

PART I - GENERAL

1.01 DESCRIPTION

- A. The purpose of this section is to specify the Division 15 responsibilities and participation in the commissioning process.
- B. Commissioning is primarily the responsibility of the Division 18 Contractor (NEBB Systems Commissioning Administrator (SCA)), with support for start-up, testing, and commissioning the responsibility of Division 15. The commissioning process does not relieve Division 15 from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.
- C. The NEBB Systems Commissioning Administrator (SCA) will verify and document the following field tests and observations:
  - 1. Field Installation Verification (FIV). Verification of all installed systems for compliance to plans and specification. These inspections are to be described in detail in the commissioning plan.
  - 2. Operation Performance Tests (OPT). Operational tests which verify proper start-up of all equipment and systems. These tests are to be described in detail in the commissioning plan.
  - 3. Functional Performance Tests (FPT). Functional system tests that verify all systems are functioning and interacting with other systems correctly. These tests are to be described in detail in the commissioning plan.
- D. The NEBB Systems Commissioning Administrator (SCA) will provide all Testing, Adjusting and Balance work.
- E. Work of Division 15 includes:
  - 1. Testing and start-up of the equipment.
  - 2. Assistance in testing and balancing.
  - 3. Providing qualified personnel for participation in commissioning tests, including seasonal testing required after the initial commissioning.
  - 4. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.

5. Providing operation and maintenance information and as-built drawings to the NEBB Systems Commissioning Firm for verification, organization, and distribution.
6. Providing assistance to the NEBB Systems Commissioning Firm to develop and edit system operation descriptions.
7. Providing training for the systems specified in this Division with coordination by the NEBB Systems Commissioning Firm.

1.02 COOPERATION

- A. Cooperate with the NEBB Test and Balance Firm and the NEBB Systems Commissioning Administrator (SCA) in the following manner:
  1. Allow sufficient time before final completion dates so that testing and balancing can be accomplished.
  2. Provide labor and material to make corrections when required without undue delay. Install balancing dampers/balancing cocks/ P&T taps as required by NEBB test and balance firm.
  3. Put all heating, ventilating, and air conditioning systems and equipment into full operation and continue the operation of the same during each working day of testing and balancing.
  4. Include the costs of dampers, sheaves, and belts, including the cost of exchange sheaves and belts as required by the NEBB Systems Commissioning Firm.
  5. Provide test holes in ducts and plenums where directed or necessary for pitot tubes for taking air measurements and to balance the air systems. Test holes shall be provided with an approved removable plug or seal. At each location where ducts or plenums are insulated, test holes shall be provided with an approved extension with plug fitting.
  6. Provide P&T (pressure and temperature) taps as noted on construction documents and as required by the NEBB Systems Commissioning Firm to adequately test and/or balance the hydronic systems.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

The test equipment will be provided by the NEBB Test and Balance Firm as part of their contract. Provide test equipment as necessary for start-up of the mechanical equipment.

2.02 TEST EQUIPMENT - PROPRIETARY

Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the NEBB Systems Commissioning Firm in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

PART 3 - EXECUTION

3.01 WORK PRIOR TO COMMISSIONING

- A. Complete all phases of work so the system can be started, tested, balanced, and otherwise commissioned. Division 15 has primary startup responsibilities with obligations to complete systems, including all sub-systems so they are functional. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc. per the contract documents and related directives, clarifications, change orders, etc.
- B. A commissioning plan will be developed by the NEBB Systems Commissioning Firm. Upon request of the NEBB Systems Commissioning Firm, Division 15 shall provide assistance and consultation. Division 15 is obligated to assist the NEBB Systems Commissioning Firm in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation.

If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alter the commissioning process, the NEBB Systems Commissioning Firm will notify the Architect.

- C. Specific pre-commissioning responsibilities of Division 15 are as follows:
  - 1. Factory start-up or Contractor start-up of all equipment and systems installed under division 15000.
  - 2. Normal start-up services required bringing each system into a fully operational state. This includes motor rotational check, cleaning, filling, purging, control sequences of operation, leak testing, full load, and part load performance, etc. The NEBB Systems Commissioning Firm will not begin the functional commissioning process until each system is complete, including normal contractor start-up.

3.02 PARTICIPATION IN COMMISSIONING

- A. Provide skilled technicians to start-up and debug all systems within Division 15. These same technicians shall be made available to assist the NEBB Systems Commissioning Firm in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc. will be requested by the NEBB Systems Commissioning Firm and coordinated by the Contractor. Contractor will ensure the qualified

technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.

- B. System problems and discrepancies may require additional technician time, NEBB Systems Commissioning Firm time, redesign and/or reconstruction of systems, and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.
- C. The NEBB Systems Commissioning Firm reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or subsystem. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the NEBB Systems Commissioning Firm to get the job done. A liaison or intermediary between the NEBB Systems Commissioning Firm and qualified factory representatives does not constitute the availability of a qualified technician for purposes of this work.

### 3.03 WORK TO RESOLVE DEFICIENCIES

- A. In some systems, mis-adjustments, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Architect, with input from the Contractor, equipment supplier, and NEBB Systems Commissioning Firm. Whereas all members will have input and the opportunity to discuss, debate and work out problems, the Architect per Division 1 will have final jurisdiction on the necessary work to be done to achieve performance.
- B. Corrective work is to be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the NEBB Systems Commissioning Firm deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the NEBB Systems Commissioning Firm will notify the Architect indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

### 3.04 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

- A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.
- B. All equipment and systems will be tested and commissioned in a peak season to observe full load performance. Heating equipment will be tested during winter design extremes. Cooling equipment will be tested during summer design extremes, with a fully occupied building. Each

Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance.

**3.05 TRAINING**

- A. In addition to the requirements of Division 1, arrange for and participate in the training of Owner's engineering and maintenance staff on each system and related components. Training will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids.
- B. Training will be conducted jointly by the NEBB Systems Commissioning Administrator (SCA), the design engineers, the equipment vendors, and the Contractor. The Contractor will be responsible for highlighting system peculiarities specific to this project.

**3.06 SYSTEMS DOCUMENTATION**

- A. In addition to the requirements of Division 1, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be redlined on one set of transparencies provided by the contractor. Division 15 as-built drawings shall include architectural floor plans, elevations and details, and the individual mechanical or electrical systems in relation to actual building layout.
- B. Maintain as built redlines as required in Division 1. Given the size and complexity of this project, redline drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular redlining of drawings is considered essential and mandatory.
- C. In addition to the requirements of Division 1 for operation and maintenance data, provide seven (5) copies of equipment technical literature, operation and maintenance literature, and shop drawings to the NEBB Systems Commissioning Administrator (SCA) as soon as they are available. This requirement does not relieve the Contractor of submitting the final operating and maintenance data at project closeout.

END OF SECTION

PART I - GENERAL

1.01 DESCRIPTION

- A. The purpose of this section is to specify the Division 16 Contractor's responsibilities and participation in the commissioning process.
- B. Commissioning is primarily the responsibility of the Division 18 Contractor (NEBB Systems Commissioning Administrator (SCA)), with support for start-up, testing, and commissioning responsibility of Division 16. The commissioning process does not relieve Division 16 from participation in the process or diminish the role and obligations of this Contractor to complete all portions of work in a satisfactory and fully operational manner.
- C. The NEBB Systems Commissioning Administrator (SCA) will verify and document the following field tests and observations:
  - 4. Field Installation Verification (FIV). Verification of all installed systems for compliance to plans and specification. These inspections are to be described in detail in the commissioning plan.
  - 5. Operation Performance Tests (OPT). Operational tests which verify proper start-up of all equipment and systems. These tests are to be described in detail in the commissioning plan.
  - 6. Functional Performance Tests (FPT). Functional system tests that verify all systems are functioning and interacting with other systems correctly. These tests are to be described in detail in the commissioning plan.
- D. Work of Division 16 includes:
  - 1. Testing and start-up of the equipment.
  - 2. Providing qualified personnel for participation in commissioning tests, including seasonal testing required after the initial commissioning.
  - 3. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.
  - 4. Providing operation and maintenance information and as-built drawings to the NEBB Systems Commissioning Firm for verification, organization, and distribution.
  - 5. Providing assistance to the NEBB Systems Commissioning Firm to develop and edit system operation descriptions.
  - 6. Providing training for the systems specified in this Division with coordination by the NEBB Systems Commissioning Firm.

1.02 COOPERATION

- B. The electrical contractor will cooperate with the NEBB Systems Commissioning Administrator (SCA) in the following manner.
  - 1. Complete equipment and system start up in accordance with the commissioning schedule.
  - 2. Attend all commissioning planning and scheduling meetings as scheduled by the NEBB Systems Commissioning Administrator (SCA).

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

Test equipment for electrical systems testing shall be provided by Division 16. Provide test equipment as necessary to start-up, test, and commission the electrical systems.

2.02 TEST EQUIPMENT - PROPRIETARY

Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the NEBB Systems Commissioning Firm in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

PART 3 - EXECUTION

3.01 WORK PRIOR TO COMMISSIONING

- A. Complete all phases of work so the systems can be energized, started, tested, and otherwise commissioned. Division 16 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are functional. This includes the complete installation of all equipment, materials, raceways, wire, termination's, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.
- B. A commissioning plan will be developed by the NEBB Systems Commissioning Firm. Upon request of the NEBB Systems Commissioning Firm, Division 16 shall provide assistance and consultation. Division 16 is obligated to assist the NEBB Systems Commissioning Firm in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alter the commissioning process; the NEBB Systems Commissioning Firm will notify the Architect.

C. Specific pre-commissioning responsibilities of Division 16 are as follows:

1. Factory start-up or Contractor startup of all equipment and systems installed under division 16000.
2. Normal start-up services required to bring each system into a fully operational state. This includes motor rotational check, cleaning, bolt tightening, control sequences of operation, etc. The NEBB Systems Commissioning Firm will not begin the commissioning process until each system is complete, including normal contractor startup.

### 3.02 PARTICIPATION IN COMMISSIONING

- A. Provide skilled technicians to start-up and debug all systems within Division 16. These same technicians shall be made available to assist the NEBB Systems Commissioning Firm in completing the commissioning program as it relates to each system and their technical specialty. Work schedules; time required for testing, etc. will be requested by the NEBB Systems Commissioning Firm and coordinated by the Contractor. Contractor will ensure the qualified technicians are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.
- B. System problems and discrepancies may require additional technician time, NEBB Systems Commissioning Firm time, redesign and/or reconstruction of systems, and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.
- C. The NEBB Systems Commissioning Firm reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or subsystem. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the NEBB Systems Commissioning Firm to get the job done. A liaison or intermediary between the NEBB Systems Commissioning Firm and qualified factory representatives does not constitute the availability of a qualified technician for purposes of this work.

### 3.03 WORK TO RESOLVE DEFICIENCIES

- A. In some systems, mis-adjustments, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Architect, with input from the Contractor, equipment supplier, and NEBB Systems Commissioning Firm. Whereas all members will have input and the opportunity to discuss, debate and work out problems, the Architect per Division I will have final jurisdiction on the necessary work to be done to achieve performance.



- B. Corrective work be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the NEBB Systems Commissioning Firm deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the NEBB Systems Commissioning Firm will notify the Architect indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

#### 3.04 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

- A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.
- B. All equipment and systems will be tested and commissioned in a peak season to observe full load performance. Heating equipment will be tested during winter design extremes. Cooling equipment will be tested during summer design extremes, with a fully occupied building. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance.

#### 3.05 TRAINING

- A. In addition to the requirements of Division 1, arrange for and participate in the training of Owner's engineering and maintenance staff on each system and related components. Training will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids.
- B. Training will be conducted jointly by the NEBB Systems Commissioning Administrator (SCA), the design engineers, the equipment vendors, and the Contractor. The Contractor will be responsible for highlighting system peculiarities specific to this project.

#### 3.06 SYSTEMS DOCUMENTATION

- A. In addition to the requirements of Division 1, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be redlined on one set of transparencies provided by the contractor. Division 16 as-built drawings shall include architectural floor plans, elevations and details, and the individual electrical systems in relation to actual building layout.

- B. Maintain as-built redlines as required in Division 1. Given the size and complexity of this project, redline drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining of drawings is considered essential and mandatory.
  
- C. In addition to the requirements of Division I for operation and maintenance data, provide five (5) copies of equipment technical literature, operation and maintenance literature, and shop drawings to the NEBB Systems Commissioning Administrator (SCA) as soon as they are available. This requirement does not relieve the Contractor of submitting the final operating and maintenance data at project closeout.

END OF SECTION

**DIVISION 15 & 16****EQUIPMENT****COMMISSIONING****1. EQUIPMENT COMMISSIONING**

The equipment specified shall be started up and tested by a factory authorized and certified technician. The manufacturer shall coordinate start up of the equipment with the NEBB Systems Commissioning Administrator (SCA) as specified in Section 15999, 16999, and 18000 of these specifications. Give cooperation to the NEBB Systems Commissioning Administrator (SCA) by providing all tests, startup services, documentation and training as required.

**DIVISION 15 & 16****SUBCONTRACTOR****COMMISSIONING****1. SUBCONTRACTOR COMMISSIONING**

This subcontractor shall provide all start up and testing by an authorized and certified technician. The subcontractor shall coordinate start up of the equipment with the NEBB Systems Commissioning Administrator (SCA) as specified in Section 15999, 16999, and 18000 of these specifications. Give cooperation to the NEBB Systems Commissioning Administrator (SCA) by providing all tests, startup services, documentation and training as required.

PART I - GENERAL

1.01...DESCRIPTION

- A. The purpose of this section is to specify the Division 17 responsibilities and participation in the commissioning process.
- B. Commissioning is primarily the responsibility of the Division 18 Contractor (NEBB Systems Commissioning Administrator (SCA)), with support for start-up, testing, and commissioning the responsibility of Division 17. The commissioning process does not relieve Division 17 from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.
- C. The NEBB Systems Commissioning Administrator (SCA) will verify and document the following field tests and observations:
  - 1. Field Installation Verification (FIV). Verification of all installed systems for compliance to plans and specification. These inspections are to be described in detail in the commissioning plan.
  - 2. Operation Performance Tests (OPT). Operational tests which verify proper start-up of all equipment and systems. These tests are to be described in detail in the commissioning plan.
  - 3. Functional Performance Tests (FPT). Functional system tests that verify all systems are functioning and interacting with other systems correctly. These tests are to be described in detail in the commissioning plan.
- D. Work of Division 17 includes:
  - 1. Testing and start-up of the equipment. Provide a complete point to point test prior to the commissioning phase.
  - 2. Providing qualified personnel for participation in commissioning tests, including seasonal testing required after the initial commissioning.
  - 3. Providing equipment, software, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.
  - 4. Providing operation and maintenance information and as-built drawings to the NEBB Systems Commissioning Firm for verification, organization, and distribution.
  - 5. Providing assistance to the NEBB Systems Commissioning Firm to develop and edit system operation descriptions.
  - 6. Providing training for the systems specified in this Division with coordination by the NEBB Systems Commissioning Firm.

1.02 COOPERATION

- A. The FMS contractor will cooperate with the NEBB Systems Commissioning Administrator (SCA) in the following manner:
  - 1. Complete equipment and system start up in accordance with the commissioning schedule.
  - 2. Attend all commissioning planning and scheduling meetings as scheduled by the NEBB Systems Commissioning Administrator (SCA).

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

Control/facility management system test equipment shall be provided by Division 17. Refer to Division 18 for specific equipment expected to be provided by Division 17.

2.02 TEST EQUIPMENT - PROPRIETARY

Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the NEBB Systems Commissioning Firm in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

PART 3 - EXECUTION

3.01...WORK PRIOR TO COMMISSIONING

- A. Complete all phases of work so the system can be started, tested, balanced, and otherwise commissioned for beneficial use by the Owner. Division 17 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are functional. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, software, etc. per the contract documents and related directives, clarifications, change orders, etc.
- B. A commissioning plan will be developed by the NEBB Systems Commissioning Firm. Upon request of the NEBB Systems Commissioning Firm, Division 15 shall provide assistance and consultation. Division 17 is obligated to assist the NEBB Systems Commissioning Firm in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alter the commissioning process; the NEBB Systems Commissioning Firm will notify the Architect.

C. Specific pre-commissioning responsibilities of Division 17 are as follows:

1. Factory start-up services for all equipment and systems installed under division 17000.
2. Normal start-up services required to bring each system into a fully operational state. This includes electrical continuity checking, elimination of ground faults, pneumatic leak checking, sensor calibration, Point to point test, test of control sequences of operation, interlocks, etc. This also includes fully functional demonstration of all software and hardware to render fully operational control systems. The NEBB Systems Commissioning Firm will not begin the commissioning process until each system is complete, including all normal contractor start-up work.

### 3.02...PARTICIPATION IN COMMISSIONING

- A. Provide skilled technicians to start-up and debug all systems within Division 17. These same technicians shall be made available to assist the NEBB Systems Commissioning Firm in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc. will be requested by the NEBB Systems Commissioning Firm and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.
- B. System problems and discrepancies may require additional technician time, NEBB Systems Commissioning Firm time, redesign and/or reconstruction of systems, and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.
- C. The NEBB Systems Commissioning Firm reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or subsystem. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the NEBB Systems Commissioning Firm to get the job done. A liaison or intermediary between the NEBB Systems Commissioning Firm and qualified factory representatives does not constitute the availability of a qualified technician for purposes of this work.

### 3.03...WORK TO RESOLVE DEFICIENCIES

- A. In some systems, mis-adjustments, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Architect, with input from the Contractor, equipment supplier, and NEBB Systems Commissioning Firm. Whereas all members will have input and the opportunity to discuss, debate and work out problems, the Architect per Division I will have final jurisdiction on the necessary work to be done to achieve performance.

- B. Corrective work is to be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the NEBB Systems Commissioning Firm deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the NEBB Systems Commissioning Firm will notify the Architect indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

**3.04 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS**

- A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.
- B. All equipment and systems will be tested and commissioned in a peak season to observe full load performance. Heating equipment will be tested during winter design extremes. Cooling equipment will be tested during summer design extremes, with a fully occupied building. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance.

**3.05 TRAINING**

- A. In addition to the requirements of Division 1, arrange for and participate in the training of Owner's engineering and maintenance staff on each system and related components. Training will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids.
- B. Training will be conducted jointly by the NEBB Systems Commissioning Administrator (SCA), the design engineers, the equipment vendors, and the Contractor. The Contractor will be responsible for highlighting system peculiarities specific to this project.

**3.06 SYSTEMS DOCUMENTATION**

- A. In addition to the requirements of Division 1, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be redlined on one set of transparencies provided by the FMS contractor. Division 15 and 16 as-built drawings shall include architectural floor plans, elevations and details, and the individual mechanical or electrical systems in relation to actual building layout.

- B. Maintain as-built redlines as required in Division 1. Given the size and complexity of this project, redline drawings at completion of construction based on memory of key personnel is not satisfactory. Continuous and regular red-lining of drawings is considered essential and mandatory.
- C. In addition to the requirements of Division 1 for operation and maintenance data, provide five (5) copies of equipment technical literature, operation and maintenance literature, and shop drawings to the NEBB Systems Commissioning Administrator (SCA) as soon as they are available. This requirement does not relieve the Contractor of submitting the final operating and maintenance data at project closeout.

### 3.07 SOFTWARE

- A. Division 17 shall supply the NEBB Systems Commissioning Administrator (SCA) with two (2) debugged printouts of all FAS software, including all user's programming and engineering manuals required to interpret the software. Included in the printouts, though not limited to, shall be the following:
  - 1. Point data base
  - 2. All custom control programs written in the FAS control language
  - 3. All parameters required for proper operation of FAS control and utility firmware such as start/stop routines, etc.
  - 4. System graphics.
- B. The software printout shall be fully documented for ease of interpretation by the NEBB Systems Commissioning Administrator (SCA) and Owner, without assistance from the Contractor. English language descriptions shall be either integrated with or attached to the FAS printout. The following shall be specifically documented:
  - 1. All point names, I/O and virtual
  - 2. All FAS programming language commands, functions, syntax, operators, and reserved variables
  - 3. Use of all FAS firmware
  - 4. The intended actions, decisions, and calculations of each line or logical group of lines in the custom control program(s). Sequences of operation are not acceptable.



5. Complete descriptions of and theories explaining all software and firmware algorithms. The algorithms to be described include, but are not limited to, PID, optimum start/stop, demand limiting, and chiller and boiler optimization.
6. A table of contents to the documentation which locates the sections of the documentation and describes which programs or program sections are for each piece of controlled/monitored equipment.
7. Flow charts using IEEE symbol nomenclature that demonstrates the software's algorithms and flow logic.

END OF SECTION

**PART 1 - GENERAL**

1.01 DESCRIPTION

- A. The purpose of the Commissioning process is to provide the Owner/ operator of the facility with a higher level of assurance that the systems have been installed in the prescribed manner and will operate within the performance guidelines. The NEBB Systems Commissioning Administrator (SCA) will provide the Owner an unbiased, objective view of the systems' installation, operation, and performance. This process is not to take away or reduce the responsibility of the system designers or installing contractors to provide a finished product. It is not intended to be an additional or redundant testing/inspection function, but will enhance the quality of system start-up and aid in the orderly transfer of systems to beneficial use by the Owner.

The function and responsibility of the NEBB Systems Commissioning Administrator (SCA) will include:

1. Responsibility: The primary point of responsibility to inform the Owner, Architect or Constructor on the integration and performance of systems within the facility.
2. Information: The NEBB Systems Commissioning Administrator (SCA) is to disseminate information and assist the design and construction teams to complete the certification process. This will include system completeness, performance, and adequacy to meet the intended performance standards of each system. Services include construction observation, testing, and providing performance information to the responsible parties, i.e., contractors, design professional, vendors, and Owner.
3. The NEBB Systems Commissioning Administrator (SCA) shall create a commissioning plan, which will describe in detail all commissioning functions, actions, tests, documentation, and schedule.
4. The NEBB Systems Commissioning Administrator (SCA) will verify and document the following field tests and observations:
  - Field Installation Verification (FIV). Verification of all installed systems for compliance to plans and specification. These inspections are to be described in detail in the commissioning plan.
  - Operation Performance Tests (OPT). Operational tests which verify proper start-up of all equipment and systems. These tests are to be described in detail in the commissioning plan.

- Functional Performance Tests (FPT). Functional system tests that verify all systems are functioning and interacting with other systems correctly. These tests are to be described in detail in the commissioning plan.
5. The NEBB Systems Commissioning Administrator (SCA) shall receive all operating and maintenance manual information from division 15, 16, and 17 contractors and compile a complete owner's operator manual.
  6. The NEBB Systems Commissioning Administrator (SCA) shall coordinate, facilitate and present a complete in depth training seminar for all owners operators. This training seminar shall include the design Engineer, each subcontractor and each major vendor to present the operating and maintenance procedures of each system. The entire seminar shall be videotaped on SVHS for future use by the owner.
  7. The NEBB Systems Commissioning Administrator (SCA) shall submit a final commissioning report. This report shall contain all commissioning test and verification check sheets, all commissioning documentation, and all commissioning correspondence.
  8. The NEBB Systems Commissioning Administrator (SCA) shall submit a post commissioning report for off-season commissioning if required by the specification.
- B. The NEBB Systems Commissioning Firm is referred to as an independent contractor in this Division and shall work under a separate Contract directly with the Owner, Architect or Constructor as specified in general and special conditions of these specifications.
  - C. The Contractor and subcontractors for this Division cannot be financially associated with any of the Division 1 through 17 contractors to avoid potential conflicts of interest unless previously approve by the owner. For any area of conflict the tests for that area will be subject to random re-tests as directed by the owner's representative. If any area of re-tests fail to produce repeatability for over 75% of the items tested then the entire system must be re-tested by the responsible party at no additional cost to the owner.
  - D. Responsibility for construction means and methods. The Commissioner is not responsible for construction means, methods, job safety, or any management function on the job site.
  - E. Hands-on work by the NEBB Systems Commissioning Firm. The contractors will provide all technician services requiring tools or the use of tools to test, adjust or otherwise bring equipment into fully operational state. The Commissioner shall observe technicians as they complete testing, and may make minor adjustments, but will not perform construction or technician services.

- F. The commissioning process does not take any responsibility for code compliance or code inspection requirements. Code compliance remains the responsibility of local code authorities. The commissioner will document code tests completed by the code authority.

1.02...QUALIFICATION

- A. The NEBB Systems Commissioning Administrator (SCA) shall have a minimum of 5 years of experience in commissioning facility technical systems and be a certified NEBB commissioner. Each NEBB Systems Commissioning Firm must be prior approved to bid this work scope. Submit complete documentation to the Architect, 15 days prior to bid, of certification, experience, qualifications, sample check sheets and at least three references of past commissioning projects with owners name and telephone number. Pre-approved commissioning agencies are: Pro Services 4633 South 36<sup>th</sup> Street, Phoenix, AZ 85040 (602) 437-8110.

1.03...SCOPE OF WORK

The NEBB Systems Commissioning Firm shall have the following responsibility for commissioning on this project:

- A. Underground Utilities.
- B. HVAC systems and subsystems, including all control systems and software.
- C. Plumbing Systems.
- D. Fire Protection systems and fire sprinkler systems.
- E. Life Safety and Fire Alarm systems.
- F. Electrical Distribution systems.
- G. Security systems and CCTV systems.
- H. Lighting Control Systems.

1.04...COORDINATION

- A. The NEBB Systems Commissioning Administrator (SCA) will coordinate directly with each contractor on the project specific to their responsibilities and contractual obligations. If the contractor is a sub-contractor to another contractor, written information will be provided to all responsible parties relative to the nature and extent of the communication. If contractual obligations are in question, then the prime contractor will be contacted by the NEBB Systems Commissioning Administrator (SCA) to determine the extent and scope of responsibilities and change orders, if appropriate.
- B. Refer to Sections 15999, 16999, and 17999 for contractor responsibilities relative to the commissioning process.

1.05...SCHEDULE

- A. Commissioning of systems will proceed per the commissioning schedule and as outlined in the commissioning plan.
- B. Commissioning of activities will commence with the installation of the mechanical and electrical systems covered by this specification.
- C. Problems observed will be addressed immediately, in terms of notification to responsible parties, and actions to correct deficiencies.
- D. Contractor schedules and scheduling is the responsibility of the General Contractor or Construction Manager. The commissioning schedule will be incorporated into the main construction schedule by the General Contractor/Construction Manager. The NEBB Systems Commissioning Administrator (SCA) must provide commissioning scheduling information to the General Contractor/Construction Manager for their review and planning activities.

1.06...RELATED WORK

- A. Commissioning is the primary responsibility of this Contractor, with secondary and support responsibility by the various subcontractors as outlined in the commissioning plan. The commissioning process does not relieve the subcontractors from participation in the process or diminish their role and obligations to complete all portions of work in a satisfactory and fully operational manner.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

- A. All industry standard test equipment required for performing the tests specified herein shall be provided by the vendor or contractor performing the tests. If any special data logging equipment is required, for any FPT, the equipment shall be provided by the NEBB Systems Commissioning Administrator (SCA).
- B. All instrumentation shall meet the following standards:
  - 1. Be of sufficient quality and accuracy to test and/or measure system performance within the tolerances required to determine adequate performance.
  - 2. Be calibrated on the manufacturer's recommended intervals with calibration tags permanently affixed to the instrument being used.
  - 3. Be maintained in good repair and operating condition throughout the duration of use on this project.
  - 4. Be recalibrated/repared if dropped and/or damaged in any way during use on this project.

PART 3 - EXECUTION

3.01 BASIS OF DESIGN DOCUMENTATION

Provide documentation of each system design criteria given to the design professional. Include a narrative for each system with its design criteria and design intent.

3.02 DESIGN DOCUMENT REVIEW

Provide a complete review of all design documents for commissioning requirements. Provide a sheet by sheet narrative indicating any areas that may prevent a complete and successful commissioning project. Areas of review are:

- A. Equipment Access and maintainability
- B. Installation clearances and available space
- C. Any specific layout or design problem that will prevent its being commissioned

3.03 COMMISSIONING PLAN

The NEBB Systems Commissioning Administrator (SCA) shall prepare a complete commissioning plan that details the entire commissioning process for this project. The plan shall include:

- A. A narrative of the NEBB Systems Commissioning Administrator (SCA)s responsibilities.
- B. A roster of the commissioning team. Usually includes the administrator and one representative from the owner, each contractor and subcontractor involved.
- C. A preliminary commissioning schedule
- D. Check sheets for each system and subsystem installation verification (FIV).
- E. Check sheets for each system and subsystem operational performance test (OPT).
- F. Check sheets for each system and subsystem functional performance test (FPT).
- G. A narrative of the type and method of project communications.

3.04 PRE-SUBMITTAL REVIEW

Provide a pre-submittal review of all equipment and vendor submittals. Verify that all submitted documentation meets or exceeds that of the design documents. Furnish a submittal report to the design professional that details all submittal deficiencies and areas of concern. The design professional will make all decisions for approval of submittal data.

3.05 FIELD INSTALLATION VERIFICATION (FIV)

The NEBB Systems Commissioning Firm shall provide field installation inspection for each system and subsystem covered in the scope of work for this project. Provide an installation observation reports weekly to the General Contractor/Construction Manager. The report shall cover any installation

deficiencies from plans and specifications. Provide a completed check sheet verifying each system installation.

**3.06 OPERATIONAL PERFORMANCE TESTS (OPT)**

The NEBB Systems Commissioning Firm shall provide Operational Performance Test verification for each system and subsystem covered in the scope of work for this project. Provide a completed check sheet verifying each system start up and calibration

**3.07 FUNCTIONAL PERFORMANCE TESTS (FPT)**

The NEBB Systems Commissioning Firm shall provide Functional Performance Test verification for each system and subsystem covered in the scope of work for this project. Provide a completed check sheet verifying each system functionality and interaction with other systems.

**3.08 OPERATING AND MAINTENANCE PROCEDURES**

The NEBB Systems Commissioning Administrator (SCA) shall prepare a complete Operating and Maintenance manual containing the operating instruction for each piece of equipment and system. Also include all maintenance information and procedures. This manual shall list the manufacturer, vendor, and installing contractor complete with name, address, phone and fax number. The NEBB Systems Commissioning Administrator (SCA) shall also gather from each contractor all technical reference manuals required for the proper operation of all systems. These will include all standard technical literature specifically orientated to the provided equipment indicating all operation and maintenance procedures, parts lists, assembly/disassembly diagrams, wiring diagrams, programming manuals and technical reference manuals as required for the owner to properly operate and maintain the systems.

**3.09 OWNER TRAINING SEMINAR**

The NEBB Systems Commissioning Administrator (SCA) shall prepare and administer an extensive owner training seminar. This seminar shall cover the operation and maintenance of each piece of equipment and system. Each vendor and contractor shall provide the training for his area of responsibility. The entire program shall be video taped with SVHS tape for future use by the owner.

**3.10 COMMISSIONING REPORT**

The NEBB Systems Commissioning Administrator (SCA) shall compile a complete commissioning report. This report shall include all commissioning check sheets for FIV, OPT and FPT tests and observations. Also include all commissioning documentation, and commissioning correspondence. The report shall also contain a complete operating narrative for each system explaining the sequence of operation for each function.

3.11 RECORD DRAWINGS

The NEBB Systems Commissioning Administrator (SCA) shall collect all redline as-built transparency drawings from all contractors and subcontractors involved in the systems commissioned. Drawings shall be bound for owner's future use. As-built updates will include backgrounds first, and mechanical/electrical systems second.

3.12 POST COMMISSIONING

The NEBB Systems Commissioning Firm and the contractors shall provide an off season FPT for the HVAC system. This test shall cover the ability of the system to maintain control setpoint during the opposite season from the original commissioning season. The NEBB Systems Commissioning Administrator (SCA) shall provide a post commissioning report.

END OF SECTION



PART 1 - GENERAL

1.01 DESCRIPTION

The purpose of this section is to describe the commissioning process specific to the underground piping/site mechanical systems and equipment.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT                      None

2.02 PROPRIETARY TEST EQUIPMENT                      None

PART 3 - EXECUTION

3.01 CONSTRUCTION OBSERVATION

- A. Obtain and review design documents for overall design intent and the overall required systems configurations.
- B. Obtain and review shop drawings and submittals for installation criteria and the required construction details, as they support and further define the systems features.
- C. The NEBB Systems Commissioning Administrator (SCA) shall make general inspections at the job site and shall review the following for configuration, quality of construction, adherence to design requirements, and conformance with shop drawings and submittal information. The Commissioner shall periodically provide site observations to check the quality of general construction as it pertains to the following:
  - 1. Sewer lines - integrity, routing, grading, and backfill - installed per plans and specifications.
  - 2. Water lines – integrity, routing, grading and backfill – installed per plans and specifications.
  - 3. Electrical Feeders - integrity, routing, grading, and backfill - installed per plans and specifications.
  - 4. Gas lines - integrity, routing, grading, and backfill - installed per plans and specifications.
  - 5. Fiber Optic LAN integrity, routing, grading, and backfill - installed per plans and specifications.

3.02 TESTS

A. Pressure Tests:

1. Sewer, Laboratory Waste and Vent Systems: Hydrostatically test the waste and vent piping system. Apply pressure to 10 feet of water column for 60 minutes; no leakage allowed.
2. Domestic Water Systems - Potable & Non-Potable: Test the water piping with water to a pressure to 100 psi for two hours. No decrease in pressure allowed. Provide a pressure gauge with a shut off and bleeder valve at the Highest point to the system tested. Inspect all joints in the system under test. The water system by be tested as a whole or by sections.
3. Storm and Roof Drainage:
  - a. Hydrostatically test the waste and vent piping system. Apply pressure to 10 feet of water column for 60 minutes; no leakage allowed.
  - b. When freezing temperatures prevent testing with water, the test shall be made with air. A pressure of 10 psi shall be applied and maintained for 15 minutes without loss of pressure. A mercury column gauge shall be used to register air pressure.
4. Gas Piping Systems – Provide an air pressure test of 6” of mercury for one hour or as required by local codes or authorities.
5. Electrical Systems – Provide phase continuity test and other tests required by local codes or authorities.
6. LAN cabling – Provide a continuity and signal strength test.

END OF SECTION

**PART 1 -GENERAL**

**1.01 DESCRIPTION**

The purpose of this section is to describe the general commissioning process specific to the HVAC systems and equipment. HVAC systems include hot water heating, chilled water, steam/condensate, supply air and exhaust air systems.

**PART 2 - PRODUCTS**

**2.01 TEST EQUIPMENT**

- A. The majority of the HVAC test equipment will be provided by the NEBB Test and Balance Firm as part of this contract. Special test equipment for electrical systems testing will be provided by the electrical contractor.
- B. Control/facility management system test equipment will be provided by the Automatic Temperature Controls Contractor.
- C. The NEBB Systems Commissioning Administrator (SCA) will ensure that proper and correct test equipment is available by the appropriate contractors. If equipment is missing, inappropriate, or not available to those contractors, the NEBB Systems Commissioning Administrator (SCA) will be responsible for procuring and making available the correct equipment.

**2.02 TEST EQUIPMENT - PROPRIETARY**

Proprietary test equipment shall be provided by the manufacturer of the equipment to be commissioned. The manufacturer's representative shall provide the equipment, demonstrate use of the test equipment and assist the NEBB Systems Commissioning Firm in the commissioning process. Proprietary test equipment shall become the property of the owner upon completion of commissioning.

**PART 3 - EXECUTION**

**3.01 COMMISSIONING OBSERVATIONS AND TESTS**

Provide all observations and tests in accordance with the commissioning specification outlined in section 18000 General Conditions. Include at a minimum the following equipment and systems:

- A. Prime Movers/Major Equipment:
  - 1. AHU, FC, Fans, Pumps, Towers, Heat Exchangers, Chillers, and Boilers:
    - a) Condition of equipment as delivered/installed
    - b) Equipment data/compliance with specifications and shop drawings
    - c) Performance curves
    - d) Installation per design documents
  
- B. Accessories:
  - 1. Supply, Return, and Exhaust Air Systems:
    - a) Fire dampers/fit and integrity
    - b) Control dampers/fit and integrity
    - c) Smoke dampers/fit and integrity
    - d) Isolation dampers/fit and integrity
  
  - 2. Chilled, Hot, and Condenser Water Systems:
    - a) Balance cocks/location and accessibility
    - b) Flow stations/location and accessibility
    - c) Strainers/location and accessibility and strainer mesh
    - d) Isolation valves/location and accessibility
    - e) Control valves/location and accessibility
  
  - 3. Steam & Condensate Systems:
    - a) Traps/location and accessibility
    - b) Drip legs and accessibility
    - c) Condensate return stations and accessibility
    - d) Boiler feed systems
    - e) Deaerator systems
  
- C. Distribution Systems:
  - 1. Duct:
    - a) Size and configuration
    - b) Fittings/transitions and takeoffs
    - c) Seams and joints/integrity and sealing
    - d) Hangers and bracing
    - e) Connections
    - f) Sealing/sealers and joints
    - g) Thickness per specifications/SMACNA standards

2. Pipe:
  - a) Size and configuration
  - b) Fittings
  - c) Connections
  - d) Hangers and bracing
  - e) Materials per specifications

D. Terminal Units:

1. Air Terminal/Boxes:
  - a) Number, size, configuration per plans and specifications
  - b) Balance dampers (if applicable)
  - c) Controls components and configurations
  - d) Entrance and exit conditions per requirements

2. Coils:
  - a) Supply and return piping connections
  - b) Ductwork transitions
  - c) Sealing of duct penetrations
  - d) Fin integrity and straightness

E. Controls:

- a) Components and configurations per shop drawings
- b) Organization and layout of control panels
- c) Sensors in proper locations
- d) Wiring and pneumatic piping per specifications
- e) Labeling and identification/all components, wiring, and piping
- f) Point to point tests
- g) Sequence of operation verification
- h) Software functionality

3.02 CLEANING

A. Equipment:

- a) Air Filters shall be clean at time of turn over to owner
- b) Enclosures shall be free of dirt and dust
- c) Tower basins shall be free of dirt and sludge

B. Duct Work:

- a) Ductwork shall be free from dirt and dust accumulation.

C. Piping:

- a) Strainers shall be cleaned before balancing.
- b) Piping system shall be filled, vented and circulated employing chemical cleaner solution for period of at least 24 hours or more in accordance with manufacturer's recommendations and job site chemical tests. Remove water filters from system for this cleaning. Bring concentration to level which raises M Alkalinity to manufacturer's recommended value above that for existing water used for fill. Conduct chemical tests to verify levels and submit results to Architect. System should be circulated, strained and flushed to achieve original M Alkalinity level. Replace strainers and reconnect permanent pumping apparatus.

3.03 EQUIPMENT SAFETY DEVICE CHECKS

All boiler safety devices shall be checked, including flame failure safeties, overpressure, low level and other safeties on primary heating equipment. Boiler FIA gas train shall be tested to insure gas overpressurization relief valves operate, solenoid shutoff valves operate and excess gas is vented from the boiler room without contamination of ventilation air for the occupied spaces.

3.04 TESTS

A. Observe Piping System Leak Tests:

1. Conduct pressure test with test medium of air or water unless specifically indicated otherwise.
2. No system to be insulated until it has been successfully tested. If required for additional pressure load under test, provide temporary restraints at expansion joints or isolate them during test. Minimum test time to be four (4) hours plus such additional time as may be necessary to conduct examination for leakage.
3. For hydrostatic tests, use clean water and remove all air from piping being tested by means of air vents or loosening of flanges. Measure and record test pressure at high point in system.
4. For air tests, gradually increase pressure to not more than one half of test pressure; then increase pressure in steps of approximately one-tenth of test pressure until required test pressure is reached. Examine all joints and connections with soap bubble solution or equivalent method. Piping system exclusive of possible localized instances at pump or valve packing shall show no evidence of leaking. Test systems at 100 psig. (690 kpa)

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5. Primary Heating Equipment Combustion Testing: Test the following flue gas analysis for boilers:
  - % Oxygen
  - % Carbon dioxide
  - % Carbon monoxide
  - Stack temperature
  - Combustion efficiency

B. Observe Duct System Leak Tests:

1. Conduct pressure test on medium or high-pressure ductwork in accordance with SMACNA duct testing standards.

3.05 TEST AND BALANCE

PART 1 - GENERAL

3.05.1 WORK INCLUDED

- A. Total system balance, as defined by NEBB, which constitutes the process of testing, adjusting and balancing each system component so that the entire system produces the capacities as shown on the contract drawings.
- B. Work shall include the proper use of instruments, evaluation of readings, adjusting the systems to design conditions, full implementation of all test report forms, and providing unbiased opinions of all deficiencies encountered and proposing corrective action.
- C. The Mechanical Contractor shall repair or make all remedial action required to allow all systems to be balanced to the specified procedures.

3.05.2 REFERENCES

- A. The following references and standards are applicable to the testing, adjusting, and balancing of mechanical equipment and systems and shall form a part if this specification:
  1. "Procedural Standards for Testing, Adjusting Balancing, of Environmental Systems"; published by NEBB.

2. "Procedural Standards For the Measurement and Assessment of Sound and Vibration"; published by NEBB.

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3.05.3 QUALIFICATIONS

- A. The testing adjusting and balancing firm shall be certified by NEBB. The Test and Balance firm shall have a minimum of 5 years experience in testing and balancing work as a NEBB certified firm. The testing and balancing firm shall hold a current contractors license. The testing and balancing firm shall demonstrate technical proficiency by having passed the technical certification tests as given by NEBB. All balancing technicians involved by the testing agency shall be trained and tested to NEBB standards.

**PART 2 – MATERIALS**

3.05.4 INSTRUMENTATION

- A. All instruments used by this agency shall be accurately calibrated and maintained in good working order. Calibration and maintenance of all instruments shall be in accordance with the requirements of the certifying agency. If requested by the engineer produce calibration certificates for instruments utilized for this project.

3.05.5 BALANCING DEVICES

- B. All material or devices which are required to make all systems able to be balanced are to be furnished and installed by the mechanical contractor. These items shall include but not be limited to; balancing dampers, gauge pressure taps, thermometer wells, clean filters, balancing valves, and DDC system man machine interface.

**PART 3 - EXECUTION**

3.05.6 TESTING

- A. All systems including the temperature control system shall be started and certified as completed by the mechanical contractor prior to beginning the testing and balancing procedure. The mechanical contractor shall install clean air filters and all strainers shall be flushed prior to the start of balancing. The mechanical contractor shall leave all balancing dampers and balancing valves in a full open position before balancing work begins.
- B. Each system shall be reviewed and tested by the balancing agency to insure operation in accordance with the plans and specifications. If operational deficiencies are encountered the NEBB testing agency shall produce corrective action list to the mechanical contractor for repair or remedial action prior to commencing the balancing procedures.



- C. The NEBB testing agency shall test, record and certify all medium or high pressure duct system pressure tests in accordance with the latest addition of SMACNA air duct leakage test manual. The mechanical contractor shall supply and install all taps and closures required for system testing.

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- D. The NEBB testing firm shall test and record that all smoke pressurization systems are functioning to design. The testing agency shall test and record that all air changes and relative pressurization are functioning to design for all hospital, clean space and biological certification areas.

3.05.7 AIR BALANCE

- A. Test, Adjust and balance all air systems to the design capacities in accordance with the NEBB procedural standards. Balance shall be, but not limited to the following:
- Test and record main supply duct pitot traverse CFM (l/s).
  - Balance and record supply, return, exhaust, and intake CFM (l/s). Adjust and record all fan RPM.
  - Test and record DB & WB of discharge and inlet air.
  - Test and record Amps and Volts of all motors and electrical heat elements.
  - Test and record static pressure of discharge and return air.
  - Test and record static pressure loss across filters and coils.
  - Test and record all room and duct pressure transmitter control device set points.
  - Balance and record all terminal box CFM, inlet & discharge static pressure, maximum and minimum flow set point CFM. (l/s)
  - Balance and record all reheat coil CFM (l/s), discharge & inlet DB, and kW & Voltage.
  - Balance and record all grille and register CFM. (Within 10% of design)
- B. Provide six copies of the certified balance report which will include all recorded data as per certified balance procedures. Report shall include but not be limited to the following:
- Cover sheet indicating names of project, architect and engineer.
  - Certification form showing certificate number.
  - Instrument certification record.
  - Equipment forms showing manufacturer, model & serial number, motor data, filter data, belt & pulley data.
  - Balance forms showing design data and final balance data.
  - Balance drawings showing location of all balanced devices with number system referencing to the associated balance form.

3.05.8 HYDRONIC BALANCE

- A. Adjust and balance all Hydronic systems to the design capacities in accordance with the NEBB procedural standard for testing, adjusting, and balancing of Environmental Systems. Balance shall be, but not limited to the following:
- Test and record Amps, Volts and phase of all motors.
  - Balance and record all reheat coil GPM, balance valve set point, discharge & inlet water pressure and temperature.

- Balance and record all coil and Heat Exchanger GPM (l/s). Record balance valve set point. Test and record inlet & outlet pressure and temperature.
- Balance and record all pump flow, shut off head, discharge head, and suction head. Test and record Amps & Volts.
- Test and record variable flow pump systems pressure set point and minimum and maximum flow values.

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- B. Provide six copies of the certified balance report which will include all recorded data as per certified balance procedures. Report shall include but not be limited to the following:
- Cover sheet indicating names of project, architect and engineer.
  - Certification form showing certificate number.
  - Instrument certification record.
  - Equipment forms showing manufacturer, model & serial number, motor data, filter data, belt & pulley data.
  - Balance forms showing design data and final balance data.
  - Balance drawings showing location of all balanced devices with number system referencing to the associated balance form.

**3.05.9 SOUND TESTING**

- A. Test and record sound data for each of the following listed areas. If more than one area exists take readings in the area with the highest perceptible noise level as determined by random weighted A scale measurements. All readings shall be taken in accordance with the latest addition of the NEBB procedural standards for measurement and assessment of sound and vibration.
- Test and Record octave band data for one ceiling or wall diffuser. Take Readings 4 feet (1.2 m) above the floor, 5 (1.5 m) feet from the center of the diffuser.
  - Test and record octave band data for one office or conference room adjacent or under a mechanical room. Take readings 4 feet (1.2m) above the floor and at least 3 feet (0.9 m) from any wall or reflective surface.
  - Test and record octave band data in an office area below one terminal box. Take readings 4 feet (1.2 m) from floor directly under box.
- B. Provide six copies of the certified balance report which will include all recorded data as per certified balance procedures. Report shall include but not be limited to the following:
- Cover sheet indicating names of project, architect and engineer.
  - Certification form showing certificate number.
  - Instrument certification record.
  - Octave band data sheet for each reading
  - Room Criterion (RC) level for each reading.

**3.05.10 VIBRATION TESTING**

- A. The balance agency shall test and record vibration measurements for all rotating machinery over 5 HP (3.8 kW). Equipment included shall be; Pumps, Fans, and Air Handlers.
- B. The mechanical contractor shall have tested, adjusted and balanced all equipment to manufacturers specifications prior to vibration testing.

- C. Inspect vibration isolation equipment for proper installation and that it is functioning properly.

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- D. Make vibration measurements in all 3 axis at each bearing location. Measure overall velocity in the frequency range as required by the speed of the rotating equipment. Record readings and note any readings that exceed manufacturer's recommendations.
- E. Provide six copies of the certified test report which will include all recorded data as per certified balance procedures. Report shall include but not be limited to the following:
- Cover sheet indicating names of project, architect and engineer.
  - Instrument certification record.
  - Vibration report for each axis reading.
  - Location drawing indicating location of readings
  - List of readings that exceed manufacturer's recommendation with recommendations correction procedures.

**3.06 AUTOMATIC TEMPERATURE CONTROL SYSTEM TEST**

- A. System Calibration: Upon completion of the installation, the System Installer shall start up the system and perform all necessary testing and diagnostics to ensure proper operation. Submit to the Owner documentation on the calibration of all equipment, including each sensor or control device. Documentation shall include:
1. Step-by-step check-off list of the calibration of each sensor, monitoring/control device and each piece of controlled equipment.
  2. Calibration records describing the actual calibration procedures, and all test equipment used, shall be provided to the NEBB Systems Commissioning Administrator (SCA) by the Temperature Control Contractor. Calibration test equipment shall have an accuracy at least equal to the tolerance of the device being adjusted. Test equipment shall provide stabilized field measurements in no more than 30 seconds per reading, utilizing a digital readout display where commercially available.
- B. Point to Point Test:
1. A point-to-point test of all system points shall be completed by the Automatic Temperature Control Contractor (ATC). The ATC contractor shall provide two men equipped with two-way communication and shall test actual field operation of each control and sensing point. The purpose is to test the calibration, response, and action of every point. Any test equipment required to prove the proper operation of the control system shall be provided by and operated

by the Contractor. The NEBB Systems Commissioning Administrator (SCA) will be present to oversee, observe, and review the test.

C. System Test:

1. The system test shall be performed after total system calibration and shall consist of an operational test of each system in the presence of the Engineer. The systems will be tested with points selected at random by the NEBB Systems Commissioning Administrator (SCA). The executive routine and each application program will be tested, the performance of the Control Sequences shall be demonstrated, and transmission link accuracy, sensor accuracy and control operation will be reviewed.
2. DDC Loop Response: The ATC contractor shall supply a trend data output in graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change in the actuator position of at least 25 percent of its full range. The sampling rate of the trend shall be from one to three minutes depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under or over-damped control shall require further tuning by the ATC contractor.
3. Systems will not be accepted on a point-by-point or subsystem basis, but only as a whole complete operating system. All executive routine and software functions shall be fully functional and sensors shall satisfy specification requirements within 95 percent confidence.

D. Documentation:

1. The ATC Contractor will supply the NEBB Systems Commissioning Administrator (SCA) with two (2) de-bugged copies of all system software, both in hard copy and disk copy. Also supply all user programming and engineering manuals required to interpret the software. The software printout shall be fully documented for ease of interpretation by the NEBB Systems Commissioning Administrator (SCA) and Owner, without assistance from the ATC Contractor. English language descriptions shall be either integrated with or attached to the printout. The intent of supplying the above software printouts is to determine compliance with specification requirements. Documentation shall include at a minimum the following:
  - a) Complete Point database
  - b) Software Block Diagram for each program
  - c) A copy of all custom control programs written for this project.
  - d) Printouts or plotted copies and disk of the interactive system graphics
  - e) Final Sequence of Operation for each controller
  - f) Operating and Maintenance Manuals
  - g) As Built Drawings.

END OF SECTION

PART 1 - GENERAL

1.01 DESCRIPTION

The purpose of this section is to describe the commissioning process specific to the fire protection/suppression systems and equipment.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

All test equipment to be furnished by the fire protection contractor.

2.02 PROPRIETARY TEST EQUIPMENT - None

PART 3 - EXECUTION

3.01 CONSTRUCTION OBSERVATION

Provide all observations and tests in accordance with the commissioning specification outlined in section 18000 General Conditions. Include at a minimum the following equipment and systems:

A. Prime Movers/Major Equipment:

1. Pumps & Storage Systems

- a) Condition of equipment as delivered/installed
- b) Equipment data/compliance with specifications and shop drawings
- c) Performance curves
- d) Installation per design documents

B. Distribution Systems:

1. Piping

- a) Size and configuration
- b) Fittings
- c) Connections
- d) Hangers and bracing
- e) Materials per specifications
- f) Check installation and placement of heads for compliance with NFPA 13 standards.

C. Accessories

1. Alarm Riser/Indicating risers/Fire Dept. Conn/CV/Backflow Preventer
  - a) Condition of equipment as delivered/installed
  - b) Equipment in compliance with specifications and shop drawings
  - c) Functional operation

D. Controls:

1. Flow Switch/Flow indicator/Dry Pipe Control/Pump Control
  - a) Condition of equipment as delivered/installed
  - b) Equipment in compliance with specifications and shop drawings
  - c) Wiring and tubing installed per specification
  - d) Functional operation
  - e) Labeling and identification

3.02 CLEANING

Piping system shall be filled, vented and circulated employing chemical cleaner solution for period of at least 24 hours or more in accordance with manufacturer's recommendations and job site chemical tests. Remove water filters from system for this cleaning. Bring concentration to level which raises M Alkalinity to manufacturer's recommended value above that for existing water used for fill. Conduct chemical tests to verify levels and submit results to Architect. System should be circulated, strained and flushed to achieve original M Alkalinity level. Replace strainers and reconnect permanent pumping apparatus.

3.03 TESTS

A. Acceptance Tests:

1. Flushing of Piping: Underground mains and lead-in connections to system risers shall be flushed thoroughly before connection is made to sprinkler piping, in order to remove foreign materials which may have entered the underground during the course of the installation or which may have been present in existing piping. The minimum rate of flow shall be not less than the water demand rate of the system which is determined by the system design, or not less than that necessary to provide a velocity of 10 feet per second (3 m/s), whichever is greater. For all systems, the flushing operations shall be continued for a sufficient time to ensure thorough cleaning. When planning the flushing operations, consideration shall be given to disposal of the water issuing from the test outlets.

Exception: When the flow rate, as listed in the following table, cannot be verified or met, supply piping shall be flushed at the maximum flow rate available to the system under fire conditions.

**Flow Required to Produce a Velocity of 10 Feet per Second (3 m/s) in Pipes**

Pipe Size (in)	Flow Rate (gpm)	Flow Rate (l/s)
4	390	24.6
6	880	55.5
8	1560	98.5
10	2440	153.9
12	3520	222.1

For SI Units: 1 inch - 25.4 mm; 1 gpm – 0.0631 l/s.

2. Provision shall be made for the disposal of water issuing from test outlets to avoid property damage.

**B. Hydrostatic Tests:**

1. All new systems including yard piping shall be hydrostatically tested at not less than 200 psi (1380 kPa) pressure for two hours, or at 50 psi (345 kPa) in excess of the maximum pressure, when the maximum pressure to be maintained in the system is in excess of 150 psi (1035 kPa).

The test pressure shall be read from a gauge located at the low elevation point of the individual system or portion of the system being tested.

Exception: At seasons of the year that will not permit testing with water, an interim test may be conducted with air pressure of at least 40 psi (276 kPa) allowed to stand for 24 hours. The standard hydrostatic test shall be conducted when weather permits.

Permissible Leakage: The inside sprinkler piping shall be installed in such a manner that there will be no visible leakage when the system is subjected to the hydrostatic pressure test. Refer to NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances, for permissible leakage in underground piping. The amount of leakage shall be measured by pumping from a calibrated container.



2. Fire Department Connection: Piping between the check valve in the fire department inlet pipe and the outside connection shall be tested in the same manner as the balance of the system.
3. Corrosive Chemicals: Additives and corrosive chemicals, sodium silicate or derivatives of sodium silicate, brine, or other corrosive chemicals shall not be used for testing systems or stopping leaks.
4. Test Blanks: Whenever a test blank is used, it shall be of the self-indicating type. Test blanks shall have red painted lugs protruding beyond the flange in such a way as to clearly indicate their presence. The installer shall have all test blanks numbered so as to keep track of their use and assure their removal after the work is completed. .

C. Test of Dry-Pipe Systems:

1. Differential Dry-Pipe Valves: The clapper of a differential type dry-pipe valve shall be held off its seat during any test in excess of 50 psi (345 kPa) to prevent damaging the valve.
2. Air Test: In dry-pipe systems, an air pressure of 40 psi (276 kPa) shall be pumped up, allowed to stand 24 hours, and all leaks that allow a loss of pressure over 1-1/2 psi (10.4 kPa) for the 24 hours shall be stopped.
3. Operating Test of Dry-Pipe Valve: A working test of the dry-pipe valve alone and with a quick-opening device, if installed, shall be made before acceptance by opening the system test connection. Trip and water delivery times shall be measured from the time the inspector's test connection is opened and shall be recorded using the Contractor's Material and Test Certificate for Aboveground Piping.
4. Tests of Drainage Facilities: Tests of drainage facilities shall be made while the control valve is wide open. The main drain valve shall be opened and remain open until the system pressure stabilizes.
5. Each pressure reducing valve shall be tested upon completion of the initial installation to ensure proper pressure reduction at both maximum and normal inlet pressures.
6. Operation of Sprinkler System Control Valves by Contractors: When work on a sprinkler system requires that a contractor operate a valve controlling water supplies to a sprinkler system, the contractor shall inform the owner so that the owner may follow the normal valve supervision procedure.

END OF SECTION

PART 1 - GENERAL

1.01 DESCRIPTION

The purpose of this section is to describe the commissioning process specific to the plumbing systems and equipment. Plumbing systems shall include sanitary waste, vent, cold water, hot water, gas, medical gas, fixtures and equipment.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

All test equipment to be furnished by the plumbing systems contractor.

PART 3 - EXECUTION

3.01 COMMISSIONING OBSERVATIONS AND TESTS

Provide all observations and tests in accordance with the commissioning specification outlined in section 18000 General Conditions. Include at a minimum the following equipment and systems:

- A. Prime Movers and Major Equipment:
  - a) Pumps and Pressure pump systems
  - b) Sewage Ejectors or Lift Stations
  - c) Storage Systems
  - d) Boilers and Water Heaters
  - e) Drinking Fountains and Systems
  - f) Water Softeners
  - g) Reverse Osmosis & Filter Systems
  - h) Ice Machines
  
- B. Piping Systems:
  - a) Sanitary Waste
  - b) Vent Piping
  - c) Roof and Storm Drains
  - d) Cold Water
  - e) Hot Water
  - f) Gas
  - g) Medical Gas

## COMMISSIONING

## PLUMBING SYSTEMS

### C. Fixtures:

- a) Water Closets
- b) Urinals
- c) Lavatories
- d) Sinks
- e) Showers
- f) Bath Tubs
- g) Kitchen Equipment
- h) Grease & Lint Traps

### D. Accessories:

- a) Back Flow Preventers
- b) Floor Drains
- c) Floor Sinks
- d) Trap Primers
- e) Roof Drains
- f) Clean Outs
- g) Steam Traps & Pressure Reducing Stations
- h) Eye wash stations

## 3.02 CLEANING

### Disinfection:

#### A. Observe disinfection of the water piping per the following manner procedures:

1. Clean and flush the water pipe with water until water at a remote tap is clear.
2. Fill the water systems with a solution containing 50 parts per million of chlorine (minimum concentration). Allow the solution to stay in the water system for 24 hours. Test the chlorine concentration at remote outlets to ensure chlorine solution distributed throughout the system.
3. Flush the water system of the chlorine solution.
4. Allow clean water to stand in the system for 24 hours. Take a sample from a remote tap for a bacteriological test.
5. Repeat steps 1 through 4 until a safe water system is obtained.

3.03 TESTS

A. Domestic Hot Water Heat Tracing:

1. Prior to start-up, with cold pipe, actuate circuit and verify total amp draw return to length of installed cable.
2. Test the heater installed on the pipe prior to insulating with a 1,000-volt direct current megger. Minimum insulation resistance shall be 20 to 1000 megohms.
3. Temperature maintenance heater shall maintain 120° F (49° C) in the hot water piping system as delivered at outlets. Hot water shall be available within 10 seconds under full flow conditions.

B. Pressure Tests:

1. Laboratory Waste and Vent Systems: Hydrostatically test the waste and vent piping system. Apply pressure to 10 feet of water (29.9 kPa) column for 60 minutes; no leakage allowed.
2. Domestic Water Systems - Potable & Non-Potable: Test the water piping with water to a pressure of 100 psi (690 kPa) for two hours. No decrease in pressure allowed. Provide a pressure gauge with a shut off and bleeder valve at the Highest point to the system tested. Inspect all joints in the system under test. The water system by be tested as a whole or by sections.
3. Storm and Roof Drainage:
  - a. Hydrostatically test the waste and vent piping system. Apply pressure to 10 feet of water (29.9 kPa) column for 60 minutes; no leakage allowed.
  - b. When freezing temperatures prevent testing with water, the test shall be made with air. A pressure of 10 psi (69 kPa) shall be applied and maintained for 15 minutes without loss of pressure.
4. Sanitary and Vent Systems:
  - a. Hydrostatically test the waste and vent piping system. Apply pressure to 10 feet of water (29.9 kPa) column for 60 minutes; no leakage allowed.

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- b. When freezing temperatures prevent testing with water, the tests shall be made with air. If tests are made with air, a pressure of 5 psi (34.5 kPa) shall be applied and maintained 15 minutes.

### C. Bacteriological Tests - Domestic Water Systems:

1. Have representative water samples taken and tested for a bacteriological safe water supply system. Test the water samples for:
  - a. Presence of coliform.
  - b. HPC (Heterotrophic [Standard] Plate Count) test.
  - c. Presence of pseudomonas aeruginosa.
2. The test results must:
  - a. Show no coliform present.
  - b. Show a maximum of 200 organisms/ml by the HPC test.
  - c. Show that pseudomonas aeruginosa are not present.
3. If the tests exceed the limits specified, clean and test the water piping system until acceptable results are obtained.
4. The bacteriological tests shall be performed shortly before the system is accepted by the Owner. These bacteriological tests should be taken at various remote locations. There should be a minimum of 10 locations for this project.

END OF SECTION

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

The purpose of this section is to describe the commissioning process specific to the life safety systems and equipment. This includes the fire alarm system, smoke control systems, elevators, emergency power system, and stair doors.

**PART 2 - PRODUCTS**

**2.01 TEST EQUIPMENT**

The following test equipment shall be provided as a minimum:

- A. Magnehelics
- B. Spring scale with a range of 0 to 50 pounds (0 to 22.7 kg)
- C. Velometer
- D. Canned smoke for activating detectors
- E. Portable two-way radios

**2.02 PROPRIETARY TEST EQUIPMENT**

Proprietary test equipment shall be provided by the manufacturer of the equipment to be commissioned. The manufacturer's representative shall provide the equipment, demonstrate use of the test equipment, and assist the NEBB Systems Commissioning Firm in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

**PART 3 - EXECUTION**

**3.01 CONSTRUCTION OBSERVATION AND TESTS**

Provide all observations and tests in accordance with the commissioning specification outlined in section 18000 General Conditions. Include at a minimum the following equipment and systems:

- 1. Major Equipment and Systems
  - a) Fire Alarm Panels
  - b) Fireman Enunciator Panels
  - c) Smoke Control System
  - d) Fire Smoke Control Doors

- e) Stair Pressurization System
  - f) Emergency Power System
  - g) Elevator Emergency System
2. Electrical Systems
- a) Conduit
  - b) Cabling System
  - c) Panel Power System
3. Accessories
- a) Outside telephone line
  - b) Emergency Panel Keys
  - c) Status Lights
  - d) Emergency Plans, Signs and Graphics
  - e) Third Party UL monitoring

3.02 TESTS

A. Walk through:

- 1. Review that all devices as shown on the construction drawings and shop drawings are installed.
- 2. Review height and locations of pull stations.
- 3. Review that smoke and duct detectors are installed according to NFPA 72E or applicable standards.
- 4. Check that fire alarm system control panel is clear with no troubles or ground faults.

B. Device-By-Device Check and Sequence Check:

- 1. Smoke detectors (Space and duct): Check the operation of each detector with a manufacturer's approved method such as canned smoke, test magnet, or cigarette smoke. Randomly remove detectors to verify proper supervision.
- 2. Heat Detectors: Check the operation of each heat detector by an approved method. Randomly remove detectors to verify proper supervision.

3. Pull Stations: Pull lever to activate pull station; do not just open cover and flip switch. Randomly remove pull station and break circuit to verify proper supervision.
4. If the system uses monitoring and control modules, randomly disconnect modules from the communication circuit to verify supervision.
5. Alarm Indicating Devices: While checking initiating devices, verify operation of all speakers and strobes. Check audibility of alarm tone and intelligibility of voice messages in all areas. Randomly remove devices to verify supervision.
6. Fire Fighters Phone System: Carry portable phone provided with the system and plug in at each jack to test. Check that panel notifies operator with a tone and flashing lamp when a phone is plugged in, voice communication is OK, and the zone labeling is correct.
7. Fire Doors: Check exit stair doors for door seals, closer operation, door latching, and coordinator operation.
8. Fire Alarm Battery Test: Disconnect 12-volt power to panel. After 24 hours, set panel into alarm and operate under alarm condition for five minutes.
9. Water Flow Switches: Test each water flow switch by flowing water and timing receipt of alarm (typically 30 seconds).
10. Valve Tamper Switches: Open and close valve and observe receipt of alarm.
11. Operation of atrium smoke control shall be verified by:
  - a) Measuring atrium smoke exhaust fan air volume and atrium supply fan air volume.
  - b) Measure differential pressure across all atrium vestibule doors between the vestibule and the atrium and the vestibule and the lab or office area.
  - c) Measure the force required to open all vestibule doors.
  - d) Injecting smoke into the atrium and observing system operation.
12. Stair Pressurization Test:
  - a) Turn on pressurization fans.
  - b) Check pressure differential on all floors between stairway and floor with Magnehelics.
  - c) Check force to open door with pressurization fan on.
  - d) Check relief at top of stair: UBC states 1,500 cfm (750 l/s) exhaust quantity (hood or rotating vane anemometer required).



13. Elevator Testing:
  - a) Recall is tested with testing of elevator lobby smoke detectors.
  - b) Test fireman's service key (Phase II) on recalled elevators.
  - c) Override of elevator to fire floor with door close button function.
  - d) Take elevator to fire floor and push door open button with test of "release-of-button" to stop door opening at any time. Once door is fully open with button depressed, door should stay open with release of button.
  - e) Emergency Power Operation: Turn off normal power and allow generator to start and supply power to the building. Each car will return to primary floor. Last car down will park with door open. Once all are down, transfer power to car of choice with key switch on elevator control panel.
14. Fire Pump: Test all input signals from fire pump; Pump run, pump trouble, generator run, generator trouble. Test pump start sequence from alarm condition.
15. Emergency Power: Test all input signals from transfer switch, generator and fuel system. Test generator start sequence through transfer switch.

END OF SECTION

PART 1 - GENERAL

1.01 DESCRIPTION

The purpose of this section is to describe the commissioning process specific to the electrical distribution systems and equipment. This includes the main Switchgear, bus ducts, feeders, motor control centers, and panelboards.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

- A. The following test equipment shall be provided by the electrical testing contractor that shall include as a minimum:
1. Amprobe
  2. Voltmeter
  3. Circuit Tracer
  4. Power factor meter
  5. Dranetz 901 or equal
  6. Insulation resistance tester
  7. Earth ground resistance tester
  8. Circuit breaker tester
  9. Themovision infrared scanning equipment
- B. Test Instrument Traceability: The electrical testing contractor shall have a calibration program which maintains all applicable test instrumentation within rated accuracy. The accuracy shall be traceable to the National Institute of Standards and Technology (NIST) in an unbroken chain. Instruments shall be calibrated in accordance with the following frequency schedule and dated calibration labels shall be visible on all test equipment.

2.02 PROPRIETARY TEST EQUIPMENT

Proprietary test equipment shall be provided by the manufacturer of the equipment to be commissioned. The manufacturer's representative shall provide the equipment, demonstrate use of the test equipment, and assist the NEBB Systems Commissioning Firm in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

## PART 3 - EXECUTION

### 3.01 CONSTRUCTION OBSERVATION AND TESTS

Provide all observations and tests in accordance with the commissioning specification outlined in section 18000 General Conditions. Include at a minimum the following equipment and systems.

1. Major Equipment and Systems
  - a) Service Entrance Switchboard
  - b) Main Distribution Switchgear
  - c) Sub-Distribution Panels
  - d) Branch Circuit Panels
  - e) Motor Control Centers
  - f) Bus Duct Systems
  - g) Distribution Transformers
  - h) Grounding Systems
  
2. Electrical Systems
  - a) Underground Conduit Systems
  - b) Conduit Systems
  - c) Wire
  - d) Cabling System
  - e) Grounding Systems

### 3.02 CLEANING

Refer to Division 16 for cleaning requirements.

### 3.03 TESTS

A. Perform inspection and tests upon the installed electrical systems according to the following:

1. Grounding Systems:
  - a. Perform three-point fall-of-potential test per IEEE Standard 81, Section 9.04 on the main grounding electrode or system. Resistance shall be no greater than 5 ohms.
  - b. Perform the two-point method test per IEEE Standard 81, Section 9.03 to determine the ground resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points. Resistance shall be no greater than 5 ohms.

2. Busway Systems:
  - a. Check tightness of bolted joints by calibrated torque wrench.
  - b. Insulation resistance test of bus
  - c. Infrared thermographic scan with maximum attainable loads.
  
3. Switchboards: Service entrance switchboards, main switchboards, sub-distribution switchboards, motor control centers, and branch circuit panels as applicable:
  - a) Check tightness of bolted joints by calibrated torque wrench.
  - b) Insulation resistance test of bus
  - c) Circuit breaker overload and short circuit tests
  - d) Ground fault systems test
  - e) Insulation resistance test of motor control center control circuits with respect to ground
  - f) Motor overload units by injection of primary current
  - g) Infrared thermographic scan
  
4. Distribution transformers as applicable:
  - a) Perform inspection and mechanical test as recommended by manufacturer.
  - b) Insulation tests winding to winding and winding to ground.
  - c) Dielectric absorption test
  - d) Alternating current over potential test on high and low windings to ground.
  - e) Infrared thermographic scan
  
5. Metal Enclosed Busway Tests:
  - a) Measure insulation resistance of each bus run phase-to-phase and phase-to-ground for one minute. Test voltage shall be 1,000 volts DC for equipment rated 600 volts. Insulation resistance values shall be in accordance with the manufacturer's specification or 100 megohms for 600-volt equipment when not specified by the manufacturer.
  - b) Perform contact resistance tests on each connection point of uninsulated bus.
  
6. Circuit Breaker Electrical Test:
  - a) Contact Resistance shall be measured and be compared to adjacent poles and similar breakers. Deviations of 50 percent or more shall be investigated.
  - a) Perform insulation resistance test pole-to-pole and from each pole to ground with breaker closed and across open contacts of each phase. Test voltage shall be 1,000 volts DC. Resistance value shall not be less than 50 megohms.
  - b) Instantaneous pickup current shall be determined by run-up or pulse method. Clearing times should be within four cycles or less. Current levels should be within 20 percent of manufacturer's published values.

- c) Time-current characteristic tests shall be performed by passing 300 percent rated current through each pole separately. Trip times shall conform to the following table, breakers with tested trip times exceeding the maximum shall be replaced.

<b>Voltage</b>	<b>Amperes</b>	<b>Maximum Tripping Time (Second)s</b>
240	110-225	200
600	110-225	250
600	250-450	300
600	500-600	350
600	700-1200	500
600	1400-2500	600
600	3000-5000	650

7. Ground Fault systems Test:
- a) Inspect neutral main bonding connection to assure:
    1. Zero sequence system is grounded upstream of sensor.
    2. Ground strap sensing systems are grounded through sensing device.
    3. Ground connection is made ahead of neutral disconnect link on zero sequence sensing systems.
8. Inspect control power transformer to insure adequate capacity for system.
- a) Monitor panels shall be manually operated for:
    - Trip test
    - No trip test
    - Non-automatic reset
  - b) Inspect core balance transformers for geometrical alignment about all current carrying conductors.
  - c) Set pickups and time delay settings according to engineer's specification.
  - d) Insulation resistance test on system neutral with neutral-ground disconnects removed. Resistance shall be minimum 100 ohms preferably 1 megohms or greater.

- e) Determine the relay pickup current by primary injection at the sensor and operate the circuit interrupting device. Pickup currents shall be within 10 percent of device setting and in no case greater than 1,200 amperes.
  - f) The relay timing shall be tested by injecting 150 percent and 300 percent of pickup current into sensor. Total trip time shall be electrically monitored. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves but in no case longer than one second for fault currents equal to or greater than 3,000 amperes.
  - g) System operation shall be tested at 57 percent of rated voltage.
  - h) Test zone interlock systems by simultaneous sensor current injector and monitoring zone blocking function.
9. Transformer Tests - Dry Type:
- a) Inspect for physical damage, cracked insulators, tightness of connections, or defective wiring and general mechanical and electrical conditions.
  - b) Verify proper auxiliary device operation such as fans and indicator.
  - c) Make a close examination for shipping brackets or fixtures that may not have been removed during original installation. Ensure resilient mounts are free.
  - d) Perform insulation resistance tests, winding-to-winding and windings to ground, utilizing a megohmmeter with a test voltage of 1,000 volts DC. Test duration shall for 10 minutes with resistances tabulated at 30 seconds, one minute, and 10 minutes. Dielectric absorption ratio and polarization index shall be calculated.
  - e) Perform power factor or dissipation factor tests in accordance with the manufacturer's instruction manual.
  - f) Perform a turns ratio test between windings at all top settings.
  - g) Perform windings resistance tests for each winding at nominal top position.
  - h) Measure secondary voltage phase-to-phase and phase-to-neutral after final energization and prior to loading.
10. Transfer Switches:
- a) Check switch to ensure positive interlock between normal and alternate sources.
  - b) Perform manual transfer operation.
  - c) Insulation resistance test phase-to-phase and phase-to-ground in both source positions.
  - d) Set and calibrate to engineer's specification voltage sensing and transfer time relays.
  - e) Perform automatic transfer by simulating loss of normal power and return to normal power. Transfer time should be less than 10 seconds.

- f) Monitor and verify correct operation and timing of:
    - Normal and alternate source voltage sensing relays
    - Time delay on transfer and retransfer
    - Automatic transfer operation
    - Interlocks and limit switch function
    - Elevator operation interlocks
    - Operation of remote indicating control panel and signals into the fire alarm system
  - g) Infrared thermographic scan
11. Emergency Generator:
- a) Verify that generator is set in place.
  - b) Verify power wiring connections, control wiring connections, fuel connections, radiator connections, battery connection, exhaust connections, and block or oil heater connection.
  - c) Check and record engine oil level, radiator water level, and battery electrolyte level.
  - d) Observe the engine manufacturer's representative start the engine. Record engine elapsed time run hours, engine temperature, oil temperature and pressure, engine speed, alternator voltage output and frequency.
  - e) Generator is to be tested to at 50, 75, 100, and 125 percent load capacity using load banks at 100 percent power factor. Run load test at all loads except 125 percent for 30 minutes recording engine and alternator readings at the start, at 15 minutes and at 30 minutes. 125 percent load to be run for 15 minutes recording readings at the start and end of test.
  - f) Simulate operation of all generator safeties such as high oil pressure, low oil pressure, high temperature, over speed, etc. Observe function of safeties under actual malfunction situation.
  - g) Observe generator operation for elevator recall and under Life Safety operation. Refer to tests under Section 18500 for Life Safety tests under emergency power.
12. Infrared Thermographic Scanning: In general, the scan 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 exact time of conducting the scan will be determined by the NEBB Systems Commissioning Administrator (SCA) near the completion of the project.
- a) Test equipment, miscellaneous tools, and materials shall be transported properly, moved, and set up by trained personnel. Equipment used in testing shall be capable to perform all recommended procedures required by the apparatus and related equipment. All test equipment shall have certification of calibration and be in working order.

- b) All hot spots shall be marked, identified and an infrared thermographic scanning report prepared and furnished to the NEBB Systems Commissioning Administrator (SCA). The report shall contain infrared photos of trouble spots with temperature readings.
- c) All sources of heating problems shall be promptly reported to the owner for corrective action by the Division 16 contractor.
- d) Infrared scanning equipment shall be an AGA (or approved equal) thermovision set capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of 0.2° C. with a liquid nitrogen reference.

**3.04 POST OCCUPANCY TESTS**

A Phase Balance: One month after occupancy of the project check the phase balance of the system at:

- 1. Each panelboard
- 2. Each feeder
- 3. Each motor control center
- 4. Each distribution switchboard
- 5. Each main switchboard

Record load on each phase and percentage in balance to the average. Any loads more than 10 percent out of balance shall be adjusted by redistribution of loads by the Division 16 contractor.

B. Harmonic Analysis: After completion of phase balancing, a harmonic content analysis shall be undertaken on the three bus ducts serving the lab floors, and switchboards EHMDPN-LIA, HMDPS1 and MDPS-G. The analysis shall measure the percentage harmonic distortion for each odd harmonic from the 3rd to the 29th. From the measured individual harmonics, the Total Harmonic Distortion (THD) shall be calculated. Any feeder showing more than 10 percent THD shall be studied further downstream to determine the sources of the harmonics.

END OF SECTION



## **COMMISSIONING**

## **SECURITY SYSTEMS**

### PART 1 - GENERAL

#### 1.01 DESCRIPTION

The purpose of this section is to describe the commissioning process specific to the security systems and equipment. This includes the card access system, door monitoring and locking system, closed circuit television system, and control room console.

### PART 2 - PRODUCTS

#### 2.01 TEST EQUIPMENT

The following test equipment shall be provided by the NEBB Systems Commissioning Firm:

- A. Light meter
- B. Portable two-way radios

#### 2.02 PROPRIETARY TEST EQUIPMENT

Proprietary test equipment shall be provided by the manufacturer of the equipment to be commissioned. The manufacturer's representative shall provide the equipment, demonstrate use of the test equipment, and assist the NEBB Systems Commissioning Firm in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

### PART 3 - EXECUTION

#### 3.01 CONSTRUCTION OBSERVATION AND TESTS

Provide all observations and tests in accordance with the commissioning specification outlined in section 18000 General Conditions. Include at a minimum the following equipment and systems.

- A. Card access control system performance testing shall include:
  - 1. Verify specified maximum response and response time on card readers.
  - 2. Verify Time Schedule for automatic functions.

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- 3. All type C readers with enable switched shall demonstrate the following:

- a) Target area for the enable switch shall meet commissioning contractor and Owner's approval.
  - b) Each door enable switch will be tested with simulated area non-authorized and authorized traffic to ensure acceptable target area and card reader function through enable switch.
4. Hazardous alarms shall be individually tested for local alarm, and local reset of alarm.
  5. Hazardous alarms shall be tested for displayed and printed alarm. The reset for the local alarm from security station. Display of alarm area by CCTV, if camera view of area available. (Coordinate with CCTV).
  6. Demonstrate the ability for the system to come back "on line-" after losing all power (except internal battery back-up).
  7. Verify alarm condition for break-in connection of door controller circuit.
  8. All alarm conditions shall be displayed on monitor and printed on alarm printer with audio signal. Verify data base archive of all alarms, alarm time and events to specification.
  9. Verify local visual and audio alarms for hazardous material. Verify alarms are separate and distinct from all fire alarm signals. (Coordinate with fire alarm system).
- B. CCTV Performance Testing shall include:
1. Resolution Test: To measure camera resolutions, an EIA Standard Resolution Test Pattern shall be placed in front of the camera being tested. The limiting resolution shall be measured by observing the wedges of the pattern on a monitor and noting the reading at the point where the lines are no longer discernible. Vertical wedges shall provide the measurement of horizontal resolution and horizontal wedges shall provide the measurement of vertical resolution from 200 to 800 lines. Resolution measurements shall be taken at different light levels since resolution will vary with the change in light level. Gray scale responses shall also be measured with this chart. The gray scale shall provide a guide to measure the ability of each camera to differentiate shaded from black to white.

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2. Sequence Camera Tests: Manually activate each camera via the system keyboard on a sequence monitor and on the alarm monitor. Set up an automatic sequence for all cameras as specified. Demonstrate different sequence rates and camera combinations.
  3. VCR Test: Demonstrate the VCR's are recording all images as seen on the monitors.
  5. Alarm Input Test: Demonstrate an alarm input from the Security Intercom and from the Card Access System by projecting on the alarm monitor and recording on the Alarm VCR the camera image for the associated camera. This test must be performed with an individual standing at the respective card reader or intercom to verify field of view for each camera location. Perform the same alarm input test for all doors with door status switches.
  6. Keyboard Control Test: Demonstrate via the keyboard controls the pan, tilt, and zoom function for all cameras. Camera viewing shall include the entire zoom focal length for all areas.
  7. Pre-position Test: Demonstrate each pre-position location for each camera based on activation of intercom alarm per the CCTV points list.
  8. Low-Light Level Tests: Demonstrate exterior CCTV coverage during diminishing daylight hours to verify scene illumination starting at dusk and proceeding at intervals of every 30 minutes until total darkness. Test shall include looking at areas of the parking lot, walkways and all building perimeter areas of high contrast and extreme low light level areas. Demonstrate recording these areas on the alarm VCR while a person is walking through the fields of view. Playback must be of a quality to identify the individual.
- C. Integrated Test: Demonstrate a fully operational system test by activating simultaneous multiple alarms from the card access door switch and security intercom for both the Quads and sequenced camera locations to verify proper system component integration. System operation test shall include acknowledgment of all alarms and a return to normal status.

END OF SECTION

**DIVISION 18  
COMMISSIONING**

**SECTION 18900  
LIGHTING CONTROL SYSTEM**

PART 1 - GENERAL

1.01 DESCRIPTION

The purpose of this section is to describe the commissioning process specific to the lighting control systems and equipment. This includes the low voltage lighting relays and the auditorium dimming system.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

The following test equipment shall be provided by the NEBB Systems Commissioning Firm:

- A. Portable two-way radios
- B. Voltmeter
- C. Ammeter

PART 3 - EXECUTION

3.01 CONSTRUCTION OBSERVATION AND TESTS

Provide all observations and tests in accordance with the commissioning specification outlined in section 18000 General Conditions. Include at a minimum the following equipment and systems.

:

- A. Test the operation of all low voltage switches, making sure that the switch operates the correct relay and only the correct relay.
- B. Test time sweep off operation on the low voltage relay system.
- C. Test operation of auditorium dimming system.
- D. Measure current on each dimmer circuit of the dimming system and the feeder to the dimmer.
- E. Verify operation of graphic control station. Verify schedule operation of each schedule sequence.

END OF SECTION