authority is with the Owner.

3) Contractor documents the resolution process.

4) If Owner and the A/E agree with Contractor’s interpretation and proposed resolution, Contractor forwards response to Owner. Contractor reschedules test with Owner. Contractor must repeat this process until satisfactory performance and Owner’s approval is obtained.

2.11 DEMONSTRATION AND OWNER TRAINING

A. Commissioning Authority, in coordination with Owner shall develop the Training Plan with project specific requirements for Owner Training, after reviewing the different systems to be installed and commissioned. The purpose of the Training Plan is to specifically communicate the required content and training durations required by the Owner based upon the type of equipment and the Owner’s past experience.

2.12 DEFERRED TESTS

A. Deferred Tests:

1. Deferred Tests shall be identified in writing and shall be approved by Owner.

2. Contractor shall complete Deferred Tests as part of this Contract during the Warranty Period. Contractor shall schedule this activity with Owner. Contractor shall perform tests and document and correct Deficiencies. Owner may observe the tests and review and approve test documentation and Deficiency corrections.


4. If any check or test cannot be completed prior to Substantial Completion due to the building structure, required occupancy condition, or other condition, performance of such test may be delayed to later in the Warranty Period, upon approval of the Owner.

5. Commissioning of systems which provide Life Safety (passive or active) to the building and its occupants shall not be deferred unless occupancy is deferred.

2.13 COMMISSIONING DOCUMENTATION

A. Commissioning Authority shall compile and organize all Commissioning documentation into a Commissioning and Close-out Manual and deliver to the Contractor and Owner for inclusion in the Project Close-out Manual.

B. The Commissioning and Close-out Manual submitted to Owner shall contain all Commissioning documentation, including, but not limited to:

1. The Commissioning Plan.

2. Final Baseline Schedule filtered to show only the Commissioning activities.


4. Completed Prefunctional Checklists with all required attachments.

5. Functional Performance Test Procedures and results.
6. Integrated System Test Procedures and results.

7. Training Plan and all supporting documentation.

8. Deficiency reports and solution results.


END OF SECTION 01 91 00
SECTION 23 09 40 – COMMISSIONING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 PURPOSE

A. The purpose of commissioning (Cx) the mechanical systems is to verify that the installed systems comply with the intent of the contract documents and to verify that interactions between systems and subsystems operate as intended.

B. The Owner’s personnel will participate in the systems tests to provide them with an opportunity to become familiar with the various systems as they are placed in service. This participation is intended to enhance their training and provide an opportunity for them to work side by side with the Commissioning Agent (CxA), Engineer of Record and the Contractors to gain a better understanding of the design intent.

C. This specification standardizes and organizes reporting to assure that all tests are documented and that reports are received.

D. Any delays in completing the tests shall be the responsibility of the contractor(s) causing the delay.

E. General Commissioning requirements and coordination are detailed in Division 01.

1.2 TYPE OF TESTING

A. Two (2) types of testing shall be performed:

1. Pre-functional Checklist are tests that will be performed under this Contract as the work progresses by the mechanical contractor with participation by the local code officials.

2. Functional Tests are tests that will be performed prior to substantial completion during a Systems Commissioning Demonstration by a team consisting of the contractors and Owner’s representatives and the Engineer.

1.3 SCOPE OF WORK

A. This section specifies the requirements for the mechanical systems commissioning to be performed. Requirements include setting pressure regulators in piping systems, start up and operation of equipment, the functional testing of HVAC controls, and reporting test results.

B. The following mechanical systems shall be tested per the attached Pre-functional Checklist and Functional Tests.

C. Refer to Section 01 91 00 General Commissioning Requirements for additional information.

1.4 CxA RESPONSIBILITIES

A. Issue copies or samples of test forms for equipment used on the project to the General Contractor.
B. Mechanical Systems Cx and Testing Meeting

1. Prepare an agenda for the meeting.
2. Attend the meeting and lead the team in testing the systems. Coordinate the requirements of this section with the responsibilities of the Engineer of Record for Division 26.
3. Witness the operational checks.
4. Prepare an attendance sheet for all test participants to sign.
5. Distribute copies of the attendance sheet and all test forms filled out during the meeting to all participants.
6. Resolve issues where tests results are deficient.

C. Final Reports

1. Assemble copies of all the test reports (Pre-function Checklist and Functional Tests) into binders and distribute.
2. Both mechanical and electrical tests forms can be assembled into one report.

1.5 MECHANICAL ENGINEER RESPONSIBILITIES

A. Mechanical Systems Cx and Testing Meeting

1. Attend the meeting and participate in testing the systems designed.
2. Witness the operational checks.
3. Help resolve issues where tests results are deficient.

B. Testing Log

1. Review logs of all tests

1.6 GENERAL CONTRACTOR’S RESPONSIBILITIES

A. General

1. The General Contractor shall be responsible for assuring that all testing is executed, that all test reports are submitted, and that this work is completed in a timely manner.

B. Mechanical Systems Cx and Testing Meeting

1. Attend the meeting and participate in the testing.
2. Schedule the meeting with the CxA, Owner’s Field Engineer, Engineer of Record, TAB Contractor, BAS Contractor and HVAC, plumbing and electrical subcontractors.
3. Coordinate the activities of all meeting participants.

C. HVAC Controls

1. Coordinate construction activities to have the systems ready for testing in accordance with the schedule.
2. Coordinate the activities of TAB Contractor, BAS Contractor and subcontractors to assure that the testing proceeds on schedule and that all testing is complete.
D. Testing Log

1. General Contractor shall prepare a log of all tests required by this section and shall monitor progress as the project proceeds. The log shall be reviewed at regularly scheduled Project Progress meetings and shall be distributed with minutes of these meetings.

2. The General Contractor shall maintain a file of all completed tests.

1.7 MECHANICAL CONTRACTOR’S RESPONSIBILITIES

A. General

1. The mechanical contractor with the electrical contractor shall put the HVAC equipment into full operation and continue operating the equipment during the testing. Ensure that all systems are operating free of vibration.

2. Notify the CxA, Owner’s Representative, Field Engineer, Engineer and TAB Firm when the systems are ready for testing. The mechanical contractor shall utilize the Pre-functional Checklists to provide the information to the TAB Firm as to what systems are complete and ready for Testing. A sample of these forms is located in the appendix of this specification.

3. The mechanical contractor shall provide and coordinate the services of sub-contractors, suppliers, and personnel as required to correct, repair or replace defective items or conditions found during the system tests.

B. Mechanical Systems Cx and Testing Meeting

1. Attend the meeting and all testing.

2. Make necessary repairs for deficiencies identified during the tests.

C. HVAC Controls

1. Verify that the installation is complete by filling out the Pre-functional Checklist and submitting the results.

2. Repair deficiencies identified by the Pre-functional Checklist.

3. Implement corrective action if required as identified in the Functional Tests as reported by the TAB Contractor.

1.8 TESTING AND BALANCING FIRM’S RESPONSIBILITIES

A. Mechanical Systems Cx and Testing Meeting

1. Attend the meeting and all mechanical testing.

2. Record the test results.

3. Turn over completed forms to the Engineer at the end of the meeting.

B. HVAC Controls

1. Perform the Operational tests and record the results.

2. Report the test results.

3. Discuss deficiencies with the Engineer.
1.9 BAS CONTRACTOR RESPONSIBILITIES

A. Mechanical Systems Cx and Testing Meeting
   1. Attend the meeting and all testing.

B. HVAC Controls
   1. Assist the TAB Firm in the Checking, Testing, and Adjusting of the Temperature Control System.
   2. BAS shall provide the Commissioning Agent (CA) with a listing of all control loops that are to be tested and the functional requirements to be tested. The Commissioning Agent (CA) shall forward it to the TAB Firm no later than the pre-balancing conference.
   3. BAS shall provide the TAB firm technical support (technicians and necessary computers) for a complete check of these systems.
   4. BAS shall calibrate all applicable control devices.
   5. BAS shall perform all testing and verification of sequences of operation for the AHU’s, terminal units, etc.
   6. Implement corrective action if required following the TAB Contractor’s testing of the Operational Verification Checklists or the Mechanical Systems Cx and Testing Meeting.

1.10 OWNER’S REPRESENTATIVE RESPONSIBILITIES

A. Mechanical Systems Cx and Testing Meeting
   1. Attend the meeting and all testing.

1.11 SCHEDULING

A. HVAC CONTROLS TESTING: Testing of the HVAC Controls will be scheduled at the same time as the final HVAC Testing, Adjusting, and Balancing. The TAB Firm shall coordinate these tests with the Field Engineer, the Mechanical Contractor and the Electrical Contractor. These tests shall be completed prior to the Systems Testing Meeting.

B. MECHANICAL SYSTEM BAS TESTING: Testing of the Mechanical Systems will be scheduled throughout the construction. The Mechanical Contractor shall coordinate these tests with the Field Engineer and the local Building Officials. All forms shall be submitted no later than three (3) weeks prior to the Systems Testing Meeting.

1.12 DEFINITIONS

A. Test: To determine quantitative performance of equipment.

B. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

C. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing. Refer to forms attached to this specification.

D. Engineer - Engineer of record who is responsible for design of Mechanical Systems.
E. Systems Testing: The functional performance testing and operational verification of the mechanical, electrical, and control systems.

F. BAS: Building Automation System.

G. NEBB: National Environmental Balancing Bureau

H. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers

I. NFPA: National Fire Protection Agency

1.13 SUBMITTALS AND TESTING REPORT PREPARATION

A. Forms:

1. An index of Pre-functional and Functional Checklists are included at the end of this section along with the checklists for the project.

B. Calibration Reports: Submit evidence that all required instrumentation has been calibrated.

C. Submit test reports indicated. The reports shall certify that the systems have been tested in accordance with the referenced standards; are an accurate representation of how the systems have been installed; and are a true representation of how the systems are operating at the completion of the testing procedures. Follow the procedures and format specified below.

1. Functional Tests:

   a. Reports: Upon completion of the Systems Testing Meeting, Functional Tests checklists for the systems tested during the Systems Testing Meeting (and for the items tested by the TAB Firm but not tested at the Meeting) will be turned over to the Engineer. Reports may be hand written, but must be complete, accurate and legible. Review by the Engineer shall be completed and comments (punch list items) returned to the general contractor.

   b. A written response addressing comments from the Engineer shall be submitted within two (2) weeks after comments are returned from the Engineer. The written response shall be submitted in accordance with the distribution indicated below for draft reports.

2. Installation Tests:

   a. The Mechanical contractors shall submit copies of Functional Tests reports to the Field Engineer and the General Contractor on the day the tests are performed. Identify any problems, so that deficiencies can be resolved. As deficiencies are found, verbally report them to the Field Engineer.

   b. The General Contractor shall turn over all subcontractor Installation test results to the CxA who will distribute them.

3. Report Format:

   a. Contractors shall use approved forms (see above).
The CxA shall bind the report forms complete with other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:

1) Pre-functional Checklist
   a) Mechanical

2) Functional Tests – Mechanical
   a) Inside Cover Sheet
   b) Sign in sheet from Mechanical Systems Testing Meeting
   c) Operational Verification Checklists
   d) Punch list
   e) Contractors’ response
   f) Follow up items

4. Report Contents: Provide the following minimum information, forms and data:
   a. General Information and Summary: Inside cover sheet to identify CxA, General Contractor, Mechanical Contractor, Sheetmetal Contractor (if separate from the Mechanical Contractor), Plumbing Contractor, Sprinkler Contractor, Owner, Architect, Engineer of Record, and Project. Include addresses, contact names and telephone numbers.

5. Distribution of Reports will be via PDF’s electronically.

1.14 QUALITY ASSURANCE

A. Codes and Standards:

1.15 RELATED DOCUMENTS

A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.

B. General requirements for testing agencies are specified in the Division -1 Section Quality Control Services.

C. Division 23
   1. Sections specify materials and installation of mechanical piping systems.
   2. Sections specify pressure testing requirements and procedures.
3. HVAC Balancing: Procedures for balancing the HVAC systems are specified in Section 23 05 93.

1.16 ACCEPTANCE AND FINAL PAYMENT

A. Acceptance and final payments shall be made in accordance with the General Conditions.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION FOR PIPING AND FLOW TESTING

A. The Mechanical Contractor shall provide the following equipment for any piping tests:

1. Instrumentation used shall be as listed herein or equal approved by the Engineer of Record.
2. Pressure Gauge  Bourdon tube type with range of 2 to 2½ times the anticipated test pressure. Accuracy 1% of range. Gauge shall comply with ASME B40.1 Grade A.
3. Manometer: Use an inclined manometer with graduations of .1 inches or less.
4. Flow Meter. Contractor may use the existing calibrated flow valves in the system to establish flow rates where such valves are installed. Where the flow being measured does not have a flow meter installed, use a pitot tube or ultrasonic meter to establish flow rate.

PART 3 - EXECUTION

3.1 HVAC SYSTEMS PRE-FUNCTIONAL CHECKLISTS

A. HVAC Equipment: The Mechanical Contractor shall fill out the Pre-functional Checklist for the equipment listed in paragraph 1.03 B -1. Submit in accordance with Part 1.

B. All forms shall be submitted no later than three (3) weeks prior to the Systems Testing Meeting.

3.2 MECHANICAL SYSTEMS CX AND TESTING MEETING

A. Prerequisites for the Mechanical Systems Cx and Testing Meeting

1. The Functional Tests for the systems shall be completed at least three (3) weeks prior to the Two Day Systems Testing Meeting.
2. Planning for this meeting shall occur at the Pre Balance meeting specified in the Testing and Balancing specification.
3. The TAB Contractor shall have filled out the “preliminary” column of the Operational Verification Checklists.

B. Test Procedures

1. Mechanical Systems Cx and Testing Meeting
   a. The systems will be Cx by a team consisting of representatives from the General Contractor, Mechanical Contractor, Electrical Contractor, TAB Contractor, BAS, Field Engineer, and the Engineer of Record.
b. The TAB Contractor shall log new data and fill out the “final walkthrough” column of Operational Verification Checklists as the team inspects each system. Any deficiencies observed during the tests shall be included on the Final Punchlist to assure corrective action is taken.

c. The intent of the meeting is to verify that the Sequence of Operation is being followed and to assure that the systems are operating properly. The checklists are intended as a guide; other issues or concerns that effect the operation of the systems should also be addressed by the team and noted on the bottom of the forms if corrective action is needed.

2. Operational Verification Checklists

a. Sequence of Operation Check: An item-by-item check of the sequence of operation shall be performed.

3. Reports

a. The CxA shall collect all of the forms filled out during the Mechanical System Testing Meeting and distribute copies to all participants. Within one (1) week following the meeting, the Engineer shall prepare an “operational punchlist” of items needing follow up and forward this to the General Contractor, the Mechanical Contractor and the Electrical Contractor for corrective action.

b. The General Contractor shall submit a report of the resolution of all corrective measures taken within two (2) weeks of receiving the operational punchlist.

c. The attendance list, forms filled out during the meeting, checklists filled out by the TAB Firm for the items tested by the TAB Firm but not tested at the Meeting, the Engineer’s operational punchlist and the General Contractor’s report of corrective measures shall be issued by the Engineer in accordance with Part 1 above.

d. Any outstanding items shall be followed up by the CxA and the Project Manager until they are resolved.

3.3 INDEPENDENT TEST PROCEDURES FOR HVAC CONTROLS

A. Prerequisites for testing the HVAC Controls

1. The Mechanical Contractor shall have competed the installation of the equipment and shall have filled out the Pre-functional Checklist (see attached) to confirm that the installation is complete and that the systems are ready for operational testing. Any deficiencies shall be corrected prior to the TAB Contractor filling out the Operational Verification Checklists.

2. The Electrical Contractor shall turn on all equipment before the tests begin and turn the equipment off at the end of the tests. Repeat for as many days as the tests require.

B. Responsibilities for testing the HVAC Controls

1. The TAB Firm shall fill out the preliminary system test column of the Functional Tests (see attached) and discuss any deficiencies with the Engineer of Record prior to the
Mechanical Systems Cx and Testing Meeting to confirm that the systems are ready for checking by the CxA, Engineer of Record and the Owner’s representatives.

2. The TAB representative will turn over the forms used for the preliminary tests to the Engineer at the Mechanical Systems Cx and Testing Meeting; these same forms will be used for the final testing. If all of the checklists have not been completed before the Mechanical Systems Meeting, the CxA will provide copies of checklists for items that still need to be tested (i.e. items that were not checked by the TAB firm and that were not checked during the Mechanical Systems Meeting) to the TAB representative so these tests can be completed immediately following the Mechanical Systems Cx and Testing Meeting.

C. Test Procedures

1. Operational Verification Checklists
   a. General Procedure: The TAB Contractor shall make observations, adjustments, calibrations, measurements, and tests of the systems and their controls and make any necessary control-system corrections to ensure that the systems function as described in the sequence of operation. Software issues will be identified by the TAB Contractor and referred to BAS for resolution.
   b. BAS Sensor Accuracy Check: An accuracy check of the calibration of each sensing element shall be performed by comparing the BAS readout to the actual value of the variable measured at the sensing element. Digital indicating test instruments shall be used. The test instrument and BAS readings shall be logged. The check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element to BAS readout accuracy is within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced by BAS and the calibration check repeated.
   c. Actuator Range Adjustments: An output signal from the BAS shall be applied to each actuator. The proper operation of the actuators for all dampers and valves shall be visually verified. The signal shall be varied from live zero of 4 ma to 20 ma, and the actuator’s travel verified from zero stroke to full stroke within the signal range. Verify that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. Example: NC actuators are closed at 4 ma and are open at 20 ma. The signal levels that move the controlled device to its extreme positions shall be logged.
   d. Sequence of Operation Check: An item-by-item check of the sequence of operation shall be performed as specified in the Operational Verification Checklist for each system. Signals used to change the mode of operation shall originate from the actual HVAC control device intended for the purpose, such as the time clock. External input signals may be simulated. Basic control sequences shall be verified, however, complex sequences such as those that initiate the economizer operation of an AHU will be verified by BAS during their check out of the BAS system and by monitoring the system after the store is open.

D. Reports
1. The TAB Firm shall submit the operational verification checklists in accordance with the procedures listed in Part 1 above.

3.4 TRAINING DOCUMENTATION

A. General: Other sections of the Division 23 specification require training of the Owner’s personnel in the operation and maintenance of the mechanical equipment and systems. Some of this training is provided by representatives of the equipment manufacturer; some is provided by the contractor.

B. Documentation Summary: The mechanical contractor shall coordinate and organize all the training required and submit the Pre-functional Checklist documenting that the training was performed and who participated in the training sessions.
INDEX

PRE-FUNCTIONAL CHECKLIST

PC-MA Plan and Documenting Requirements  
PC-MB Calibration and Leak-by Test Procedures  
PC-M1 Building Automation System  
PC-M2 Air Handler Unit  
PC-M3 Terminal Units  
PC-M4 TAB Plan

FUNCTIONAL CHECKLIST

FT-M1 Building Automation System  
FT-M2 Cooling Air Handling Unit  
FT-M3 Terminal Units  
FT-M4 Test and Balance TAB

END OF SECTION 230940
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

A. The purpose of this Section is to define Contractor responsibilities in the commissioning process, which are being directed by the Contractor. Other electrical system testing is required under other Division 26 Specification Sections. National Electrical Installation Standards (NEIS) NECA 90-2004; “Recommended Practice for Commissioning Building Electrical Systems”, 27th Volume of the NEIS Series, provides additional guidance for the commissioning of electrical systems.

B. Commissioning requires the participation of the Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. General Commissioning requirements and coordination are detailed in Division 01. Division 26 shall be familiar with all parts of the Commissioning Plan and shall execute all Commissioning responsibilities assigned to them in the Contract Documents and include the cost of Commissioning in the Contract price.

C. Electrical systems to be commissioned include the following:

2. Unit Substations.
3. Distribution and Branch Circuit Panelboards.
4. Grounding Systems
5. Medium and Low-Voltage Feeders
7. Dry-Type Transformers

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards.
1.04 DEFINITIONS

A. Commissioning: A systematic process confirming that building systems have been installed, properly started, and consistently operated in strict accordance with the Contract Documents, that all systems are complete and functioning in accordance with the Contract Documents at Substantial Completion, and that Contractor has provided Owner adequate system documentation and training.

B. Commissioning Authority (CxA): The Professional, appointed by the Owner, to direct and coordinate the commissioning process.

C. Commissioning Plan: Document that provides the structure, schedule, and coordination plan for the Commissioning process from the construction phase through the warranty period. The Commissioning Plan must satisfy the Owner’s test requirements.

D. Commissioning Team: Working group made up of representative(s) from the Architect/Engineer (AE), the CxA, Contractor, Owner’s Test, Adjust, and Balance (TAB) Firm, Building Automation System (BAS) provider, specialty manufacturers and suppliers, and Owner. Contractor will provide ad-hoc representation of Subcontractors on the Commissioning Team as required for implementation of the Commissioning Plan.

E. Deferred Tests: Functional Performance or Integrated System Tests performed after Substantial Completion due to partial occupancy, partial equipment acceptance, seasonal requirements, design, or other Site conditions that prohibit the test from being performed prior to Substantial Completion.

F. Deficiency: Condition of a component, piece of equipment or system that is not in compliance with Contract Documents.

G. Factory Testing: Testing of equipment at the factory, by factory personnel with an Owner’s representative present if deemed necessary by Owner.

H. Functional Performance Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configuration and steps required to determine if the system is performing and functioning properly. Contractor prepares these procedures to document Functional Performance Tests.

I. Functional Performance Test (FPT): Test of dynamic function and operation of equipment and systems executed by Contractor. Systems are tested under various modes, such as high loads, component failures, power failure, etc. Systems are run through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Functional Performance Tests are executed after start-ups and Prefunctional Checklists are complete.

J. Integrated System Test: Test of dynamic function and operation of multiple systems. Integrated System Tests are tested under various modes, such as fire alarm and emergency situations, life safety conditions, power failure, etc. Systems are integrally operated through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Integrated System Tests are executed after Functional Performance Tests are complete and prior to Substantial Completion. Integrated System Tests provide verification that the integrated systems will properly function according to the Contract Documents.

K. Integrated System Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configurations and steps required to determine if the interacting systems are performing and functioning properly. Contractor prepares these procedures to document Integrated System Tests.
L. Prefunctional Checklist: A list of static inspections and material or component tests that verify proper installation of equipment (e.g., labels affixed, sensors/meters calibrated, etc.). The word Prefunctional refers to before Functional tests. Prefunctional Checklists must include the manufacturer’s Start-up checklist(s). Contractor shall sign Prefunctional Checklists as complete and submit with the Request for Start-up/Functional Performance Test Form.

M. Start-up: The activities where equipment is initially energized, tested, and operated. Start-up is completed prior to Functional Performance Tests.

N. Test Requirements: Requirements specifying what systems, modes and functions, etc. must be tested. Test requirements are not detailed test procedures. Test requirements and acceptance criteria are specified in the Contract Documents.

1.05 SUBMITTALS

A. Commissioning Authority shall prepare Prefunctional Checklists and Functional Performance Test (FPT) procedures and document results. Refer to Examples in Sections 26 08 13 and 26 08 16. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Commissioning Authority shall submit those forms to the Commissioning Team for review and approval.

B. Contractor shall provide Owner with documentation required for Commissioning work. At minimum, documentation shall include: Detailed Start-up procedures, Factory Test Reports, Full sequences of operation, Operating and Maintenance data, Performance data, Control Drawings, and details of Owner-Contracted tests.

C. Contractor shall submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

D. Contractor shall review and approve other relative documentation for impact on FPT’s of the systems:

1. Shop Drawings and product submittal data related to systems or equipment to be commissioned. The Subcontractor responsible for the FPT shall review and incorporate comments from the Owner and AE via the Contractor.

2. Incorporate manufacturer’s Start-up procedures with Prefunctional checklists.

3. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT’s.

4. Completed equipment Start-up certification forms along with the manufacturer’s field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT’s.

5. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

PART 2 - PRODUCTS

2.01 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
2.02 TEST EQUIPMENT

A. Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.

B. All specialized tools, test equipment, and instruments required to execute Start-up, checkout, and testing of equipment shall be of sufficient quality and accuracy to test and/or measure system performance within specified tolerances. A testing laboratory must have calibrated test equipment within the previous twelve (12) months. Calibration shall be NIST traceable. Contractor must calibrate test equipment and instruments according to manufacturer’s recommended intervals and whenever the test equipment is dropped or damaged. Calibration tags must be affixed to the test equipment or certificates readily available.

C. Infrared Thermographic Scanner:
   1. Infrared scanning equipment shall be capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of < 50mK.
   2. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified.

PART 3 - EXECUTION

3.01 PREPARATION

A. Construction Phase:
   1. Include the following requirements for submittal data, Commissioning documentation, testing assistance, Operating and Maintenance (O&M) data, and training, as a minimum.
   2. Attend Pre-Commissioning Meeting(s), Pre-Installation Meeting(s), and other Project meetings to facilitate the Commissioning process.
   3. Provide manufacturer’s data sheets and shop drawing submittals of equipment.
   4. Provide additional requested documentation, prior to O&M manual submittals, for development of Prefunctional Checklist and Functional Performance Tests procedures.
      a. Typically, this will include detailed manufacturer’s installation and Start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified.
      b. In addition, the installation, Start-up, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted.
      c. This information and data request may be made prior to normal submittals.
   5. With input from the BAS Provider, the Owner and AE, clarify the operation and control of commissioned equipment in areas where the Specifications, BAS control drawings, or equipment documentation are not sufficient for writing detailed test procedures.
   6. Commissioning Authority develops the Commissioning Plan using manufacturer’s Start-up procedures and the Prefunctional Checklists. Submit manufacturer’s detailed Start-up procedures and other requested equipment documentation to Owner for review.
7. Commissioning Authority develops the Functional Performance Test procedures specified in Section 26 08 16. Ensure that Functional Performance Test procedures address feasibility, safety, and equipment protection and provide necessary written alarm limits to be used during the tests.

8. During the Start-up and initial checkout process, execute and document related portions of the Prefunctional Checklists for all commissioned equipment.

9. Perform and clearly document all completed Prefunctional Checklists and Start-up procedures. Provide a copy to the Owner prior to the Functional Performance Test.

10. Address current AE and Owner punch list items before Functional Performance Tests.

11. Provide skilled technicians to execute starting of equipment and to assist in execution of Functional Performance Tests. Ensure that they are available and present during the agreed-upon schedules and for a sufficient duration to complete the necessary tests, adjustments, and problem solving.

12. Correct deficiencies (differences between specified and observed performance) as interpreted by the Owner’s Project Manager, the CxA and AE and retest the system and equipment.

13. Compile all Commissioning records and documentation to be included in a Commissioning and Closeout Manual.

14. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

15. During construction, maintain as-built marked-up Drawings and Specifications of all Contract Documents and Contractor-generated coordination Drawings. Update after completion of Commissioning activities (include deferred tests). The as-built drawings and specifications shall be delivered to the Owner both in electronic format and hard copies as required by the Owner.

16. Provide training of the Owner’s operating personnel as specified.

17. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

B. Warranty Phase:

1. Execute seasonal or deferred tests, witnessed by the Owner, according to the Specifications.

   a. Complete deferred tests as part of this Contract during the Warranty Period. Schedule this activity with Owner. Perform tests and document and correct deficiencies. Owner may observe the tests and review and approve test documentation and deficiency corrections.

   b. If any check or test cannot be completed prior to Substantial Completion due to the building structure, required occupancy condition, or other condition, execution of such test may be delayed to later in the Warranty Period, upon approval of the Owner. Contractor shall reschedule and conduct these unforeseen deferred tests in the same manner as deferred tests.

2. Correct deficiencies and make necessary adjustments to O&M manuals, Commissioning documentation, and as-built drawings for applicable issues identified in any seasonal testing.

C. Electrical Testing Agency (ETA):

1. The Contractor shall retain an independent Electrical Testing Agency (ETA). This generally requires checking and testing of the electrical power distribution equipment per National Electrical Testing Association (NETA).
2. Attend Pre-Commissioning Meeting(s), Pre-Installation Meeting(s), and other Project meetings scheduled by the Contractor to facilitate the Commissioning process.

3. Obtain all required manufacturer’s data to facilitate tests.

4. Aid the Contractor in preparation of the specific Prefunctional Checklist and Functional Performance Test procedures specified in Section 26 08 13 and 26 08 16. Generally, ETA shall provide their standard forms to document the NETA tests to be incorporated into the Prefunctional Checklist and Functional Performance Tests record.

5. During related tests, execute and document the tests in the approved forms and/or test record.

6. Perform and clearly document all completed Start-up and system operational checkout procedures, providing a copy to the Contractor.

7. Clearly indicate any deficiencies identified during testing and add to an action list for resolution and tracking. The field technicians shall keep a running log of events and issues. Submit handwritten reports of discrepancies, deficient or uncompleted work by others, Contract interpretation requests and lists of completed tests to the Contractor at least twice a week and provide technical assistance in the resolution of deficiencies.

8. Provide skilled technicians to execute testing. Ensure that they are available and present during the agreed-upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.

9. Warranty Phase: Perform thermographic imaging of loaded panel at time designated by Electrical Sub-Contractor or Contractor.

3.02 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer’s published recommendations.

3.03 TESTING

A. Prefunctional Checklists and Start-up:

1. Follow the Start-up and initial checkout procedures listed in this Section. Start-up and complete systems and sub-systems so they are fully functional, meeting the requirements of the Contract Documents.

2. Prefunctional Checklists shall be complete prior to commencement of a Functional Performance test.

3. Refer to Section 26 08 13 for specific details on required Prefunctional Checklists.

B. Functional Performance Tests:

1. Functional Performance Tests are conducted after system Start-up and checkout is satisfactorily completed.

2. Refer to Section 26 08 16 for specific details on the required Functional Performance Tests.

C. Coordination Between Testing Parties:
1. Factory Start-ups: Factory Start-ups are specified for certain equipment. Factory Start-ups generally are Start-up related activities that will be reviewed and checked prior to Functional Performance Tests. All costs associated with factory Start-ups shall be included with the contract price unless otherwise noted. Notify the Commissioning Team of the factory Start-up schedule and coordinate these factory Start-ups with witnessing parties. The Commissioning Team members may witness these Start-ups at their discretion.

2. Independent Testing Agencies: For systems that specify testing by an independent testing agency, the cost of the test shall be included in the Contract price unless otherwise noted. Testing performed by independent agencies may cover aspects required in the Prefunctional Checklists, Start-ups, and Functional Performance Tests. Coordinate with the independent testing agency so that Owner, CxA and/or AE can witness the test to ensure that applicable aspects of the test meet requirements.

3.04 TRAINING

A. Submit a written training plan to the Owner, CxA and Architect/Engineer for review and approval. Contractor’s training plan shall cover the following elements:

1. Equipment included in training.
2. Intended audience.
3. Location of training.
4. Objectives.
5. Subjects covered.
6. Duration of training on each subject.
7. Instructor for each subject.
8. Methods (classroom lecture, video, Site walk-through, actual operational demonstrations, written handouts, etc.).
9. Instructors and qualifications.

B. Contractor shall have the following training responsibilities:

1. Provide a training plan fourteen(14) calendar days prior to the scheduled training, in accordance with Division 01.
2. Provide Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned equipment or system.
3. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including Start-up, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This representative may be the Start-up technician for the piece of equipment, the installing contractor, or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
6. The training sessions shall follow the outline in the Table of Contents of the O&M manual and illustrate whenever possible the use of the O&M manuals for reference.

7. Training shall include:
   a. Usage of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. Review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include Start-up, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanation of information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.

8. Hands-on training shall include Start-up, operation in all modes possible, including manual, shutdown, and any emergency procedures and maintenance of all pieces of equipment.

9. Training shall occur after Functional Performance Tests are complete and shall be scheduled with the Owner’s Project Manager.

10. Provide training on each system/piece of equipment as specified in other sections.

END OF SECTION 26 08 00
SECTION 26 08 13 – ELECTRICAL SYSTEMS PREFUNCTIONAL CHECKLISTS AND START-UPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

A. This Section expands on and defines responsibilities of the Contractor regarding Prefunctional Checklists and start-up portions of the Commissioning process and addresses validation of proper and thorough installation of mechanical, plumbing and fire protection systems.

B. Contractor shall oversee the Commissioning activities with the Contractor’s Subcontractors and the Architect/Engineer (AE).

C. Contractor shall completely install, thoroughly inspect, start-up, test, adjust and integrate Electrical Testing Agency (ETA) on systems and equipment. All activities shall be documented on specific, procedural forms developed for that purpose. Contractor shall notify AE and Owner in writing that systems are complete and ready for verification and Functional Performance Tests.

D. Completed Prefunctional Checklists for all pieces of equipment shall be submitted to the Owner prior to Functional Performance testing.

E. Responsibilities of the various parties involved in the Commissioning process are defined in Section 26 08 00.

F. Refer to Attachments A, B, C, and D at the end of this Section for example forms that indicate level of documentation required for the Commissioning process.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.04 SUBMITTALS

A. Prefunctional Checklists, Prefunctional Tests, and Start-up documents are the normal procedure of ensuring that the system components are properly installed.

B. The Commissioning Authority shall develop Prefunctional Checklists and Prefunctional Tests during the Construction Phase.
C. Completeness of Prefunctional Checklists: This Section summarizes the minimum standard for systems and equipment checkout. A record of testing and acknowledgement that a procedure has been completed and that it checks out acceptably must be included in the Prefunctional Checklists. The Prefunctional Checklist shall identify in columnar format each device, location, test method, control sequence of operation reference, device code reported, and other data as appropriate.

D. Equipment Data Documentation: Provide completed, as-installed, specific product nameplate data, product numbers, serial numbers, etc. to fully define the asset for Owner’s use in maintenance management and asset tracking. This data may be incorporated within an Equipment List/Matrix as a spreadsheet format or electronic database. In addition to specific manufacturer’s name and specific product identifiers such as model number, serial numbers, date of manufacture, etc., the following information shall be included with the equipment data documentation:

1. Capacity data: Where applicable, use equipment schedules on the Drawings as a guideline for fields to be used.
2. Location identifier field for each of the three dimensions (Floor Level, X axis, and Y axis) using the Drawing column grids as the basis for location.

E. Submit the equipment data documentation to the Owner for approval. CxA, AE and Owner will review the Prefunctional Checklists and request any additional information required to meet the Commissioning Plan criteria.

F. Written Certification: The Contractor shall certify that the installation, Start-up, Prefunctional Checklist, and initial operation of the system or component is in accordance with the Contract Documents, Commissioning Plan, and manufacturer’s requirements, and that the system is ready for Functional Performance Tests. Any outstanding items or non-conformance shall be clearly indicated and highlighted on the Prefunctional Checklist and an action item shall have been initiated. Refer to Division 01 for specific details on non-conformance issues relating to Prefunctional Checklists.

G. Refer to Section 26 08 00 for additional documentation requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. The Prefunctional Checklist procedures described in this Section provide minimum guidelines for development of Prefunctional Checklists; Start-up procedures, and Prefunctional Tests. Contractor shall prepare the Prefunctional Checklists using these procedures and that of the manufacturer’s and/or applicable codes and standards.

C. The Prefunctional Checklist form shall acknowledge that installation and Start-up procedures were successfully adhered to and completely performed and shall document relevant parameters (panel and equipment connections, measured values, ground faults, trip settings, etc.). When indicated as performing a checkout on multiple items or multiple procedure items, Prefunctional Checklist forms shall itemize each individual item.

D. Provide temporary/permanent control power so operation of digital metering, HMI and control sequences can be verified prior to utility energizing the feeders.

2.02 TEST EQUIPMENT

A. Refer to Section 26 08 00 – Electrical Systems Commissioning.
PART 3 - EXECUTION

3.01 PREFUNCTIONAL CHECKLIST PROCEDURES

A. Thermographic Scanning:
   1. Contractor shall provide thermographic scanning on all switchgear and distribution boards. In general, the thermographic scanning shall be made when the equipment is energized and is operating at its normal capacity. It is intended that the scan be made after the equipment has been in full operation; however, the Contractor near the completion of the Project will determine the exact time of conducting the scan. Some scanning for occupant-created load shall be performed during the Warranty Period as a Deferred Test.
   2. Test equipment, miscellaneous tools, and materials shall be transported properly, moved, and set up by trained personnel. Equipment used in testing shall be capable of performing all recommended procedures required by the apparatus and related equipment. All test equipment shall have certification of calibration and be in working order.
   3. All hot spots shall be marked, identified, and an infrared thermographic scanning report prepared and furnished to the Owner.
   4. The report shall contain infrared photos of trouble spots with temperature readings.
   5. The Contractor shall promptly report all sources of heating problems to the Owner for corrective action.

B. Grounding Systems:
   1. Perform three-point fall-of-potential test per Institute of Electrical and Electronics Engineers (IEEE) Standard 81 on the main grounding electrode or system. Resistance shall be no greater than 5 ohms.
   2. Perform the two-point method test per IEEE Standard 81 to determine the ground resistance between the main ground system and all major electrical equipment frames, system neutral, and/or derived neutral points. Resistance shall be no greater than 5 ohms.
   3. Refer to Section 26 05 26 GROUNDING.

C. AC Motors – General Across Systems:
   1. Verify proper alignment, installation, and rotation.
   2. Measure the insulation resistance, phase balance, and resistance to ground. This measurement will generally be the responsibility of the electrical Subcontractor who is connecting the motor. Correction of any deficiencies will be the responsibility of the motor supplier. Where the electrical Subcontractor wires to a single point of a packaged device that is shipped with multiple motors, electrical Subcontractor shall check all motors in the package.
   3. Verify that properly sized overloads are in place.
   4. Measure voltage available to all phases at time of initial connection and again after motor has been placed in operation under load measure amps and RPM.
   5. Record all motor nameplate data.

D. Medium Voltage Feeders:
   1. Start-up checklists: Perform the following final checks before Start-up:
a. Inspect underground duct banks.
b. Inspect cable and perform field testing on reels.
c. Inspect splicing and terminations. Medium voltage terminations at existing “Mid-Way” Switchgear is by owner.

2. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:
   a. Visually and mechanically inspect to include the following: Exposed cable, compression type terminations, splices where approved by the Engineer and the Owner, and fire proofing in manholes, cable vaults, etc.
   b. Correct color code identification and phasing arrangements.
   c. Perform shield continuity test.
   d. Perform insulation resistance test on new and existing cables.
   e. Perform high potential test on new cables only.

3. Refer to Section 33 71 49 MEDIUM VOLTAGE CABLES.

E. Medium Voltage Primary Load Interrupter Switches:
   1. General: Provide the services of a factory-trained manufacturer’s representative to assist the Contractor in the installation and start-up service of the equipment and to train Owner's personnel as specified.
   2. Start-up checklists: Perform the following final checks before Start-up:
      a. Inspect incoming power cable terminations.
      b. Inspect grounding.
   3. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:
      a. Visually and mechanically inspect to include the following: anchoring, grounding, torque of bus and cable connections, and mechanical operation of switch and operating mechanisms.
      b. Perform contact resistance test.
      c. Perform insulation resistance tests on switch and control wiring.
      d. Perform mechanical (key) interlock system operations.

F. Medium Voltage Transformer:
   1. Provide the services of a factory-trained manufacturer’s representative to assist the Contractor in the installation and start-up service of the equipment and to train Owner's personnel as specified.
   2. Start-up checklists: Perform the following final checks before Start-up:
      a. Inspect primary and secondary power connections.
      b. Inspect control interconnections.
c. Inspect grounding.

3. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:
   a. Visually and mechanically inspect to include the following: vibration isolation, anchoring, grounding, installation verification using manufacturer’s checklist, flexible bus connections, torque of bus and cable connections, and tap changer operation.
   b. Verify operation of temperature controls/alarms.
   c. Perform winding insulation tests.
   d. Conduct turns ratio test.
   e. Perform power factor/dissipation test on windings and bushings.
   f. Perform medium voltage and low voltage winding and core resistance measurements.
   g. Check and confirm percentage of impedance is identical for all transformers comparing nameplates.

G. 600V Disconnect Switches/480V Secondary Distribution:

1. Provide the services of a factory-trained manufacturer’s representative to assist the Contractor in the installation and Start-up service of the equipment and to train Owner's personnel as specified.

2. Start-up checklists: Perform the following final checks before Start-up:
   a. Inspect connections.
   b. Inspect grounding.
   c. Verify control interconnections.
   d. Check installation of warning nameplates.

3. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:
   a. Visually and mechanically inspect to include the following: anchoring, grounding, torque of bus/cable connections, and mechanical operation of switch and operating mechanisms.
   b. Conduct insulation resistance tests on switch and control wiring.
   c. Conduct contact resistance test.

H. 600V Service Switchgear/480V Secondary Distribution:

1. Provide the services of a factory-trained manufacturer’s representative to assist the Contractor in the installation and Start-up service of the equipment and to train Owner's personnel as specified.

2. Start-up checklists: Perform the following final checks before Start-up:
   a. Inspect connections to main breakers.
   b. Inspect grounding.
   c. Inspect feeder connections to busways and cables.
d. Inspect installation of main, tie and feeder breaker elements.

e. Inspect control and alarm interconnections.

f. Check calibration/setting of trip devices using system coordination study.

g. Verify calibration/setting of digital metering.

3. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

   a. Visually and mechanically inspect to include the following: anchoring, grounding, torque of feeder and incoming bus duct connections, feeder cable and integral main bus connections, switchgear section alignments, electrical clearances, mechanical operation of breaker/fuse drawout elements and operating mechanisms, manual trip function, main bus safety shutters, and installation verification using manufacturer's checklist.

   b. Check current and potential instrument transformer ratios.

   c. Conduct insulation resistance and over potential tests on each type of each breaker element contacts, switchgear control wiring, breaker element control wiring and each bus section.

   d. Conduct resistance test through switchgear bus joints.

   e. Conduct current test using primary or secondary current injection.

   f. Conduct phasing test on double-ended switchgear.

   g. Conduct contact resistance test on each type breaker element.

   h. Conduct ground resistance test.

   i. Conduct operational/functional tests of protective relaying. Time-current tests shall be conducted and trip points shall be set per Architect/Engineer’s direction.

   j. Conduct operational/functional tests of digital metering.

   k. Perform electrical and mechanical (key) interlock system operational tests on service switchgear.

I. Human-Machine Interface (HMI):

1. Provide the services of a factory-trained manufacturer’s representative to assist the Contractor in the installation and Start-up service of the equipment and to train Owner's personnel as specified.

2. Inspect control and alarm interconnections.

3. Review display of single line diagram for accuracy of as-built condition.

J. 600V Feeder and Subfeeders/480V Secondary Distribution:

1. Start-up checklists: Perform the following final checks before Start-up:

   a. Inspect cable terminations.

2. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:
a. Visually and mechanically inspect to include the following: large junction and pull boxes, supports of raceways and cable bus, and compression type terminations.

b. Correct identification and phasing arrangements.

c. Conduct continuity test of each feeder.

d. Conduct insulation resistance test of each feeder.

K. Distribution and Branch Circuit Panelboards/480V/208V/120V Secondary Distribution:

(Appplies to existing Panelboards affected by project)

1. Start-up checklists: Perform the following final checks before Start-up:

a. Inspect wiring connections.

b. Conduct insulation resistance tests on new feeders.

L. 600V Branch Circuits/480/208/120V Secondary Distribution:

1. Start-up checklists: Perform the following final checks before Start-up:

a. Inspect wiring connections.

2. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

a. Visually and mechanically inspect to include the following: large junction and pull boxes, supports of raceways, and compression type terminations.

b. Correct identification and phasing arrangements.

c. Perform random continuity test of any branch circuit.

d. Receptacle Polarity Test: Test every receptacle installed or reconnected under this Contract with a receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.

M. Lighting Fixtures and Lighting Controls / 277 / 120V Lighting:

1. Provide the services of a factory-trained manufacturer’s representative to assist the Contractor in the installation and Start-up service of the lighting inverter system and train Owner's personnel as specified below. Representative will confirm the proper installation and operation of all system components.

2. Start-up checklists: Perform the following final checks before Start-up:

a. Ensure all labeling is affixed and accurate.

b. Verify quantity, type and location of fixtures.

c. Verify type and location of switches.

d. Ensure all fixture supports are installed and terminations are tight.

e. Ensure adequate access is provided to the inverter and that documentation is provided in it.

f. Ensure all circuits for the loads are energized and ready for testing.
N. Fire Alarm Equipment / Fire Alarm and Detection System:

1. Provide the services of a qualified fire alarm specialist to supervise the installation, make adjustments, and perform tests on the fire alarm system and to train Owner's personnel.

2. Start-up checklists: Perform the following final checks before Start-up.
   a. Ensure all labeling is affixed and accurate.
   b. Ensure all terminations are tight.
   c. Ensure adequate access is provided to all panels and that documentation of that panel is provided in the panel.
   d. Review that all fire alarm devices as shown on the Fire Protection Signed and Sealed Shop Drawings are installed.
   e. Review height and locations visual alarms to comply with ADA.
   f. Review that smoke and duct detectors are installed according to NFPA 90A.
   g. Check that fire alarm system control panel is clear with no trouble or ground faults.
   h. Check wire supervision on all devices.
   i. Check location of all sensors and switches to ensure conformance with requirements.
   j. Verify interfaces with all other inter-related systems or equipment including building automation system (BAS), Preaction fire protection system, HVAC systems, etc. on a point by point basis for all points
   k. For Operator Interfaces:
      1) Verify all elements on the graphics are programmed, functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
      2) Output all specified reports for review and approval.
      3) Verify the alarm printing and logging is functional and per requirements.

3.02 ACCEPTANCE CRITERIA
A. Acceptance criteria for tests being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.

3.03 TRAINING
A. Training requirements are indicated in the Specification Sections applicable to the systems and in Section 26 08 00 - Electrical Systems Commissioning.

END OF SECTION 26 08 13
REQUEST FOR START-UP/FUNCTIONAL PERFORMANCE TEST

(Check applicable request below)
Request for Initial Startup ______  Request for Owner’s Demonstration ______

Project: ____________________________  Project #: __________________________

Identification of Equipment or System: __________________________________________

Location of Equipment or System: _____________________________________________

Specification Section: __________________ Detail/Drawing Number: ________________

Manufacturer / Supplier: ______________________________________________________

This Date: _________________________  Inspection Requested for (Date): ____________

CONTRACTOR'S CERTIFICATION OF PERFORMANCE:
I hereby certify that the above described equipment or system, has been energized, operated, adjusted, and balanced in accordance with the requirements of the Contract Documents and the manufacturer’s recommendations for a sufficient period to confirm that operation complies in all respects with the Contract Requirements.

_______________________________  ________________________________  ___________
Signature                          Printed Name                           Date

Installing Subcontractor:

_______________________________  ________________________________  ___________
Signature                          Printed Name                           Date

Manufacturer’s Representative:  I hereby certify that I have been personally and actively involved with energizing, operational checkout, adjustments, and balancing of the above described equipment or system; and that such has been accomplished in accordance with the manufacturer’s recommendations and is operating correctly.

_______________________________  ________________________________  ___________
Signature - Manufacturer’s Representative                          Printed Name                           Date

CONFIRMATION or COMMENTS from Owner:

Results of Test Acceptable? ______YES ______NO  Re-Test Required? ______YES ______NO
Punch List: ______Attached  ______To Follow  ______N/A
System Acceptable for "User Training”? ______Yes  ______No

_______________________________  ________________________________  ___________
Signature(s) – University of Missouri – Facility Manager                          Printed Name(s) – University of Missouri                           Date

_______________________________  ________________________________  ___________
Signature(s) – University of Missouri – Project Manager                          Printed Name(s) – University of Missouri                           Date
EXAMPLE - PREFUNCTIONAL CHECKLIST
Switchgear, Panelboards, Motor Control Centers, Transformers

Project: ____________________________  Project #: ________________________

Identification of Equipment or System: ________________________________________

Location of Equipment or System: ____________________________________________

Specification Section: ____________________  Detail/Drawing Number: ____________

Manufacturer / Supplier: ____________________________________________________

This Date: ____________________  Inspection Requested for (Date): ______________

Prefunctional Checklist Number: ______________

Components Included: _____ Disconnects  _____ Fuses  _____ Meters  _____ Other

__________________________________________________________________________

Associated Prefunctional Checklists: ____________________  ____________________

1. General:
   a. The above systems and components integral to this equipment are complete and ready for Functional Performance Tests. The Prefunctional Checklist items are complete and have been checked off only by parties having direct knowledge of the event, as indicted below, respective to each responsible contractor. This Prefunctional Checklist is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Deficiency Form upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.
   b. _____ Deficiency Form attached.
   c. This Prefunctional Checklist does not take the place of the manufacturer's recommended checkout and Start-up procedures or report.
   d. Contractors assigned responsibility for sections of the Prefunctional Checklist shall be responsible to ensure that their subcontractors complete and check off their Checklist items.
   e. Prefunctional Checklist items shall be completed as part of Start-up and initial checkout, preparatory to functional testing.
<table>
<thead>
<tr>
<th>Contractor/Entity</th>
<th>Company</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU HealthCare Staff</td>
<td></td>
<td>MUHC</td>
</tr>
<tr>
<td>Architect/Engineer</td>
<td></td>
<td>AE</td>
</tr>
<tr>
<td>General Contractor / Construction Manager</td>
<td></td>
<td>GC</td>
</tr>
<tr>
<td>Mechanical Contractor</td>
<td></td>
<td>MC</td>
</tr>
<tr>
<td>Electrical Contractor</td>
<td></td>
<td>EC</td>
</tr>
<tr>
<td>Building Automation System Provider</td>
<td></td>
<td>BAS</td>
</tr>
<tr>
<td>Test, Adjust, and Balance Firm</td>
<td></td>
<td>TAB</td>
</tr>
<tr>
<td>Commissioning Agent</td>
<td></td>
<td>CxA</td>
</tr>
</tbody>
</table>

2. Requested Documentation Submitted:

<table>
<thead>
<tr>
<th>Specified Requirement</th>
<th>Yes</th>
<th>No</th>
<th>Date to be Submitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Manufacturer’s Product Data including Performance Data and Shop Drawings, as approved by Architect/Engineer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Required Test Reports and/or Certifications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Installation and Start-up Manual and Plan</td>
<td></td>
<td></td>
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<tr>
<td>d) Wiring Diagrams, Control Schematics and Sequences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) Operating and Maintenance Manual Content for Applicable System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Equipment List/Matrix</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

3. Equipment Verification:

<table>
<thead>
<tr>
<th>Item</th>
<th>Specified</th>
<th>Submitted</th>
<th>Installed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Number</td>
<td></td>
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</tr>
<tr>
<td>Serial Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment Rating (amps)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage/Phase</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

4. Installation Checks:

<table>
<thead>
<tr>
<th>a) Unit and General Installation</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Permanent labels affixed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Physical condition acceptable, no visible damage, cabinets in place</td>
<td></td>
<td></td>
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<tr>
<td>3. Properly mounted on equipment pad and anchored</td>
<td></td>
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<tr>
<td>4. Maintenance access acceptable</td>
<td></td>
<td></td>
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<tr>
<td>5. Interior clean and dry</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6. Meter(s) installed per Contract Documents</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7. Disconnects installed and labeled</td>
<td></td>
<td></td>
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<tr>
<td>8. Disconnects are pad lockable in open position</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Circuit breakers installed and labeled</td>
<td></td>
<td></td>
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<tr>
<td>10. Fuses installed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Unit and General Installation</td>
<td>Yes</td>
<td>No</td>
<td>Comments</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----</td>
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</tr>
<tr>
<td>11. Conduits installed and connected</td>
<td></td>
<td></td>
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<tr>
<td>12. Cable/conduit routing does not obstruct access</td>
<td></td>
<td></td>
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<tr>
<td>13. Equipment room properly ventilated, air-conditioned, heated, fire/smoke wall separated, fire/smoke dampered, fire sprinklered, fire alarmed and illuminated (normal, emergency and battery backed-up fixtures)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>14. As-built drawings updated</td>
<td></td>
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</tr>
</tbody>
</table>

| b) Switchgear (service entrance 1500kVA and above) and Switchboards (service entrance less than 1500 kVA) | Yes | No | Comments |
|------------------------------------------------------------------------------------------------------------------|
| 1. Free standing metal enclosure |     |    |          |
| 2. Copper buses |     |    |          |
| 3. Penetration to utility service area and equipment per code |     |    |          |

<table>
<thead>
<tr>
<th>c) Distribution Panelboards and other Panelboards</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tin plated copper buses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Each circuit identified and labeled</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3. Space for additional circuits exist</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>d) Motor Control Centers</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tin plated copper buses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Main breakers installed and labeled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Each circuit identified and labeled</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>e) Transformers</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dry type installed</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Unit properly labeled and identified</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>f) Electrical and Controls</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Panel devices labeled and wiring tagged per Contract Documents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I/O devices labeled and wiring tagged per Contract Documents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Digital inputs and outputs operational</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. All electrical connections tight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Proper grounding installed for the electrical system, equipment, components, and unit</td>
<td></td>
<td></td>
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<tr>
<td>6. Safeties in place and operable</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7. Meters calibrated (see below)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Control system interlocks hooked up and functional</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. All control devices and wiring complete</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Main-Tie-Main Logic Programming Completed by Manufacturer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Surge protection installed</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
5. Operational Checks:
   
a. These checks supplement the manufacturer's list. This is not the Functional Performance Test.

<table>
<thead>
<tr>
<th>Operational Checks</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Associated Prefunctional Checklists are complete and accepted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Fuses are good</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3. Resistance check(s) complete with results attached</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Disconnect switch operates smoothly with full contact</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5. Specified point-to-point checks have been completed and documentation record submitted for this system</td>
<td></td>
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</tbody>
</table>

6. Meter Calibration:
   
a. All field-installed meters on this piece of equipment shall be calibrated. Meters installed in the unit at the factory with calibration certification provided are not required to be field calibrated.

b. All test instruments have had a certified calibration within the last 12-months: Y / N

c. All meters are calibrated within required tolerances ___ YES ___ NO
Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Deficiency form.

<table>
<thead>
<tr>
<th>General Contractor:</th>
<th>Print Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Signature:</td>
</tr>
<tr>
<td></td>
<td>Title:</td>
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<td></td>
<td>Date:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrical Subcontractor</th>
<th>Print Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Signature:</td>
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<tr>
<td></td>
<td>Title:</td>
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<tr>
<td></td>
<td>Date:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Subcontractor:</th>
<th>Print Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Signature:</td>
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<tr>
<td></td>
<td>Title:</td>
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<td></td>
<td>Date:</td>
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</tbody>
</table>

Prefunctional Checklist received and reviewed for completeness by MU HEALTHCARE representatives. Functional Performance Test can proceed.

<table>
<thead>
<tr>
<th>MUHC:</th>
<th>Print Name:</th>
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<tbody>
<tr>
<td></td>
<td>Signature:</td>
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<tr>
<td></td>
<td>Title:</td>
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<td>Date:</td>
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</table>

<table>
<thead>
<tr>
<th>MUHC:</th>
<th>Print Name:</th>
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<td></td>
<td>Signature:</td>
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<td></td>
<td>Title:</td>
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<td></td>
<td>Date:</td>
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</tbody>
</table>
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

A. This Section expands on and defines responsibilities of the Contractor in regards to Functional Performance Tests (FPT’s) of the Commissioning process.

B. Contractor shall oversee the Commissioning activities with the Contractor’s Subcontractors and the Architect/Engineer (AE).

C. Prefunctional Checklists, tests and Start-ups are to be completed and documented for the record prior to commencing with FPT’s. Refer to Section 26 08 00 and 26 08 13 for additional requirements.

D. Completed FPT Forms for all pieces of equipment and systems shall be submitted to the Owner prior to Substantial Completion.

E. Refer to Attachments A and B at the end of this Section for example forms that indicate level of documentation required for the Commissioning process.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.04 SUBMITTALS

A. Maintain and use an action item tracking system, “Action Item List,” that indicates as a minimum, required information, identified deficiencies, work required, etc.). Each item shall be tracked with the initiator, the parties responsible, due date, the date of closure, and a description of the resolution. Each item shall be categorized for sorting and tracking and for documentation on applicable forms. Action Item List shall be distributed and documented using Microsoft Excel or a database format approved by Owner.

B. Disseminate this list as appropriate to keep all parties involved with the FPT informed.

C. Functional Performance Test procedure forms must include the following:

   1. System and equipment or component name(s).

   2. Equipment location and identification number in the Equipment List/Matrix.
3. Unique test identification number and reference to unique Prefunctional Checklist and Start-up Documentation Identification Numbers for the equipment.

4. Date and time of test.

5. Project name.

6. Participating parties.

7. Specific sequence of operation or other specified parameters, including performance data being verified.

8. Instructions for setting up a Functional Performance Test.

9. Specific script-type, step-by-step procedures to perform a Functional Performance Test, in a clear, sequential and repeatable format that is customized for the system being tested.

10. A Yes/No checkbox (or data entry box as appropriate) for clearly indicating whether or not proper performance of each part of a Functional Performance Test was achieved with space for actual readings.

11. Section for comments.

12. Signatures and date block for participants and Owner approvals.

D. Refer to Division 01 and 26 08 00 for additional documentation requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 TEST EQUIPMENT

A. Refer to Section 26 08 00 – Electrical Systems Commissioning.

PART 3 - EXECUTION

3.01 PREPARATION

A. The objective of FPT’s is to demonstrate that each system operates according to the Contract Documents through all specified modes of operation.

B. Contractor shall operate each system through all modes of operation (Main-Tie-Main scenarios, etc.) where there is a specified system response. Verification of each sequence in the sequences of operation is required.

C. All equipment, components and devices applicable to the FPT must be started and this Start-up must be documented. Refer to Section 26 08 13 for additional Prefunctional Checklist and Start-up requirements.

D. Unless specifically agreed to by the Commissioning Team, all support systems shall be complete prior to FPT.

E. Commissioning Team members shall assist in development and review of the optimal sequence of testing.
3.02 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer’s published recommendations.

3.03 FUNCTIONAL PERFORMANCE TEST PROCEDURES

A. The purpose of a Functional Performance Test is to verify and document compliance with the stated criteria of acceptance. Commissioning Authority shall develop specific script-type test procedures and associated test forms to verify and document proper operation of each piece of equipment and system.

B. Contractor shall operate, or cause to be operated, each system, device, or equipment item, both intermittently and continuously, for duration a period as indicated in the Specification Section(s) for such item and/or in accordance with the manufacturer's written recommendations, the Contract Documents, and the Commissioning Plan.

C. Contractor shall operate each component device and each building system to the full extent of its capability, from minimum to maximum, and under automatic control and manual control.

D. Contractor and manufacturer's representatives shall supervise and coordinate adjustments of all devices and systems for proper operation prior to requesting the Functional Performance Test(s).

E. Sampling: Some types of identical equipment (such as circuit breakers, receptacles etc.) will be tested using a sampling strategy.

F. Failure Limit on Sample Tests: With the sampling percentages is listed a failure limit. This limit indicates the maximum percentage of the tested devices that may have any test that fails before an entirely new sample must be tested. When the maximum number of failures is reached, testing on that sample will be terminated and re-testing will be scheduled.

1. Where sample tests involve multiple systems (ie: checking breaker in different switchboards) the maximum failure limit will apply per system.

G. Deferred Tests: Contractor shall schedule with the Owner and complete Deferred Tests as part of this Contract during the Warranty Period. Testing procedures shall be repeated and/or conducted as necessary. Deferred tests will be required where scheduling prohibits thorough testing in all modes of operation.

H. Provide and deliver the required submitted documentation convenient to testing area. Validate that all required documentation has been submitted to the Owner and is per the Contract Document requirements.

I. Review the Start-up documentation at the start of FPT’s. Ensure that any items indicated as outstanding in the Prefunctional Checklist is entered as an Action Item and enter one if it is not. The Prefunctional Checklists and Start-up tests/measurements shall be spot checked at the beginning of FPT’s to ensure accuracy. Complete a test that indicates Contractor has reviewed the Prefunctional Checklists and finds the Prefunctional Checklists acceptable and notes any outstanding items.

J. Check for and as applicable direct the Subcontractor to demonstrate that access is sufficient to perform required maintenance.

K. Validate that all prerequisite work is complete and confirm this validation via a test record for documentation.

L. Specifically check labeling and ensure conformance to the Contract Documents.

M. Check proof indication, alarming on failure and restart/acknowledgement as applicable.
N. Observe operating conditions encountered at the start of the FPT. Contractor shall examine for normal functionality and record parameters as a test.

O. All dynamic systems powered by electricity shall be tested to simulate a power outage to ensure proper sequencing. Those on Main-Tie-Main systems shall be tested on all sources. This test shall generally be coordinated with electrical power systems testing addressed in the Contract Documents.

P. Inspect the installation and compare it to the Contract Documents. Record the inspection as a test.

Q. Capacities and adjusted and balanced conditions as applicable will generally be checked.

R. Verify all sequence modes and sequences of operation. Contractor must initiate all modes and may not refer to or rely on a Prefunctional Test done by the building automation system. Some examples of generic modes that apply to most systems include:

1. Off mode.
2. Failed mode: Proof, safeties, power outage etc. See below for crash testing.
3. Start sequence in various modes.
4. Stop sequences in various modes.

S. All adjusted, balanced, controlled systems shall be assessed to determine the optimal setting for the system as applicable. The optimal settings should be determined to establish reliable, efficient, safe and stable operation. The Contractor is responsible for placing systems in optimal condition for occupancy and not simply relying on initial design estimated settings.

T. Dynamic Graphics: The graphic for all components, systems, and areas sampled and required to be represented by a graphic shall be checked for adequacy and accuracy. Furthermore, when setpoints are required to be adjustable, verify that they can be adjusted directly from the graphic screen.

U. All interfaces between two systems or equipment of different manufacturers must be checked for accuracy and functionality.

V. “Crash Testing”: Contractor shall analyze systems to identify possible conditions where functionality may be compromised. Contractor shall design non-destructive tests that will demonstrate either the automated response to the conditions or so that team can identify the best method for responding or fixing the condition. All tests and their findings shall be documented in a Microsoft Excel spreadsheet.

3.04 SPECIFIC SYSTEM FUNCTIONAL TEST PROCEDURES

A. Switchgear:

1. Participants shall include Contractor, Electrical Subcontractor, and Commissioning Team.
2. Review the Start-up documentation.
3. Spot check breaker settings against Short Circuit Study.
4. Inspect for conformance to Contract Documents in concert with reviewing the ETA reports.
5. Contractor shall incorporate the ETA reports into the Microsoft Excel software.
6. Open medium voltage normal power feeder breakers to simulate various levels of power outages including all utility feeds, single feed, transformers, and distribution panels. All medium voltage breakers in “Mid-Way” Switchgear shall be operated by the owner.
7. With each partial outage, record timing parameters of tie breaker closure.
8. Restore normal breakers and observe systems retransfer to normal operating conditions. Record timing of tie breakers opening.

9. Validate the digital metering integral to the switchboard. The Utility Revenue Metering outlined in Section 33 71 73.33 shall be installed and programmed by the Owner.

10. Test the manual tie operation and mechanical (key) interlocks.

B. Distribution Transformers:

1. Participants shall include Contractor, Electrical Subcontractor, and Commissioning Team.

2. Test all transformers.

3. Review Start-up documentation.

4. Spot check insulation resistance and polarity for each type of transformer to ensure they are per the requirements.

C. Tie Breakers:

1. Participants shall include Contractor, Electrical Subcontractor, and Commissioning Team.

2. Sample 50 percent.

3. Test operation by opening normal breakers. Record timing parameters of breaker closure and coordination with other breakers.

4. Test manual tie operation and key lock out.

D. Human-Machine Interface (HMI):

1. Participants shall include Contractor, Electrical Subcontractor, and Commissioning Team.

2. Review the Start-up documentation.

3. Review display of all metering data and status indicators and check for accuracy.

4. Test Main-Tie-Main remote operation per the specified Sequence of Operations.

E. Lighting and Lighting Inverter System:

1. Participants shall include Contractor, Electrical Subcontractor, and Commissioning Team.

2. Spot check the lighting systems Start-up and ensure that the all fixtures are operational and clean.

3. Check all switches to ensure proper operation and circuiting.

4. Individually check all lighting panel schedules to ensure that room numbers and areas are correctly listed and they are programmed per the Owner Representative’s direction.

5. Test operation of inverter by interrupting power supply to demonstrate all fixtures are operational. Verify transfer from normal power to battery and retransfer to normal.

F. Fire Alarm System:

1. Participants shall include Contractor, Electrical Subcontractor, MU HEALTHCARE Environmental Health & Safety, and Commissioning Team.

2. Spot check location of sensors and switches to ensure conformance with requirements.
3. Verify sampling of all types of devices. Cause activation of the device, assure alarms are initiated and resulting response is per the requirements.

4. Verify interfaces with all other inter-related systems or equipment including building automation system (BAS), pre-action fire protection system, HVAC systems, etc. on a point by point basis for all points.

5. Validate output devices (speakers and strobes) meet the code criteria (96 dBa at 10 feet and 117 candela at peak).

6. Test all functions and sequences associated with the pre-action fire protection system.

7. Activate sprinkler flow switches. Validate that appropriate zone enunciates and alarms sound.

8. Verify audio aspects of the system function as required. Verify paging messages can be heard.

9. Ensure that the system functions while using all sources of power including normal, emergency, and battery. Check battery life by simulating an extended outage.

3.05 PARTICIPATION

A. Required participating parties are indicated with the individual tests. Typically, multiple parties are required for any given test, yet participation for any given party is only required for the respective portion of the test for which the party is responsible. In many cases, the maximum required time in hours is indicated in parenthesis for any given test. The time is typically per unit system unless indicated otherwise. If no time is indicated, participation is required throughout the entire test.

B. Frequently, on multiple samples where a given party does not directly conduct the test, the participation of that party will only be required for an initial quantity of systems/equipment. It is required that the parties be available on-site throughout the testing of any given system for which they are required participants. Therefore time for which they are not directly involved can be spent performing other work (typically addressing identified punch list items or failed test).

C. No party involved with the Project is prohibited from participation in or witnessing of any tests. Any Subcontractor may elect to witness all tests on their systems even if their involvement is not directly required.

D. Coordinate effectively with the individual Subcontractors throughout the development and execution of FPT’s and maximize Subcontractors’ involvement.

3.06 NON-CONFORMANCE

A. Record results of Functional Performance Tests. Commissioning Authority shall report all deficiencies and non-conformance issues to Owner on the Functional Performance Test report form and in a Commissioning deficiency report.

B. At the sole discretion of Owner, Owner may permit the Contractor to make corrections of minor deficiencies observed during a Functional Performance Test. However, the Contractor must document the deficiency and resolution on the appropriate report form.

C. Contractor and Owner will attempt to resolve deficiencies in the following manner:

1. When there is no dispute about a deficiency and Contractor accepts responsibility for correction.

   a. Contractor documents the deficiency and the corrective actions, and then proceeds to another test or sequence. Contractor submits a deficiency report to Owner. Contractor corrects the deficiency, completes the statement of correction form certifying that the equipment or system is ready for retesting, and sends the certification to Owner.
b. Contractor reschedules test with Owner.

2. When there is a dispute about whether or not the test indicates a Deficiency, or the Contractor’s responsibility for the correction of the apparent Deficiency.
   a. Commissioning Authority documents the apparent Deficiency and proceeds to another test or sequence. Commissioning Authority submits a Deficiency report to Owner, including the apparent Deficiency.
   b. Contractor facilitates resolution of Deficiency and provides recommendations to the Owner. Contractor and Owner may bring other parties into the discussions as needed. Final technical interpretive authority is with the Architect/Engineer. Final acceptance authority is with the Owner.
   c. Contractor documents resolution process.
   d. If Owner agrees with Contractor’s interpretation and proposed resolution, Contractor forwards response to Owner. Contractor reschedules test with Owner. Contractor must repeat this process until satisfactory performance and Owner’s approval is obtained.

3.07 ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in the Specification Sections applicable to the systems being tested. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device.

END OF SECTION 26 08 16
EXAMPLE – FUNCTIONAL PERFORMANCE TEST
Switchgear

Project: ___________________________________  Project #: ___________________

Identification of Equipment or System: _________________________________________

Location of Equipment or System: _____________________________________________

Specification Section: _______________  Detail/Drawing Number: _______________

Manufacturer / Supplier: ______________________________________________________

This Date: ________________  Time of Test: ________________

Functional Performance Test Procedure Number: ___________________

Prefunctional Checklist Number: ___________

Components Included:
___ Transformer, ___ Main-Tie-Main, ___ HMI, ___ Circuit Breakers

Other Related Functional Performance Tests: _________________________________

1. General:

This Functional Performance Test is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Commissioning Deficiency Report upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.

2. ___ Commissioning Deficiency Report attached.

3. Participants:

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Role/Participation</th>
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</table>
4. Functional Performance Test Prerequisites:

<table>
<thead>
<tr>
<th>Specified Requirement</th>
<th>Yes</th>
<th>No</th>
<th>Date to be Submitted</th>
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<tbody>
<tr>
<td>a) The Prefunctional Checklist for this system is complete and approved</td>
<td></td>
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<tr>
<td>b) The Prefunctional Checklist for the switchgear and related accessories is complete and approved</td>
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<td>c) All Architect/Engineer punchlist items for this system and related equipment have been addressed and corrected</td>
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<td>d) Sequence of operation is attached</td>
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<tr>
<td>e) These Functional Performance Test procedures have been reviewed and approved by installing contractor and applicable subcontractors</td>
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5. Functional Performance Test Procedure:

<table>
<thead>
<tr>
<th>Step</th>
<th>Mode</th>
<th>Test Procedure</th>
<th>Expected Response</th>
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<tbody>
<tr>
<td>1</td>
<td></td>
<td>Functional Performance Test No. 1:</td>
<td>Verify that: Line A Main Circuit Breaker opens. Line B Main Circuit Breaker Closes and Power has been transferred to Line B.</td>
</tr>
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<td>Open Line A (preferred) utility feeder overcurrent protective device.</td>
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<td>Perform test and record data. At end of test, restore normal power.</td>
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<tr>
<td>2</td>
<td>Incremental</td>
<td>Functional Performance Test No. 1:</td>
<td>Verify that: Line B Main Circuit Breaker opens. Line A Main Circuit Breaker Closes and Power has been transferred to Line A.</td>
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<tr>
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<td></td>
<td>Close Line A utility feeder overcurrent protective device.</td>
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<td>Perform test and record data. At end of test, restore normal power.</td>
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</tr>
<tr>
<td>3/4</td>
<td>Incremental</td>
<td>Repeat Steps 1 and 2 above with Line B as preferred utility source</td>
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6. Comments:
Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Commissioning Deficiency Report.

<table>
<thead>
<tr>
<th>General Contractor:</th>
<th>Print Name:</th>
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<th>Electrical Subcontractor</th>
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<tr>
<th>Other Subcontractor:</th>
<th>Print Name:</th>
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Functional Performance Test procedure received and reviewed for completeness by MU HEALTHCARE representatives. Integrated System Test can proceed.

<table>
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<th>MUHC:</th>
<th>Print Name:</th>
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SECTION 262213 - TRANSFORMERS

PART 1 - GENERAL

1.01  RELATED DOCUMENTS:
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02  SUMMARY:
A. This SECTION specifies transformer work as indicated by drawings and schedules.
B. Types of transformers specified in this SECTION include the following:
   1. Dry-type transformers, 600V and less.

1.03  RELATED REQUIREMENTS:
A. SECTION 260526 – GROUNDING for grounding.

1.04  REFERENCE STANDARDS:
A. American National Standards Institute (ANSI):
   2. C57.12.01 - General Requirements for Dry-Type Distribution and Power Transformers.
   3. C57.12.50 - Requirements for Ventilated Dry-Type Distribution Transformers 1-500 kVA, Single-Phase, and 15-500 kVA, Three-Phase with High-Voltage 601-34,500V, Low Voltage 120-600V.
   4. C57.12.51 – Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and larger, Three-Phase, with High-Voltage 601V to 34,500V; Low-Voltage 208Y/120V to 4160V.
   5. C57.12.91 - Test Code for Dry-Type Distribution and Power Transformers.
B. National Electrical Manufacturers Association (NEMA):
   3. TR1 - Transformers, Regulators, and Reactors. ( Supplements ANSI C57 - Series Standards.)
   4. TR27 - Commercial, Institutional, and Industrial Dry-Type Transformers.
   5. ST20 - Dry-type Transformers for General Applications.
   6. 250 - Enclosures for Electrical Equipment.
C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC). Comply with NEC as applicable to installation and construction of electrical power/distribution transformers.
D. Underwriters Laboratories (UL): Comply with applicable requirements of ANSI/UL 506 Safety Standard for Specialty Transformers. Provide transformers and components which are UL-listed and labeled.
   1. UL 1561 - Large General Purpose Transformers.

1.05  SUBMITTALS:
A. Refer to DIVISION 01 and SECTION 260510 - BASIC ELECTRICAL REQUIREMENTS for administrative and procedural requirements for submittals.
B. Include, but not limited to, the following:
   1. Product Data: Submit manufacturer's technical product data including rated kVA, frequency, primary and secondary voltages, wiring diagram, percent taps, polarity,
SECTION 262213 - TRANSFORMERS: continued

impedance and certification of transformer performance efficiency at 100% load, percentage voltage regulation at 100% load at 75ºC, full-load losses in watts, percent impedance at 75ºC, hot-spot and average temperature rise above 40ºC ambient temperature, sound level in decibels, and standard published data.

2. Submit all field test data.
3. Submit Operation and Maintenance manuals.

1.06 QUALITY ASSURANCE:
A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers.”

1.07 DELIVERY, STORAGE, AND HANDLING:
A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.08 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete bases are specified in SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.
B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Subject to compliance with requirements, provide products of one of the following (for each type of transformer):
   2. General Electric Company.
   3. Square D, a brand of Schneider Electric.
   4. ABB.

2.02 TRANSFORMERS
A. General: Except as otherwise specified or indicated, provide manufacturer's standard materials and components as indicated by published product information, designed and constructed as recommended by manufacturer, and as required for complete installation. Comply with NEMA TP 1, Class 1 efficiency levels for all transformers 15 kVA and larger. Core material shall be grain-oriented, non-aging silicon steel. Coils shall be continuous windings without splices except for taps. Internal coil connections shall be brazed or pressure type.
B. Dry-Type Transformers (45 kVA or less): Factory-assembled and -tested, general-purpose, air-cooled, dry-type transformers; of sizes, characteristics, and rated capacities indicated.
SECTION 262213 - TRANSFORMERS: continued

1. Single-phase transformer (where indicated):
   a. 60-hertz.
   b. 10-kV BIL.
   c. Manufacturer's standard impedance.
   d. 480V primary and 240/120V secondary with grounded neutral.

2. Three-phase transformer (where indicated):
   a. 60-hertz.
   b. 10-kV BIL.
   c. Manufacturer's standard impedance.
   d. 480V delta connected primary and 208/120V wye connected secondary with grounded neutral.
   e. Copper primary and secondary windings.
   f. Provide primary winding with 4 full capacity taps; two 2-1/2% increments below and above full-rated voltage for deenergized tap-changing operation.
   g. Insulate with 220ºC, UL-component-recognized insulation system with a maximum of 115ºC rise above 40ºC ambient temperature.
   h. Rate transformer for continuous operation at rated kVA.
   i. Limit transformer surface temperature rise to maximum of 65ºC.
   j. Provide terminal enclosure, with cover, to accommodate primary and secondary winding connections and raceway connectors. Equip terminal leads with connectors installed.
   k. Limit terminal compartment temperature to 75ºC when transformer is operating continuously at rated load with ambient temperature of 40ºC.
   l. Provide wiring connectors suitable for copper wiring.
   m. Cushion-mount transformers with external vibration isolation supports; sound-level ratings shall not exceed ANSI/NEMA standards.
   n. Electrically ground core and coils to transformer enclosure by means of flexible metal grounding strap.
   o. Provide transformers with ventilated or fully enclosed sheet steel enclosures. Apply manufacturer's standard light gray indoor enamel over cleaned and phosphatized steel enclosure.

3. Provide transformers suitable for wall mounting, floor mounting, or suspended from structure. Provide all accessories including wall brackets for mounting location indicated on Drawings.

C. Dry-Type Transformers (above 45 kVA): Factory-assembled and -tested, general-purpose, ventilated, dry-type transformers; of sizes, characteristics, and rated capacities indicated.
1. 3-phase.
2. 60-hertz.
3. 10-kV BIL.
4. 5.75% impedance.
5. 480V delta-connected, primary; and 208Y/120V 4-wire, wye-connected secondary with grounded neutral.
6. Provide primary windings with a minimum of 6 full capacity taps; four 2-1/2% increments above full-rated voltage and two 2-1/2% increments below full-rated voltage for deenergized tap-changing operation.
7. Copper primary and secondary windings.
8. Insulate with 220ºC, UL-component-recognized insulation system with a maximum of 115ºC rise above 40ºC ambient temperature.
SECTION 262213 - TRANSFORMERS: continued

9. Rate transformer for continuous operation at rated kVA.
10. Limit transformer surface temperature rise to maximum of 65ºC.
11. Provide terminal enclosure, with hinged cover, to accommodate primary and secondary winding connections and raceway connectors. Provide terminal board with clamp type connectors.
12. Limit terminal compartment temperature to 75ºC when transformer is operating continuously at rated load with ambient temperature of 40ºC.
13. Provide wiring connections suitable for copper wiring.
14. Integritly mount vibration isolation supports between core and coil assembly and transformer enclosure.
15. Electrically ground core and coils to transformer enclosure by means of flexible metal grounding strap.
16. Do not exceed maximum sound-level rating in accordance with ANSI/NEMA standards.
17. Provide transformers with ventilated steel enclosures and lifting lugs.
18. Apply manufacturer's standard light gray outdoor enamel over cleaned and phosphatized steel enclosure.
19. Provide transformers suitable for wall mounting, floor mounting, or suspended from structure. Provide all accessories including wall brackets for mounting location indicated on Drawings.

D. Equipment/System Identification: Provide equipment/system identification nameplates complying with SECTION 260553 - ELECTRICAL IDENTIFICATION.

E. Finishes: Coat interior and exterior surfaces of transformer, including bolted joints, with manufacturer's standard color gray baked-on enamel.

PART 3 - EXECUTION

3.01 INSPECTION
A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
D. Verify that ground connections are in place and requirements in SECTION 260526 – GROUNDING have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION
A. Install transformers as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NESC, NEMA, ANSI and IEEE standards, and in accordance with recognized industry practices to ensure that products fulfill requirements. Arrange equipment to provide adequate space for access and for cooling air circulation.
B. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A-486B.
SECTION 262213 - TRANSFORMERS: continued

C. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions and requirements in SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.

3.03 CONNECTIONS
A. Provide equipment grounding connections for transformers as specified, indicated, and as required. Tighten connections to comply with tightening torques specified in UL 486A-486B to assure permanent and effective grounding. Provide grounding in accordance with SECTION 260526 - GROUNDING.
B. Connect wiring according to SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.04 IDENTIFICATION
A. Provide identification of transformers as specified in SECTION 260553 - ELECTRICAL IDENTIFICATION.

3.05 TESTING
A. Prior to energization of transformers, check all accessible connections for compliance with manufacturer's torque tightening specifications. Clean out any dust and dirt.
B. Prior to energization, check circuitry for electrical continuity and for short circuits.
C. Adjust transformer primary taps for nominal system voltage at initial installation.

END OF SECTION 262213
SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:
A. This SECTION specifies panelboards, including cabinets and boxes, as indicated by drawings and schedules, and as specified herein.
B. Types of panelboards and enclosures required for the project include the following:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.03 RELATED REQUIREMENTS:
A. Wires/cables, electrical boxes, fittings, and raceways required in conjunction with the installation of panelboards and enclosures: Other DIVISION 26 SECTIONS.
B. SECTION 260526 - GROUNDING for grounding.
C. SECTION 260553 - ELECTRICAL IDENTIFICATION for electrical identification.

1.04 REFERENCE STANDARDS:
A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000V Maximum).
   2. PB1 - Panelboards.
   3. PB1.1 - Instructions for Safe Installation, Operation, and Maintenance of Panelboards Rated 600V or Less.
B. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC): Comply with applicable local code requirements of the authority having jurisdiction and NEC as applicable to installation and construction of electrical panelboards and enclosures.
C. Underwriters Laboratories (UL): Provide panelboard units which are UL listed and labeled.
   1. 50 - Electrical Cabinets and Boxes.
   2. 67 - Electrical Panelboards.
   3. 486A-486B - Wire Connectors.
   4. 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures.
   5. 1449 – Surge Protective Devices.
D. Federal Specification (FS) Compliance: Comply with applicable requirements of the following standards.
   1. FS W-C-375 Series - Molded-Case Circuit-Breakers, Branch Service and Circuit.

1.05 SUBMITTALS:
A. Refer to DIVISION 01 and SECTION 260510 - BASIC ELECTRICAL REQUIREMENTS for administrative and procedural requirements for submittals.
B. Includes, but not limited to, the following:
   1. Product Data: Submit manufacturer's data on panelboards and enclosures.
      a. Panelboard dimensions and weight.
      b. Complete data on circuit breakers and fuses. Submit time - current characteristic curves of all devices.
SECTION 262416 - PANELBOARDS: continued

c. Panelboard short-circuit interrupting capacity, and information on buses: phase, neutral, and ground.
d. Information on whether panelboard is fed from top or bottom.
e. Data on maximum and minimum incoming and outgoing feeder and branch circuit wire size.
f. Data on door, locks, and mounting: surface or flush.
g. Data on total number of poles and number of unused poles that are available for future use.

C. All Field Test Data.

1.06 MAINTENANCE MATERIAL SUBMITTALS:
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
B. Operation and Maintenance Manual.

1.07 QUALITY ASSURANCE:
A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
D. Comply with NEMA PB 1.
E. Comply with NFPA 70.

1.08 DELIVERY, STORAGE, AND HANDLING:
A. Handle and prepare panelboards for installation according to NEMA PB 1.

1.09 PROJECT CONDITIONS:
A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding -23°F to +104°F.
      b. Altitude: Not exceeding 6,600 feet.
B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6,600 feet.
C. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCD/SEI 7.
   1. The term “withstand” means “the unit will remain in place without separation of any parts from the device when subjected to the seismic forces applied.”
SECTION 262416 - PANELBOARDS: continued

1.10 COORDINATION:
A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete bases are specified in SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.

1.11 WARRANTY:
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace surge protective devices that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:
A. Subject to compliance with requirements, provide panelboard products of one of the following (for each type and rating of panelboard and enclosure):
   2. General Electric Company.
   3. Square D, a brand of Schneider Electric.
   4. ABB

2.02 GENERAL REQUIREMENTS FOR PANELBOARDS:
A. Except as otherwise indicated, provide panelboards, enclosures, and ancillary components of types, size, and ratings indicated, which comply with manufacturer's standard materials and with the design and construction in accordance with published product information.
B. Where types, sizes, or ratings are not indicated, comply with NEC, UL, and established industry standards for those applications indicated.
C. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces.
D. Equip with proper number of panelboard switching and protective devices as required for complete installation.
E. Provide ground fault circuit interrupter type circuit breakers where indicated.
F. Enclosures: Flush- and surface-mounted cabinets as indicated.
   1. Provide enclosures fabricated by same manufacturer as panelboards which mate and match properly with panelboards.
   2. Rated for environmental conditions at installed location. Provide NEMA type as described below, unless indicated or specified otherwise.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
   4. Front: Secured to box with adjustable, concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
SECTION 262416 - PANELBOARDS: continued

5. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Front doors shall have flush locks with three keys per panelboard, all panelboard enclosures keyed alike.

6. Finishes:
   a. Color: Baked gray enamel finish over a rust inhibitor coating.
   b. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.


G. Phase, Neutral, and Ground Buses:
   1. Bus shall be braced to withstand available short circuit currents as indicated.
   2. Provide suitable lugs on neutral bus for incoming and outgoing feeders requiring neutral connections.
   3. Equipment Ground Bus: Bare, uninsulated, adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
   4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box. Provide as indicated.
   5. Extra-Capacity Neutral Bus and Lugs: Neutral bus and lugs rated 200% of phase bus and UL listed as suitable for nonlinear loads. Provide as indicated.

H. Conductor Connectors: Suitable for use with conductor material and sizes.
   1. Material: Hard-drawn copper, 98% conductivity, suitable for use with copper conductors.
   2. Main and Neutral Lugs: Mechanical type.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
   5. Subfeed (Double) Lugs: Prohibited.
   6. Extra-Capacity Neutral Lugs: Rated 200% of phase lugs mounted on extra-capacity neutral bus. Provide as indicated.
   7. Provide terminals UL rated for 75°C (Minimum) conductors.

I. Overcurrent Protection Devices: All devices on essential power system shall allow for electrical coordination.

J. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals as indicated. Series rated devices are not permitted. Panelboards rated 250 Vac or less shall have short-circuit current rating as indicated on drawings or as scheduled herein, but not less than 10,000 amperes RMS symmetrical. Panelboards rated 480/277 Vac shall have short-circuit current rating as indicated on drawings or as scheduled herein, but not less than 14,000 amperes RMS symmetrical.

2.03 DISTRIBUTION PANELBOARDS:

A. Panelboards: NEMA PB 1, dead front, safety type, power and feeder distribution type, 480Y/277V and 208Y/120V (voltage rating as required), 3 phase, 4 wire, 60 hertz with full-sized neutral bus, as indicated with panelboard switching and protective devices in quantities, ratings, types, and with arrangement shown; with anti-turn solderless pressure type main lug.
connectors approved for use with copper conductors. Provide full height panels for all distribution panels.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   1. For doors more than 36 inches high, provide two latches, keyed alike.

C. Incoming Mains Location: Top or Bottom as required.

D. Mains: Electronic trip circuit breaker with field replaceable rating plug or field adjustable trip unit.

E. Branch Overcurrent Protective Devices:
   1. Bolt-on, molded-case circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal. Electronic trip type with field replaceable rating plug or field adjustable trip unit.
   2. Molded-case circuit breakers shall have toggle handles that indicate when tripped.
   3. Where multiple pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously.
   4. Circuit breakers shall be replaceable without disturbing adjacent units.
   5. Provide double branch mounting configuration for all branch circuit breakers. Single mounting (center mounted) configuration is not permitted.

F. Provide distribution panels with minimum enclosure height of 86” tall.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS:

A. Panelboards: NEMA PB 1, dead front, safety type, 480Y/277V and 208Y/120V (voltage rating as required), 3 phase, 4 wire, 60 hertz with full-sized neutral bus, lighting and appliance branch-circuit type as indicated with switching and protective devices in quantities, ratings, types, and arrangements shown.

B. Incoming Mains Location: Top or Bottom as required.

C. Mains: Electronic trip circuit breaker with field replaceable rating plug or field adjustable trip unit.

D. Branch Overcurrent Protective Devices:
   2. Molded-case circuit breakers shall have toggle handles that indicate when tripped.
   3. Where multiple pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously.
   4. Circuit breakers shall be replaceable without disturbing adjacent units.
   5. Provide electronic trip type circuit breakers with field replaceable rating plug or field adjustable trip unit for circuits 30 amps and larger and where required for coordination to the 0.1 second interval for panelboards connected to the essential electrical system.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.05 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES:

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and \( I{\text{t}} \) response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).


7. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
   a. Factory assembled, bolt-on, standard frame sizes, trip ratings, and number of poles.
   b. Voltage Ratings:
      (1) All circuit breakers applied at 208Vac or 240Vac shall be rated 250Vac.
      (2) All circuit breakers applied at 480Vac shall be rated 480Vac.
   c. Interrupt Ratings:
      (1) Minimum of 10,000 A rms, symmetrical for 120Vac, 208Vac, and 240Vac unless indicated otherwise.
      (2) Minimum of 14,000 A rms, symmetrical for 277Vac, 480Vac, and 600Vac unless indicated otherwise.
   d. Lugs: Mechanical style, suitable for number, size, trip ratings, and rated for use with copper conductor materials.
   e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   g. Shunt Trip: 120V trip coil energized from separate circuit, set to trip at 75% of rated voltage.
   h. Undervoltage Trip: Set to operate at 35 to 75% of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
   i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
   j. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
   k. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
   l. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
   m. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

B. Arc Energy Reduction: Provide circuit breakers rated, or can be adjusted to, 1200A or higher with means to reduce circuit breaker clearing time using maintenance switching with local status indicator.
SECTION 262416 - PANELBOARDS:  continued

2.06  PANELBOARD SUPPRESSORS:
A.  Surge Protection Device:  IEEE C62.41-compliant, externally mounted, wired-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
1.  Accessories:
   a.  Fuses rated at 200-kA interrupting capacity.
   b.  Fabrication using bolted compression lugs for internal wiring.
   c.  Integral disconnect switch.
   d.  Redundant suppression circuits.
   e.  Redundant replaceable modules.
   f.  Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   g.  LED indicator lights for power and protection status.
   h.  Audible alarm, with silencing switch, to indicate when protection has failed.
   i.  Form-C contacts rated at 5 A and 250Vac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   j.  Four-digit, transient-event counter set to totalize transient surges.
2.  Peak Single-Impulse Surge Current Rating:  120 kA per mode/240 kA per phase.
   a.  Line to Neutral:  70,000 A.
   b.  Line to Ground:  70,000 A.
   c.  Neutral to Ground:  50,000 A.
4.  Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277V, 208Y/120V, three-phase, four-wire circuits shall be as follows:
   a.  Line to Neutral:  800V for 480Y/277, 400V for 208Y/120.
   b.  Line to Ground:  800V for 480Y/277, 400V for 208Y/120.
   c.  Neutral to Ground:  800V for 480Y/277, 400V for 208Y/120.

2.07  ACCESSORY COMPONENTS AND FEATURES:
A.  Accessories:  Provide panelboard accessories and devices including, but not limited to, cartridge and plug time-delay type fuses, ground fault circuit interrupter (GFCI) breakers, split bus construction, circuit breaker handle locks, etc., as recommended by panelboard manufacturer for ratings and applications as indicated. Provide circuit breaker handle locks on all circuits that supply night lights, exit signs, emergency lights, emergency power, public address system panels, energy management and control system (EMCS) panels, and fire alarm panels.
B.  Accessory Set:  Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.01  EXAMINATION:
A.  Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF PANELBOARDS:
A. Install panelboards and enclosures as indicated, providing NEC required working space, in accordance with manufacturer's written instructions, applicable requirements of NEC and in compliance with recognized industry practices to ensure that products fulfill requirements.
B. Construct concrete bases and anchor floor-mounting panelboards according to manufacturer's written instructions and requirements in SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.
C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A-486B.
D. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored.
E. Provide properly wired electrical connections for panelboards within enclosures.
F. Install numbers on all circuit breakers, and type the panelboard's circuit directory card upon completion of installation work. Clearly identify the load on each circuit and the circuit number.
G. Insert fuses if any, of ratings indicated, within installed panelboards.
H. Provide filler plates in all unused spaces.
I. Provision for future circuits at all flush mounted panelboards (unless indicated otherwise): Extend four 1-inch empty conduit from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Extend four 1-inch conduit into raised floor space or below floor slab (not required for slabs on grade or basement floor slabs).

3.03 GROUNDING:
A. Provide equipment grounding connections for panelboard enclosures as indicated and as required by NEC. Tighten connections to comply with tightening torques specified in UL 486A-486B to assure permanent and effective grounds. Provide grounding as specified in SECTION 260526 - GROUNDING.

3.04 IDENTIFICATION
A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with SECTION 260553 – ELECTRICAL IDENTIFICATION.
B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in SECTION 260553 - ELECTRICAL IDENTIFICATION.
D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified SECTION 260553 - ELECTRICAL IDENTIFICATION.
3.05 FIELD QUALITY CONTROL:
A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to
      inspect components, assemblies, and equipment installations, including connections, and
      to assist in testing.
B. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder,
      and control circuit.
   2. Test continuity of each feeder and branch circuit 30 amps and larger.
C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate
      compliance; otherwise, replace with new units and retest.
   3. Prior to energization of electrical circuitry, check all accessible connections to
      manufacturer's tightening torque specifications.
   4. Prior to energization, check panelboard circuits for short circuits, electrical continuity of
      circuits, enclosure grounding and neutral grounding at service entrance and at incoming
      derived source transformer.
   5. Prior to energization of panelboards, check with insulation resistance tester: phase-to-
      phase and phase-to-ground insulation resistance levels of each phase bus to ensure
      requirements are fulfilled. Record and submit test results.
   6. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days
         after Final Acceptance, perform an infrared scan of each panelboard. Remove front
         panels so joints and connections are accessible to portable scanner.
      b. Instruments and Equipment:
         (1) Use an infrared scanning device designed to measure temperature or to detect
             significant deviations from normal values. Provide calibration record for
             device.
   7. Panelboards will be considered defective if they do not pass tests and inspections.
   8. Prepare test and inspection reports, including a certified report that identifies panelboards
      included and that describes scanning results. Include notation of deficiencies detected,
      remedial action taken, and observations after remedial action.

3.06 ADJUSTING AND CLEANING:
A. Set field-adjustable overcurrent device trip characteristics according to overcurrent protective
   device study results.
B. Adjust moving parts and operable component to function smoothly, and lubricate as
   recommended by manufacturer.
C. Load Balancing: After Substantial Completion, but not more than 60 days after Final
   Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of
      the facility and at time directed. Avoid disrupting critical 24-hour services such as fax
      machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings
      before and after changes and submit test records.
SECTION 262416 - PANELBOARDS: continued

4. Tolerance: Difference exceeding 20% between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Upon completion of installation, clean interior and exterior of panelboards. Remove paint splatters, spots, dirt and debris.

E. Touch-up scratched or marred surfaces to match original finishes.

3.07 DEMONSTRATION:

A. Subsequent to wire and cable hook-ups, energize panelboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION 262416
SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY
   A. This SECTION includes transfer switches rated 600 V and less, including the following:
      1. Automatic transfer switches.
      2. Bypass/isolation switches.
      3. Remote annunciation and control systems.

1.03 SUBMITTALS
   A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
   B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
      1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
      2. Detailed description of equipment anchorage devices and their installation requirements.
   C. Field quality-control test reports.
   D. Seismic Qualification Certificates: For transfer switches, accessories, and components, from manufacturer.
      1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
      3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
   E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in DIVISION 01 include the following:
      1. Features and operating sequences, both automatic and manual.
      2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.04 QUALITY ASSURANCE
   A. Source Limitations: Obtain automatic transfer switches, bypass/isolation switches through one source from a single manufacturer.
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
SECTION 263600 – TRANSFER SWITCHES: continued

1.05 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete bases are specified in SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.

1.06 REFERENCES
A. Applicable Standards:
   1. Institute of Electrical and Electronic Engineers (IEEE): Provide components which comply with the following standards
   2. National Electrical Manufacturers Association (NEMA) and Insulated Cable Engineer association (IECA): Provide components which comply with the following standards.
      b. IEC 947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment.
   3. National Fire Protection Association (NFPA): Comply with the following standards.
   4. Underwriters Laboratories (UL): Provide components which are listed and labeled by UL under the following standards.
      a. UL 1008 – Standard for Transfer Switch Equipment.
      b. UL 508 – Industrial Control Equipment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Manufacturers:
   1. Contactor Transfer Switches:
      a. Russelectric RTS-03 Series.

2.02 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS
A. Automatic transfer switches shall include a 2-way bypass isolation switch and shall be closed transition type.
B. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.
C. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
D. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
E. Provide load shed options for all transfer switches.
F. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
SECTION 263600 – TRANSFER SWITCHES: continued

G. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

H. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

I. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   1. Switch Action: Double throw; mechanically held in both directions.
   2. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

J. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

K. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in SECTION 260553 - ELECTRICAL IDENTIFICATION.
   1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
   2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
   3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

L. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
   1. Provide pull box section with buss extensions mounted to top of enclosure for front access only installation.

2.03 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:
   1. Fully automatic make-before-break operation.
   2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
   3. Provide interface as required by paralleling switchgear integrator for voltage and frequency bias of generator.
   4. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
      a. Source differential sensing for closed transition operating mode. The sensor shall enable transfer/retransfer between energized sources in the closed-transition mode only when the two sources have a maximum voltage differential of 5%, frequency differential of 0.2 Hz, and are within 5 electrical degrees of each other.
      b. Time delay on failure to synchronize normal and emergency sources prior to closed-transition transfer (1 Min to 5 min), factory set at 5 min.
c. Voltage, frequency, and phase rotation sensing on both the normal and emergency sources.

5. Failure of power source serving load initiates automatic break-before-make transfer.

D. Switches shall have switched neutrals and shall have fully rated neutral transfer contacts which shall momentarily interconnect the neutrals of the sources and load during the transfer/retransfer operation. The neutrals shall remain so interconnected until the line contacts close on the alternate source. Line and neutral contacts shall be driven by a single main operator.

E. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

I. Automatic Transfer-Switch Features:
   1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
   2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
   3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
   4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, factory set at 10 minutes. Automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
   5. Test Switch: Simulate normal-source failure.
   6. Switch-Position Pilot Lights: Indicate source to which load is connected.
      a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
   8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-Vac.
9. **Transfer Override Switch:** Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

10. **Engine Starting Contacts:** One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

11. **Engine Shutdown Contacts:** Time delay adjustable from zero to fifteen minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

12. **Load Shed Circuit:** Terminals shall be provided for a remote contact which opens to signal the automatic transfer switch to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial port.

### 2.04 Bypass/Isolation Switches

**A.** Comply with requirements for Level 1 equipment according to NFPA 110.

**B.** Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Bypass to the load-carrying source shall be accomplished with no interruption of power to the load (make before break contacts). The bypass handle shall have three operating modes: “Bypass to Normal,” “Automatic,” and “Bypass to Emergency.” The operating speed of the bypass contacts shall be the same as the associated transfer switch and shall be independent of the speed at which the manual handle is operated. In the “Automatic” mode, the bypass contacts shall be out of the power circuit so that they will not be subjected to fault currents to which the system may be subjected. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.

2. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.

3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.

4. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.

5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.

6. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.

7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

**C.** Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.
SECTION 263600 – TRANSFER SWITCHES: continued

2.05 SOURCE QUALITY CONTROL
   A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.01 INSTALLATION
   A. Floor-Mounting Switch: Install transfer switches on concrete bases.
      1. Anchor transfer switches to concrete bases according to manufacturer's written instructions and requirements in SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.
      2. Comply with manufacturer requirements for seismic anchoring
      4. Provide workspace and clearances required by NFPA 70.
   B. Identify components according to SECTION 260553 - ELECTRICAL IDENTIFICATION.
   C. Set field-adjustable intervals, delays, and relays.

3.02 CONNECTIONS
   A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
   B. Ground equipment according to SECTION 260526 - GROUNDING.
   C. Connect wiring according to SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.03 FIELD QUALITY CONTROL
   A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
   B. Perform tests and inspections and prepare test reports.
      1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
         a. Check for electrical continuity of circuits and for short circuits.
         b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
         c. Verify that manual transfer warnings are properly placed.
         d. Perform manual transfer operation.
      4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
SECTION 263600 – TRANSFER SWITCHES:  continued

a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
b. Simulate loss of phase-to-ground voltage for each phase of normal source.
c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
a. Verify grounding connections and locations and ratings of sensors.
C. Report results of tests and inspections in writing. Record adjustable settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
D. Remove and replace malfunctioning units and retest as specified above.

3.04 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
B. Coordinate this training with that for generator and paralleling switchgear equipment.

END OF SECTION 263600
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