

<b>1</b>	<b>GUIDELINES FOR PROJECT TESTING AND COMMISSIONING .....</b>	<b>3</b>
<b>1.1</b>	<b>INTRODUCTION.....</b>	<b>3</b>
1.1.1	Scope .....	3
1.1.2	References .....	3
1.1.3	General.....	3
<b>1.2</b>	<b>DEFINATION AND RESPONSIBLITES.....</b>	<b>7</b>
1.2.1	Purpose Of Document .....	7
1.2.2	Definitions.....	8
1.2.3	Process .....	9
1.2.4	Systems And Assemblies To Be Commissioned.....	11
1.2.5	Standards For Equipment, Instrumentation And Calibration.....	14
1.2.6	Costs And Expenses .....	14
<b>1.3</b>	<b>GENERAL RESPONSIBILITIES .....</b>	<b>14</b>
1.3.1	Commissioning Responsibilities.....	14
1.3.2	Commissioning Agency (CxA) Responsibilities:.....	14
<b>1.4</b>	<b>ROLES AND RESPONSIBLITES MATRIX.....</b>	<b>15</b>
1.4.2	Contractor's Responsibilities:.....	16
1.4.3	Owner Representative's Responsibilities: .....	18
1.4.4	Commissioning Responsibilities – Sub-Contractors: .....	18
1.4.5	Commissioning Responsibilities - TAB Agency (hired by the CONTRACTOR): .....	20
1.4.6	Commissioning Responsibilities - Controls Contractor: .....	21
<b>1.5</b>	<b>USE OF PARTS AND MATERIALS.....</b>	<b>22</b>
1.5.1	General.....	22
<b>1.6</b>	<b>SPECIFIC GSAS AND/OR LEED REQUIREMENTS .....</b>	<b>22</b>
1.6.1	General.....	22
1.6.2	Commissioning Plan .....	23
<b>1.7</b>	<b>CONSTRUCTION PHASE COMMISSIONING .....</b>	<b>23</b>
1.7.1	Introduction.....	23
1.7.2	Construction Phase Responsibilities: .....	23
1.7.3	Construction Phase Activities:.....	24
1.7.4	Construction checklists .....	26
<b>1.8</b>	<b>COMMISSIONING EXECUTION PLAN .....</b>	<b>26</b>
1.8.1	MANUAL .....	26
<b>1.9</b>	<b>PRE-FUNCTIONAL TESTS (PFT) .....</b>	<b>28</b>
1.9.1	General.....	28
1.9.2	Contractor's General Duties.....	28
1.9.3	PFT Checklists .....	29
1.9.4	PFT Sheets.....	29
1.9.5	PFT Status Index .....	29
1.9.6	PFT Issue's Log.....	29
1.9.7	PFT Dossier.....	30
<b>1.10</b>	<b>FUNCTIONAL PERFORMANCE TESTING (FPT) .....</b>	<b>31</b>
1.10.1	General.....	31
1.10.2	FPT Procedures .....	31
1.10.3	Test Data.....	32

1.10.4	General Test Procedures.....	33
1.10.5	Preliminary Checks and Inspections.....	33
1.10.6	Unit Functional Testing.....	34
1.10.7	System Functional Tests.....	34
<b>1.11</b>	<b>INTEGRATION AND OPERATIONAL TESTING .....</b>	<b>35</b>
1.11.1	General.....	35
1.11.2	Integration Tests.....	35
1.11.3	Operational Test.....	36
<b>1.12</b>	<b>DEFERRED TESTING.....</b>	<b>36</b>
1.12.1	General.....	36
1.12.2	Stadium Cool-Down Study.....	36
1.12.3	Seasonal Performance Tests.....	37
<b>1.13</b>	<b>READY-FOR-START-UP DOSSIER .....</b>	<b>38</b>
1.13.1	Manual.....	38
<b>1.14</b>	<b>WARRANTY PHASE COMMISSIONING.....</b>	<b>38</b>
1.14.1	Introduction.....	38
1.14.2	Warranty Phase Responsibilities .....	39
1.14.3	Warranty Phase Activities .....	39
1.14.4	Performance Review .....	40
1.14.5	Warranty Phase Completion .....	40
1.14.6	Warranty Phase Documentation .....	40
1.14.7	Warranty Phase, Sectional Occupancy Handover.....	40
1.14.8	Warranty Lists.....	41
<b>1.15</b>	<b>COMMISSIONING DOCUMENTATION.....</b>	<b>41</b>
1.15.1	General.....	41
1.15.2	Commissioning Report .....	42
1.15.3	Report Distribution.....	46
<b>1.16</b>	<b>COMMISSIONING REQUIREMENTS/ OPERATION AND MAINTENANCE.....</b>	<b>46</b>
1.16.1	Manual.....	46
1.16.2	Commissioning Process Overview.....	46
1.16.3	Systems And Assemblies To Be Commissioned.....	48
1.16.4	Codes And Regulations .....	49
1.16.5	Costs And Expenses .....	49
1.16.6	General Roles And Responsibilities.....	49
1.16.7	Commissioning Process .....	52
1.16.8	Design Development Review.....	54
1.16.9	General Review of Drawings and Specifications.....	55
1.16.10	Commissioning Progress Reporting.....	57

# 1 GUIDELINES FOR PROJECT TESTING AND COMMISSIONING

## 1.1 INTRODUCTION

### 1.1.1 Scope

- 1 This Section specifies the requirements for project testing and commissioning.
- 2 The purpose of QCS is to provide as a general technical guide for acceptable construction work practices in the State of Qatar, considering this; any addition for technology, material, specification, standard that are not mentioned in this section or their modification, shall be subject to approval as stated in the introduction of QCS (00-02).
- 3 For voltages and frequencies, regulations and requirements of Kahramaa and relevant authorities should be taken into account.

### 1.1.2 References

- 1 The following standards are adopted and/or referred to in this Section:  
ASHRAE Guideline 0 .The Commissioning Process  
ASHRAE 202 .....Standard 202- Commissioning Process for Buildings and Systems  
ASHRAE Guideline 1.1- HVAC&R Technical Requirements for The Commissioning Process  
ASTM E779 .....Standard Test Method for Determining Air Leakage Rate by Fan Pressurization  
BS 7671 .....Requirements for Electrical Installations. IET Wiring Regulations  
NFPA 3.....Standard for Commissioning of Fire Protection and Life Safety Systems

### 1.1.3 General

- 1 Preambles - PROJECT COMMISSIONING AND CLOSE OUT
  - (a) This section outlines the Commissioning and Close Out requirements applicable for the Construction and Post-Construction of The Project and how the Commissioning is managed and monitored in the activities related to project and product realization.
  - (b) Each party involved on the PROJECT program will have a Commissioning focal point who will liaise with the Owner's focal point to ensure that all quality related matters are managed appropriately.
  - (c) Then, the approved commissioning plan and program shall become part of the Final Project Specific Handover Plan.
- 2 PM/CM Commissioning Policy
  - (a) PM/CM's Commissioning Policy Statement; set forth the minimum requirements and guidelines for the inspection, start-up, tuning, and commissioning of the equipment, facilities, plant, and systems on the WORKS by the CONTRACTOR in order to meet the requirements of the Client.
- 3 Project Commissioning Management Plan

The PM AND/OR CM will ensure that Contractor (s) will have performed the following key activities:

- (a) systematic process for verifying that building equipment, systems, and integrated systems have been installed, properly started, and consistently operated in strict accordance with the Contract Documents, and that OWNER has been provided with required system documentation and training. This purpose can be defined by set forth the minimum requirements and guidelines for the inspection, start-up, tuning, and commissioning of the equipment, facilities, plant, and systems on the WORKS by the CONTRACTOR in order to meet the requirements of the CONTRACT.
- (b) Tests formalize the review and integration of all project systems and equipment during the design, construction, and occupancy phases of the facility by audit, inspection and functional performance testing and production of commissioning record documentation. Tests are divided into Pre-Functional, Functional and Integration/Performance tests.

4 Authorities' approvals and Reference Documents

- (a) Commissioning management plan must be carried out in accordance with the authorities listed below or any other commissioning Standard or Code approved by OWNER:
  - (i) KAHRAMA
  - (ii) QCDD
  - (iii) GSAS AND/OR LEED
  - (iv) ASHRAE
  - (v) BSRIA
  - (vi) CIBSE
  - (vii) NFPA
  - (viii) British Standards

5 Documentation

- (a) PM/CM shall monitor the Documentation which shall be provided in a format and quantity as required by the GSAS AND/OR LEED Service Provider, where Commissioning Documentations are:
  - (i) Testing and Inspection Plans
  - (ii) Pre-Functional and Functional Test Procedures
  - (iii) Construction Checklists
  - (iv) Issues Logs

6 Service Provider's Control

- (a) The development, implementation, training, monitoring, auditing and continuous improvement is the responsibility of the Commissioning focal point of each respective party as per the following table:

The Project	
Company Role:	PM AND/OR CM
Company Name:	PM/CM
QA/QC Focal Point:	Eng. ....
PROJECT: Construction of Main Package	
Company Role:	D&B Construction Management Supporting services through construction stage

Company Name:	TBA
Commissioning Focal Point:	TBA
PROJECT: Operations and Maintenance Works	
Company Role:	Post Construction Works
Company Name:	TBA
Commissioning Focal Point:	TBA

7 Deliverables to the Owner

- (a) Commissioning Authority (Agency) shall monitor the work of the site construction supervision engineers with regard to building services throughout the construction and commissioning periods. Whenever the first piece of equipment or system of a specific type is inspected or tested the PM AND/OR CM shall utilize it as a benchmark for all future inspections and tests of a similar type. The PM AND/OR CM will retain records, both written and photographic of all benchmarks as reference for the project team.
- (b) Periodic reports and records are as follows:
  - (i) Fortnightly Progress report.
  - (ii) Inputs to the Owner on Cost and Budget Update reports.
  - (iii) Project Risk Register.
  - (iv) RFI Responses.
  - (v) Review of project calendar / meeting matrices.
  - (vi) Commissioning Execution Plan Tracker, including Commissioning LOG's.
  - (vii) Commissioning Risk Management Plan.

8 Project Key Performance Indicators (KPI's)

- (a) This is project specific and will be developed as the project schedule of deliverables materializes. KPIs will also generally be defined in conjunction with the Project team.

9 System Performance Measurement (Audits): Non-Conformance, Corrective and Preventive Actions

- (a) Any Non-Conformances (NCR's) / Corrective and Preventive Actions (CA/PA) identified by PM/CM are raised and managed in accordance with Control of Non Conformance, corrective and preventive actions procedure.
- (b) Any NCR's / CA/PA identified by Consultant / Contractors shall rise through their internal system and also inform PM/CM in writing. Sub consultants and Subcontractors shall inform their respective Owner, who shall inform PM/CM in writing. The respective Consultant / Contractor are responsible for tracking and ensuring the close-out of the NCR.

10 Review and Improvement

- (a) The PM/CM PMP and Consultants / Contractors PQP's remain as live documents throughout the duration of the project and shall be regularly updated as the project progresses.

11 Commissioning Risk Management Plan

- (a) At the Construction phase, the PM/CM will manage the project risks. A risk register shall be maintained, identifying issues that may affect the project's successful development and conclusion. Main risks to be managed from Lessons Learned are:
- (b) NOT to define Commissioning works liability within the MEP designs documents i.e. typical details and design specifications prior the construction stage; consequences Inability to handover in time due to high potential of having contradictions between MEP systems installed works and systems operating. This will lead to rework of some MEP installations and abortive civil/Arch works as well for walls and ceilings specially
- (c) PM AND/OR CM Commissioning team absence at design stage running thru early stage of construction period till project handover; consequences Introduce abortive works for devices replacement to allow for systems integrations (these issues will not be seen until the very end i.e. after MEP installation completion).

## 12 SYSTEMS and Assemblies to be commissioned

- (a) Mechanical: Domestic Cold Water, Domestic Hot Water, Sanitary Waste, and Storm Drainage systems, HVAC systems
- (b) Environmental Controls Systems (EPM): Work includes inspections and checks of installation and operation of all devices; complete operation of all controls sequences, in coordination with commissioning of all controlled systems.
- (c) Dedicated and Non-Dedicated Smoke Control Systems: Work includes installation inspections and checks; flow adjustments, and calibration coordinated with controls and air balancing; controls operation including fire alarm system controls response.
- (d) Lighting Control Systems: Work includes aiming, positioning and calibration of all lighting control devices; in accordance with specification sections of the LIGHTING CONTROL SYSTEMS and WIRING DEVICES.
- (e) Solar Panel Systems: in accordance with specification sections SOLAR ENERGY COLLECTORS and GRID-TIE IN UTILITY INTERACTIVE INVERTERS and the Drawings.
- (f) Security Systems: in accordance with specification sections ELECTRONIC SECURITY SYSTEM HEAD END EQUIPMENT, ACCESS CONTROL, VIDEO SURVEILLANCE, ACTIVE VEHICLE BARRIERS, and – PARKING CONTROL EQUIPMENT and the Drawings.
- (g) Fire Suppression Systems: Work also applies to systems outside the building footprint to the connection to existing systems.
- (h) Fire Alarm Systems: in accordance with specification sections DIGITAL ADDRESSABLE FIRE ALARM SYSTEM and AIR SAMPLING SMOKE DETECTION SYSTEM and the Drawings.
- (i) Telecommunications Systems: in accordance with specification section COMMUNICATIONS, PREMISES DISTRIBUTION SYSTEM and the Drawings.
- (j) Earthing and Lightning Protection Systems.
- (k) Motor Controllers and Variable Frequency Drives Systems: in accordance with specification section ENCLOSED CONTROLLERS and the Drawings.
- (l) Power Distribution Systems.
- (m) Emergency and Standby Power Systems: in accordance with specification sections ENGINE GENERATORS AND AUTOMATIC TRANSFER SWITCHES and BATTERY-INVERTER EMERGENCY POWER SYSTEM and the Drawings; complete operation of all controls sequences, in coordination with commissioning of all controlled systems.
- (n) Irrigation Systems.

- (o) Water Features.
- (p) Vertical Transportation Systems: Work includes testing and commissioning of elevators in accordance with ASME requirements and the project specifications.
- (q) Critical Leakage Construction.

## 1.2 DEFINATION AND RESPONSIBILITIES

### 1.2.1 Purpose Of Document

- 1 The purpose of this document is to set forth the minimum requirements and guidelines for the inspection, start-up, tuning, and commissioning of the equipment, facilities, plant, and systems on the WORKS by the CONTRACTOR in order to meet the requirements of the CONTRACT.
- 2 The CONTRACTOR's responsibilities for the Construction, Acceptance and Warranty phases of the commissioning process will include without limitation, the following and all other items detailed herein.
  - (a) The employment of a specialist professional Commissioning Engineering Team (and a 3rd party Commissioning Agency as defined) of suitably experienced and qualified personnel in accordance with the approved plans, schedules, and procedures. The CONTRACTOR's commissioning team shall report to the OWNER REPRESENTATIVE. The personnel shall have experience with installing and commissioning similar systems and shall have knowledge about the design aspects to rectify and/or modify quickly at site, if so required. OWNER shall have the right to approve all members of the Commissioning Engineering Team. OWNER shall have the right to seek replacement of any member of the Commissioning Engineering Team, in OWNER's opinion, performance is unsatisfactory.
  - (b) The CONTRACTOR shall deploy to SITE within ninety (90) days of project award a suitably experienced Commissioning Manager (CxM). The CxM shall serve as the OWNER single point of contact within the Contractor's organization for all issues related to the commissioning scope of work. The CxM shall have no other responsibilities than commissioning and will work full-time on the project until turnover to OWNER.
  - (c) The CONTRACTOR's CxM shall satisfy the following requirements:
    - (i) Recent experience of commissioning at least one other project of similar scale;
    - (ii) A minimum of 10 years commissioning experience on building services systems;
    - (iii) Extensive experience in the operation and troubleshooting of HVAC systems, energy management control systems, security systems and the like;
    - (iv) Extensive field experience;
    - (v) Detailed knowledge in building operation and maintenance and O&M training;
    - (vi) Detailed knowledge in the test and balance of both air and water systems;
    - (vii) Experienced in energy-efficient equipment design and control strategy optimization;
    - (viii) Direct experience in monitoring and analyzing system operation using energy management control system trending and stand-alone data logging equipment;
    - (ix) Excellent verbal and writing communication skills using the English language;
    - (x) Highly organized and able to work with both management and trade contractors;
    - (xi) Experienced in authoring Commissioning Plans, method statements, and execution programmes;



- (xii) A professional certification in building commissioning is required. The following certificates are acceptable:
  - Building Commissioning Association (BCA) – Certified Commissioning Provider (CCP)
  - Commissioning Specialist Association (PMA) – Grade 6 Accreditation;
  - American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) – Commissioning Process Management Professional (CPMP);
  - National Environmental Balancing Bureau (NEBB) – Building Systems Commissioning Certification (BPM);
- (xiii) A minimum of a Bachelor's degree in Mechanical/Electrical or Building Services Engineering together with P.E./C.Eng certification is desired; however, other technical training, past commissioning and field experience will be considered;
- (xiv) Proven track record of providing commissioning services for the formal Sustainability Rating System being utilized on the project, which is GSAS AND/OR LEED Sports and GSAS AND/OR LEED Construction Management. (2 years minimum required).
  - The Commissioning Engineering Team shall include a specialist O&M Technical Author to organize, write and assemble the as-built and O&M documentation for the WORKS. Submit all CV's for the Technical Author to OWNER for approval. Only personnel who have been approved in writing shall be employed on this project.
  - The CONTRACTOR's personnel shall bring their own necessary tools, utility software, personal computers, etc. to site as required

### 1.2.2 Definitions

- 1 Commissioning: A systematic process for verifying that building equipment, systems, and integrated systems have been installed, properly started, and consistently operated in strict accordance with the Contract Documents, and that OWNER has been provided with required system documentation and training.
- 2 Other definitions and abbreviations:
  - (a) ASHRAE - The American Society of Heating, Refrigerating and Air-Conditioning Engineers;
  - (b) BISRIA – The Building Services Research and Information Association;
  - (c) BOD – Basis of Design. Consists of the Project Summary Report including the discipline narratives.
  - (d) CIBSE – Chartered Institution of Building Services Engineers;
  - (e) CEP – Commissioning Execution Plan; A document prepared by the contractor detailing how the requirements of the Commissioning Plan will be planned, organized, performed and documented. (See ASHRAE Guideline 0-2013 for Commissioning Plan requirements.
  - (f) CP – Commissioning Plan; A document prepared by the Commissioning Agency and approved by OWNER that provides the commissioning roles and responsibilities of the Project Team, and the structure, process and procedures for commissioning from the design phase through the warranty period.
  - (g) CS – Construction Supervision
  - (h) PM – The project management and construction supervision group.



- (i) CxA– Commissioning Agency; The CONTRACTOR's third party Commissioning Agency/specialist are assigned to execute, manage, monitor, coach, oversee and audits the execution and testing of the commissioning process, and ensures that the CONTRACTOR provides and documents a project that functions and performs as called for in the OPR and BOD.
- (j) CxM – CONTRACTOR's Commissioning Manager; the individual employed by the CONTRACTOR to organize and execute the commissioning of the project.
- (k) Deferred Test – A test or inspection that is conducted after turnover of the project to OWNER or an OWNER REPRESENTATIVE. The Deferred Tests include, but are not limited to, seasonal performance test, GSAS AND/OR LEED related warranty tests and inspections, and any tests authorized to be moved from the construction phase of the works to after turnover.
- (l) FPT – Functional Performance Test; Test of dynamic function and operation of equipment and systems executed by Contractor. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Functional Performance Tests are executed after start-ups and Pre-Functional Checklists are complete.
- (m) GSAS AND/OR LEED Requirements. Which are GSAS AND/OR LEED Sports and GSAS AND/OR LEED Construction Management
- (n) NFPA – National Fire Protection Association.
- (o) OCM – Owner's Commissioning Manager
- (p) OPR – Owner's Project Requirements document
- (q) PFT – Pre-Functional Test; A list of static inspections and material or component tests that verify proper installation of equipment (e.g., belt tension, oil levels, labels affixed, gages in place, sensors calibrated, etc.). The word Pre-Functional refers to before Functional tests. Pre-Functional Checklists must include the manufacturer's Start-up checklist(s). Contractor shall sign Pre-Functional Checklists as complete and submit with the Request for Start-up/Functional Performance Test Form.
- (r) OWNER; Owner or the Party identified as such in the FORM OF AGREEMENT including its legal successors and permitted assigns.
- (s) Start-up – The activities where equipment is initially energized, tested, and operated. Start-up is completed prior to Functional Performance Tests.
- (t) TAB – Testing, Adjusting and Balancing: The process of tuning ductwork and piping systems so that proper amounts of air and water move through the project as required by the Design. Detailed requirements for the execution of TAB are provided in the Project Specifications.

### 1.2.3 Process

- 1 Commissioning formalizes the review and integration of all project systems and equipment during the design, construction, and occupancy phases of the facility by audit, inspection and functional performance testing and production of commissioning record documentation.

- 2 The Commissioning Process as described in ASHRAE Guideline 0–2013, ASHRAE Guideline 202-2013, ASHRAE Guideline 1.1-2007, NFPA 3-2015 or later editions shall be followed together with any other specific document required by the contract specifications in regards to specific elements. Specific elemental guidance is provided by learned institutions as ASHRAE, CIBSE, BISRIA , ACG, etc, this guidance shall be considered as best practice. If any scoping conflicts exist within this document, or with other project documentation, the most stringent requirement shall apply.
- 3 The following is an outline of the commissioning process to be implemented by the CONTRACTOR on this project, the whole contents of this document shall be complied with and it shall be read in-conjunction with all other project documents and the drawings:
  - (a) Establish the CONTRACTOR Commissioning Engineering Team and deploy the CxM within ninety (90) days of contract execution.
  - (b) Develop Commissioning Execution Plan and Commissioning Program by approximately 25% completion of the project and submit for approval. (See Appendix 'G' for specific deliverable dates.) The Commissioning Program shall form an integral part of the project master program. ASHRAE Guideline 0-2013 provides details on the requirements for a Commissioning Execution Plan.
  - (c) Develop commissioning related inspection test plans and method statements for the execution of all construction completion inspections, equipment start-ups, system tuning, testing & balancing, and component tests. These documents are to be submitted for approval by approximately 50% completion of the project. (See Appendix 'G' for specific deliverable dates.)
  - (d) For systems not included in the CxA scope of work, CONTRACTOR shall develop commissioning related inspection plans and method statements for Functional Performance Tests, Integration Tests, and Operational Tests. These documents are to be submitted for approval by approximately 70% completion of the project. (See Appendix 'G' for specific deliverable dates.)
  - (e) CxA scope is to develop commissioning related inspection plans, Functional Performance Tests, Integration Tests, and Operational Tests; however, the development of method statements for the execution of these activities remains with the CONTRACTOR. These documents shall be submitted for approval before 70% completion of the project
  - (f) All inspection test plans shall be oriented on a system basis and not on a component or discipline basis. (For example, an Air Handling System shall have one inspection test plan for a construction completion inspection and one inspection test plan for Functional Testing. It is not to have tests and inspections divided into an air-side mechanical inspection, a water-side mechanical inspection, an electrical power inspection, a variable frequency drive inspection, and controls inspection)
  - (g) The following process will be conducted for the starting, testing, and turnover of each building system (All steps shall be signed off by the CONTRACTOR, the involved Subcontractors, the PM, and other entities as appropriate):
    - (i) System Construction Completion Inspection (Hold Point for Step 2)
    - (ii) System Pre-Functional Testing (Energization, Startup, Tuning, and Component Testing). Individual discipline tests are to be combined into a dossier. (Hold Point for Step 3)
    - (iii) System Functional Test (After completion of groups of systems it will be possible to move ahead with Integration Testing. This is determined on a case by case basis.)

- (iv) Integration Testing
- (v) Operational Testing (Prerequisite for project handover)
- (vi) Deferred Testing
- (h) CONTRACTOR shall provide and install all necessary electrical power, temporary electrical power, spare parts, and consumables (such as filters) necessary for the commissioning process and on-going equipment operation and maintenance, at no additional cost to OWNER.
- (i) CONTRACTOR shall keep all equipment and systems energized and operational from the time of commissioning through project turnover and shall provide all staff necessary for safety and maintenance of the operational equipment and systems, at no additional cost to OWNER.
- (j) Contractor shall ensure that all permanent components, equipment, systems, etc. utilized on the project are capable of being operated on temporary electrical power without voiding the manufacturer's warranty. Manufacturers shall provide a statement to this affect within their product submittals. If the proposed manufacturer will not accept this requirement, the CONTRACTOR shall assume the warranty requirement for the component, equipment, system, etc. Lack of permanent electrical power will not be cause for delay in the commissioning works and temporary electrical power is to be provided as directed by OWNER, with no additional cost to OWNER.

#### 1.2.4 Systems And Assemblies To Be Commissioned

- 1 All building systems and components included in the Technical Specifications shall be commissioned by the CONTRACTOR including oversight, review and inspection. Test witnessing shall be performed as identified at the ITPs to OWNER satisfaction.
- 2 The following is a subset of systems and assemblies where the CONTRACTOR commissioning is to be conducted. (This list is representative only. All systems as included in the Technical Specifications shall be commissioned.)
  - (a) Domestic Cold Water, Domestic Hot Water, Sanitary Waste, and Storm Drainage Piping Systems:
  - (b) Water Storage Tanks: Work includes installation inspections and checks; confirmation of water filling sequence, overflow safety sequence, and overflow drainage; leak testing.
  - (c) Pumps: Work includes documented checks on alignment, rotation, motor current draw, flows and pressures.
  - (d) Water Heaters: Work includes installation inspections and checks; checkout and start-up by manufacturer's representative as specified; documented capacity tests for heating; operation of all controls.
  - (e) Environmental Controls Systems (EPM): Work includes inspections and checks of installation and operation of all devices; complete operation of all controls sequences, in coordination with commissioning of all controlled systems.
  - (f) Chilled Water Piping Systems: Work includes installation inspections and checks; pressure tests and documentation; expansion tanks; confirmation of flow balancing completion. Work also applies to systems outside the building footprint to the connection to existing systems.
  - (g) Duct and Air-Handling Systems: Work includes installation inspections and checks; confirmation of flow balancing completion; leak testing as applicable.
  - (h) Heat Exchangers: Work includes installation inspections and checks; documented performance measurements including capacity, flow rates, and controls operation.

- (i) Refrigeration Compressor/Condensing Unit(s): Work includes installation inspection and checks; checkout and start-up by manufacturer's representative as specified; documented performance measurements including capacity, evaporator and condenser pressures, motor current draw, and controls operation.
- (j) Pumps: Work includes documented checks on alignment, rotation, motor current draw, flows and pressures.
- (k) Supply, Return, Relief and Exhaust Fans: Work includes checks on installation, rotation, sound levels, motor current draw, and airflows and pressures.
- (l) Air Handling Units (both packaged and built-up): Work includes installation inspections and checks; checkout and start-up by manufacturer's representative as specified; documented capacity tests for heating, cooling, air flow and static pressures; operation of all controls; sound level.
- (m) Air Terminal Devices: Work includes installation inspections and checks; for VAV units, flow adjustments, and calibration coordinated with controls and air balancing; controls operation including flow modulation, reheat, controls responses.
- (n) Fan-Coil Units: Work includes installation inspections and checks; performance and controls checks.
- (o) Dedicated and Non-Dedicated Smoke Control Systems: Work includes installation inspections and checks; flow adjustments, and calibration coordinated with controls and air balancing; controls operation including fire alarm system controls response.
- (p) Lighting Control Systems: Work includes aiming, positioning and calibration of all lighting control devices; inspections and checks of installation and operation of all devices in accordance with specification sections of the LIGHTING CONTROL SYSTEMS and WIRING DEVICES and the Drawings; coordination with Commissioning Agent; integration of new systems with existing systems at QSTP and Education City; complete operation of all controls sequences, in coordination with commissioning of all controlled systems.
- (q) Solar Panel Systems: Work includes aiming, positioning and calibration of all solar panels; performance testing of all associated equipment; coordination with Commissioning Agent; inspections and checks of installation and operation of all devices in accordance with specification sections SOLAR ENERGY COLLECTORS and GRID-TIE IN UTILITY INTERACTIVE INVERTERS and the Drawings.
- (r) Security Systems: Work includes aiming, positioning and calibration of all CCTV cameras; performance testing of cameras, access control devices (including active vehicle barriers and parking control equipment), door intercommunication stations, and network video recorders; integration of new systems with existing systems at QSTP and Education City; inspections and checks of installation and operation of all devices in accordance with specification sections ELECTRONIC SECURITY SYSTEM HEAD END EQUIPMENT, ACCESS CONTROL, VIDEO SURVEILLANCE, ACTIVE VEHICLE BARRIERS, and – PARKING CONTROL EQUIPMENT and the Drawings.
- (s) Fire Suppression Systems: Work includes testing fire suppression piping for pressure, flow and drainage; testing and commissioning of fire pump systems including electric and diesel engine driven fire pumps. Verify systems operate correctly with complete operation of all control sequences and associated systems. Work also applies to systems outside the building footprint to the connection to existing systems.
- (t) Clean Agent Fire Suppression Systems: Work includes testing clean agent fire suppression systems in accordance with specification section 2 – CLEAN AGENT SYSTEMS. Verify systems operate correctly with complete operation of all control sequences and associated systems.

- (u) Fire Alarm Systems: Work includes aiming, positioning and calibration of all fire alarm devices; inspections and checks of installation and operation of all devices in accordance with specification sections DIGITAL ADDRESSABLE FIRE ALARM SYSTEM and AIR SAMPLING SMOKE DETECTION SYSTEM and the Drawings; integration of new systems with existing systems at QSTP and Education City; complete operation of all controls sequences, in coordination with commissioning of all controlled systems.
- (v) Telecommunications Systems: Work includes coordination with OWNER IT and QSTP in positioning of data drops, raceways, and boxes for future wireless access points and TETRA radio systems; verification of installation and test results in accordance with specification section COMMUNICATIONS, PREMISES DISTRIBUTION SYSTEM and the Drawings; integration of new systems with existing systems at QSTP and Education City.
- (w) Earthing and Lightning Protection Systems: Work includes verification of installation and testing in accordance with specification sections EARTHING (GROUNDING) AND BONDING FOR ELECTRICAL SYSTEMS and LIGHTNING PROTECTION FOR STRUCTURES and the Drawings.
- (x) Motor Controllers and Variable Frequency Drives: Systems: Work includes performance testing and calibration of all motor control devices; inspections and checks of installation and operation of all devices in accordance with specification section ENCLOSED CONTROLLERS and the Drawings; complete operation of all controls sequences, in coordination with commissioning of all controlled systems.
- (y) Emergency and Standby Power Systems: Work includes performance testing and calibration of the diesel engine generator, automatic transfer switch, central battery inverters and auxiliary and control devices; inspections and checks of installation and operation of all devices in accordance with specification sections ENGINE GENERATORS AND AUTOMATIC TRANSFER SWITCHES and BATTERY-INVERTER EMERGENCY POWER SYSTEM and the Drawings; complete operation of all controls sequences, in coordination with commissioning of all controlled systems.
- (z) Irrigation Systems: Work includes installation inspection and checks, hydrostatic test, control operations test, booster pump flows and pressures, system cleaning, start-up services including programming of the watering schedule and flow adjustments, demonstration and training of maintenance personnel and documentation of system operations and maintenance.
- (aa) Water Features: Work includes 24 hour leak test for reservoir, control panel operation and function testing, automatic drain-flush-fill testing and adjustment. Fountains: Work includes 24 hour leak test for reservoir, control panel operation and function testing, automatic drain-flush-fill testing and adjustment (determine drain time-set flush time), flow rate adjustment to upper weir (24 hour test), Ozone system ORP test, and adjust flow rate ultra violet system.
- (bb) Vertical Transportation Systems: Work includes testing and commissioning of elevators in accordance with ASME requirements and the project specifications.
- (cc) Critical Leakage Construction: Test each completed room in the building protected by a Clean Agent Fire Protection system to demonstrate that the air leakage rate of the room envelope does not exceed 1.25 L/s\*m<sup>2</sup> at a pressure differential of 75 Pa in accordance with ASTM's E779 (2003) – Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door



### 1.2.5 Standards For Equipment, Instrumentation And Calibration

- 1 The instrumentation utilized in performing the specified testing duties shall be in correct, proper operating condition and shall be used in accordance with manufacturer's recommendations. Only equipment with current certified calibration certificates may be used for verifying and recording results. (Without exception, all instruments must be certified as calibrated within 12 months of use.)
- 2 Each instrument must have been specifically designed to meet the criteria (Minimum Accuracy, Range, and Resolution) of the function. Instrumentation with multiple capabilities can be accepted for more than one function when submitting documentation. However each separate function must meet OWNER requirements. Information and data regarding accuracy of all submitted instrumentation for the stated functions must be available from the manufacturer to show compliance with these requirements.
- 3 The accuracy and range as reported by the instrument manufacturer shall be verified by a testing laboratory which uses methods and equipment traceable to the National Institute of Standards and Technology or equivalent institute in countries other than the United States. Calibration requirements for each function are specified and shall be met. Some instruments such as U-tube manometers and inclined manometers may not require calibration. However, if a "mechanical / electrical" device is substituted or employed in place of these types of instruments, the indicated calibration requirements noted shall apply.
- 4 Instruments shall be used in accordance with manufacturer's recommendations. The most suitable instrument, or combination of instruments, should be employed for a particular measurement or reading.

### 1.2.6 Costs And Expenses

- 1 All costs and expenses associated with the complete commissioning process for all phases of the project, including, but not limited to, the employment of specialist staff, maintenance and operation of systems, replacement of consumables, electrical power, water & waste water disposal, data-loggers, and participants required for the execution of performance and operational tests, as required by the Owner, shall be deemed to have been included in the CONTRACT PRICE as defined in the GCOC.

## 1.3 GENERAL RESPONSIBILITIES

### 1.3.1 Commissioning Responsibilities

- 1 Multidisciplinary team carries out commissioning. The commissioning responsibilities of some non-contractor team members during the construction and acceptance phases of the Project are provided here for information, and to provide some context for the overall process. (See Table ; Roles and Responsibilities Matrix).

### 1.3.2 Commissioning Agency (CxA) Responsibilities:

- 1 Plan, organize, and implement the commissioning process as specified herein.
- 2 Prepare the Commissioning Plan, and ensure its distribution for review and comment.
- 3 Revise the Commissioning Plan as required during construction.

## 1.4 ROLES AND RESPONSIBILITIES MATRIX

Project Team Member	Activity or Deliverable											
	Commissioning Management Plan	Submittal Reviews and Progress Inspections	Commissioning Execution Plan	Author All Construction and Startup Inspection and Testing	Author Post Startup, TAB, and Calibration Test Procedures	Execution of Construction Static Tests	Execution of Final Installation Inspections	Startup, TAB, Calibration, Etc.	Functional Tests	Integration Tests	Operation & Performance Tests	Post Occupancy Test
Owner (OW)	C,R		C,R		C,R							
Project Manager (PM)	C,A	L,A	C,R	L,A	C,A	L,W,A	L,W,A	L,W,A	L,W,A	W	W	W
Design Consultant (DC)					C							
Contractor (C)		P	P	P	P	P	P	P	P	P	P	P

**Legend:**  
L = Lead / Guide / Coordinate  
P = Perform / Action / Produce  
C = Contribute / Participate  
R = Review & Comment  
A = Review & Approve / Accept  
M = Monitor & Audit  
W = Witness

**Notes:**  
1) Whenever the first piece of equipment or system of a specific type is inspected or tested the CxA, PM, and C shall utilize it as a benchmark for all future inspections and tests of a similar type.  
2) CxA review and comments on the Contractor documents/works shall be adopted as part of the Owner's requirements and approval procedure without any cost implication on the Owner.



- 1 Chair commissioning meetings, and prepare and distribute minutes to all commissioning team members, whether or not they attend the meeting.
- 2 In conjunction with the Contractor, coordinate commissioning activities among all contractors, sub-trades, suppliers, the PM and OWNER REPRESENTATIVE.
- 3 Review all pertinent approved shop drawings to support the commissioning process;
- 4 Monitor system verification checks, and ensure the results are documented as the checks are done.
- 5 Monitor controls point-to-point checks done by the controls contractor, and ensure results are documented as the checks are done.
- 6 Review all project start-up and commissioning records
- 7 Witness or participate in select Pre-Functional Inspections, start-ups, and all commissioning testing.
- 8 Direct the contractors to operate Equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes.
- 9 Prepare and submit a Commissioning Report which documents all checks and tests done throughout the Commissioning process, and results obtained from each.
- 10 Ensure all required O&M manuals, instructions, and demonstrations are provided to OWNER REPRESENTATIVE's designated individuals.

#### 1.4.2 Contractor's Responsibilities:

- 1 Development of Commissioning Execution Plan:
  - (a) Plan and schedule the Construction, Acceptance and Warranty phases of the commissioning process including but not limited to pre-commissioning, commissioning, testing and demonstrating activities for each and every element and system in the project. The commissioning program shall incorporate all commissioning activities and milestones, and be integrated into the project master program.
  - (b) Collate the Commissioning Execution Plan into a complete and co-ordinated program for executing post construction inspection, startup, and testing activities and agreeing to this plan with OWNER and the CxA, including review during a series of pre-construction workshops.
  - (c) Preparing updates to the Commissioning Execution Plan and program, as applicable.
  - (d) Undertake scoping meeting(s) where the commissioning process is reviewed with the commissioning team and OWNER, include all additional meetings, as necessary, throughout the construction, to plan, scope, coordinate and schedule future activities and resolve issues. Write and distribute minutes;
- 2 Lead, manage and co-ordinate all external interfaces related to Commissioning.
- 3 Provide checklists and method statements for each and every element of the commissioning process and have these approved by OWNER prior to any work being undertaken;
- 4 Executing all scheduling, planning and progress reporting procedures.
- 5 Coordinating all activities of the CONTRACTOR, SUB-CONTRACTORS, Vendors, and Suppliers participating in the WORK.
- 6 Conducting all required work planning meetings.
- 7 Preparing and distributing interface and Commissioning co-ordination procedures.

- 8 Preparing safety audits and maintaining records of all approved safety audit items.
- 9 Organizing, preparing for, attending, recording and gaining approval for any off-site testing of equipment, systems, software or other elements as required by the SPECIFICATIONS and equipment Data Sheets, including any re-testing as required. This may include transport of equipment or materials to the testing facility if tests are not at the supplier or manufacturer's works. CONTRACTOR shall make arrangements for the attendance of OWNER and their representatives at no cost to OWNER.
- 10 Supplying, operating, maintaining, and removing materials, and equipment (such as oils, hydraulic fluids, lubricants, chemicals, tools, fittings, and other consumables) and services required for PFT, Commissioning, and Start-Up activities at no additional cost to OWNER.
- 11 Employing a specialist contractor to undertake the cleaning and flushing of the hydraulic systems who will have the necessary expertise, plant and equipment to clean, flush and chemically inhibit the relevant systems. This process shall be concluded prior to the balancing and commissioning of the systems.
- 12 Employing a specialist contractor to undertake the hygienic cleaning/sterilization and flushing of the air systems and who will have the necessary expertise, plant and equipment to clean and disinfect/sterilize the relevant systems. This process shall be concluded prior to the balancing and commissioning of the systems.
- 13 Ensuring that the commissioning of plant and equipment, such as Hydronic Systems, Air systems, Electrical Systems, Pressurization Units, Generators, Fire Engineering and Sprinkler System, Environmental Control Systems (EPM) and Fire Alarms, etc., are commissioned and tested by the manufacturer or appointed service agency. Electrical Systems shall be commissioned in full accordance of BS 7671, latest edition and guidance notes issued by the Institute of Electrical Engineers, United Kingdom.
- 14 Executing smooth operation test runs for all elements of the WORK, including fire and gas detection and protection systems, and integrated system tests for all life safety and emergency systems.
- 15 Coordinating with OWNER's designated Representative to achieve the GSAS AND/OR LEED requirements for the project, including arranging all necessary attendances and the timely issuing of documentation.
- 16 Performing troubleshooting and repair works for defective systems and re-testing as necessary or as required by CxA and approved by the OWNER.
- 17 Updating all documentation and drawings with As-Built and As-Commissioned information.
- 18 Compiling a Commissioning Dossier for all systems and sub-systems.
- 19 During the course of the construction, the CxA shall visit the site to inspect the progress of the construction with respect to the systems being commissioned. Any issues identified by these inspections shall be rectified by the CONTRACTOR expeditiously.
- 20 The CONTRACTOR shall provide monthly a comprehensive commissioning report and hold commissioning team meetings as directed by the CxA and approved by the OWNER.
- 21 The CONTRACTOR and Subcontractors shall execute the required tests and inspections under the direction of, and documented by, the CONTRACTOR's Commissioning Engineering Team.
- 22 Witnessing of tests and inspections shall be conducted by the PM, CxA as appropriate for individual system types. The Contractor will coordinate all testing and inspection activities with remainder of the project team.

- 23 Produce a detailed Interface Diagram and Cause-Effect Matrix Table for all project systems. Include any interfaces that exit with OWNER systems that exist beyond the boundary of the WORKS.
- 24 Any items of non-compliance identified by the commissioning program are to be corrected at the CONTRACTORS own expense and any systems re-tested. All such items shall be logged in the appropriate issues log.
- 25 All Functional Tests, Integration Tests, and Operation Tests shall be completed before project turnover. The CONTRACTOR shall ensure adequate provision is made in the overall project schedule to allow sufficient time for a full and effective startup, testing, and turnover process.
- 26 Undertake the Warranty visits as required by OWNER and as detailed herein.
- 27 CxA review and comments on the Contractor documents/works shall be adopted as part of the Owner' s representative review and approval procedure without any cost implication on the Owner.

#### 1.4.3 Owner Representative's Responsibilities:

- 1 The OWNER REPRESENTATIVE will review the Commissioning Execution Plan, Training Materials, and O&M Documentation. The may review and provide direction on any submittal during the execution of the program.
- 2 During the acceptance phase of the commissioning process, the OWNER REPRESENTATIVE may be on Site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.
- 3 OWNER REPRESENTATIVE will ensure the availability of operating staff for all scheduled instruction and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.

#### 1.4.4 Commissioning Responsibilities – Sub-Contractors:

- 1 The plumbing, mechanical, electrical, and landscape contractors, and all the subcontractors and suppliers shall cooperate with the Commissioning Agency and other commissioning team members, to facilitate the successful completion of the commissioning process.
- 2 The Plumbing, Mechanical, and Electrical contractors shall each assign a representative to the commissioning team, and submit the person's name to the Commissioning Agency, within one month of award of the Contract. The representative shall have the authority to make decisions on behalf of the respective contractor as they relate to organization and scheduling of commissioning. The representative shall ensure communications between contractors and suppliers and all other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- 3 The plumbing, mechanical, Landscape and electrical contractors, and all subcontractors and suppliers, shall cooperate with the CxA in carrying out the commissioning process. In this context, the plumbing, mechanical, and electrical contractors shall:
  - (a) Ensure that each contractor and subcontractor include in their quotes the cost of participating in the commissioning process as specified herein.
  - (b) Ensure the controls contractor performs commissioning responsibilities as listed, including the operation of all systems for Functional, Operational, Integration, Seasonal, and Deferred Testing.

- (c) Provide instruction and demonstrations for OWNER REPRESENTATIVE's designated operating staff, in conjunction with the CxA, and with the participation of qualified technicians from major Equipment suppliers and the controls contractor.
- (d) Include requirements for Submittal data, O&M data, and training information in each purchase order or subcontract written.
- (e) Ensure cooperation and participation of specialty subcontractors such as sheet metal, piping, refrigeration, and water treatment as applicable.
- (f) Ensure participation of major Equipment manufacturing in appropriate start-up, testing, and training activities.
- (g) Attend commissioning meetings scheduled by the CxA.
- (h) Notify the CxA a minimum of two weeks in advance of scheduled Equipment and system start-ups, so that the CxA may witness system verifications.
- (i) Provide sufficient personnel to assist the CxA as required during system verification and functional performance testing.
- (j) Document the results of all inspections and checks and sign off on them. If deficient or incomplete work is discovered, ensure corrective action is taken and recheck until the results are satisfactory, and the system is ready for safe verification and functional performance testing.
- (k) Notify the CxA a minimum of two weeks in advance, of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
- (l) Provide Equipment and systems start-up resources as specified and required. If during an attempted Equipment or system start-up, deficient or incomplete work is discovered that would preclude safe operation, the start-up shall be aborted until corrective action has been taken. Ensure such action is taken and verified before rescheduling a new start-up. Those responsible for deficient or incomplete work will be responsible for costs in accordance with this Section.
- (m) Carry out performance checks to ensure that all Equipment and systems are fully functional and ready for the CxA to witness formal testing.
- (n) Operate Equipment and systems for formal testing in accordance with the Commissioning Execution Plan as directed by the CxA. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CxA. Those responsible for deficient or incomplete work will be responsible for costs in accordance with in this Section. Ensure that all corrections necessary for full and complete system operation as specified are completed; then with the controls contractor and other applicable subcontractors, carry out functional performance checks to confirm correct operation before applying to the CxA to reschedule the FPTs for the system in question.
- (o) Prepare preliminary schedule for plumbing, mechanical, and electrical system orientation and inspections. O&M manual submission, training sessions, pipe and duct system testing, TAB, and task completion for use by the CxA. Update schedule as appropriate throughout the construction period.
- (p) Attend O&M staff training session.
- (q) Update drawings to as-built condition and review with the CxA.
- (r) Gather O&M data on all Equipment, and assemble in binders as dossiers as required. Submit to CxA prior to completion of construction.
- (s) Participate in, and schedule vendors and contractors to participate in O&M staff training sessions as set up by the CxA.
- (t) Conduct system orientation and tours for OWNER staff as part of the Training process

- (u) Provide written notification to the general Contractor and CxA- that the following Plumbing Systems work has been completed in accordance with the Contract Documents, and Equipment systems and subsystems are operating as required.
  - (i) Drainage systems, including storm drainage overflow.
  - (ii) Water storage tank filling, and safety features.
  - (iii) Domestic water distribution system including supply pumps.
  - (iv) Fire stopping in the fire-rated construction, caulking, gasketing, and sealing of smoke barriers.
  - (v) Domestic hot water systems including water heaters, pumps and domestic water return loops.
  - (vi) That the building control system is functioning to control plumbing Equipment as required.
- (v) Provide written notification to the general Contractor and CxA that the following Mechanical Systems work has been completed in accordance with the Contract Documents, and Equipment systems and subsystems are operating as required.
  - (i) HVAC equipment including all fans, air-handling units, dehumidification units, ductwork, dampers, terminals, and all DIVISION 23 Equipment.
  - (ii) Refrigeration Equipment, pumping systems, and heat rejection Equipment.
  - (iii) Fire stopping in the fire-rated construction, including fire and smoke damper installation, caulking, gasketing, and sealing of smoke barriers.
  - (iv) Dedicated smoke control systems including atrium systems.
  - (v) Non-dedicated systems using the air-handling units for smoke control.
  - (vi) Fire detection and smoke detection devices furnished under other Divisions of these Specifications as they affect the operation of the smoke control systems.
  - (vii) That the building control system is functioning to control mechanical Equipment and smoke control systems as required.

#### 1.4.5 Commissioning Responsibilities - TAB Agency (hired by the CONTRACTOR):

- 1 With respect to Plumbing and HVAC commissioning, the TAB agency shall:
  - (a) Include costs for Plumbing and HVAC commissioning requirements in the quoted price.
  - (b) Provide a commissionability review for all systems that will undergo TAB before the overall project reaches 25% completion. A report shall be generated and provided to the CxA and OWNER REPRESENTATIVE. Corrective actions as recommended in the report will be actioned by the Project Team.
  - (c) Attend commissioning meetings scheduled by the CxA prior to and during the time when on-Site TAB work is being done.
  - (d) Submit proposed TAB procedures to the CxA and Mechanical Engineer for review and acceptance.
  - (e) Attend the TAB planning meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the plumbing and HVAC systems.
  - (f) At the completion of the TAB work, submit the final TAB report to the general Contractor, with copies to the OWNER REPRESENTATIVE, CxA, and Mechanical Engineer.

- (g) Participate in verification of the TAB report by the CxA for verification or diagnostic purposes. This will consist of repeating a sample (normally 10% to 20%) of the measurements contained in the TAB report as directed by the CxA. Additional back testing may be required at the discretion of OWNER or the CxA if excessive problems are identified.
- (h) Participate in O&M personnel training sessions as scheduled by the CxA.

#### 1.4.6 Commissioning Responsibilities - Controls Contractor:

With respect to commissioning, the controls contractor shall:

Include cost for commissioning requirements in the quoted price.

- 1 Review design for controllability with respect to Equipment selected for the Project:
  - (a) Ensure the proper sizing of control valves and actuators, based on design pressure drops. Ensure that control valve authority will result in capacity control as specified. Include valve sizing and authority information in submittal to Mechanical Engineer.
  - (b) Ensure the proper sizing of control dampers. Ensure damper authority to control air flows as specified. Review and confirm in writing proper damper positioning for mixing to prevent stratification. Ensure correct actuator vs. damper movement for smooth operation. Include damper sizing, control authority, and actuator selection data in submittal to Mechanical Engineer.
  - (c) Ensure the proper selection of sensor ranges, and include data with submittal to Mechanical Engineer.
  - (d) Clarify all questions concerning sequences of operation with the Mechanical Engineer.
- 2 Attend commissioning meetings scheduled by the CxA.
- 3 Provide the following Submittals to the CxA for review:
  - (a) Hardware and software Submittals.
  - (b) Control panel construction Shop Drawings.
  - (c) Diagrams showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access, all superimposed on diagrams of the physical Equipment.
  - (d) Narrative description of all control sequences for each piece of Equipment controlled.
  - (e) Logic diagrams showing the logic flow of all control sequences.
  - (f) A list of all control points, including analog inputs, analog outputs, digital inputs, and digital outputs. Include the values of all parameters for each system point. Provide a separate list of each stand-alone control unit.
  - (g) A complete control language program listing including all software routines employed in operating the control system. Also provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and subroutine. It should also explain individual math or logic operations that are not clear for reading the software listing.
  - (h) Hardware operation and maintenance manuals.
  - (i) Application software and Project applications code manuals.
  - (j) Complete set of graphics that will be utilized on the operator computers for the Control System. Submittal required by 75% completion of overall project.
- 4 Inspect, check, and confirm the proper installation and performance of controls hardware and software provided by others.



- 5 Integrate installation and programming scheduling with construction and commissioning schedules.
- 6 Inspect, check, and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.
- 7 Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the Commissioning Plan.
- 8 In conjunction with the mechanical contractor, demonstrate system performance to the CxA including all modes of system operation (e.g. unoccupied, emergency) during the functional performance tests (FPTs). If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CxA. Those responsible for deficient or incomplete work will be responsible for costs in accordance with this Section.
- 9 Provide control system technicians to assist during system verification and functional performance testing. Sufficient technicians are to be provided as to not delay the commissioning process.
- 10 Provide support and coordination with TAB Agency on all interfaces between controls and TAB scopes of work. Provide, at no additional cost to the TAB and commissioning agencies, all devices, such as portable operator's terminals and all software for the TAB Agency to use in completing TAB procedures.
- 11 All controls equipment and programming is to be completely functional at the time of a systems mechanical commissioning so that testing can be performed simultaneously on both systems.

## **1.5 USE OF PARTS AND MATERIALS**

### **1.5.1 General**

- 1 Only brand new parts and materials shall be used for the repair and/or replacement of defective WORK.
- 2 The CONTRACTOR shall provide any special tools, software or programming devices or the instruction on their use that are required for start-up, testing, balancing, commissioning or operation of any technical system be provided by the manufacturer or installing contractor to the firm or individual providing those services free of any additional cost or fees.
- 3 The CONTRACTOR shall be responsible for the provision and installation of all replacement parts and consumable materials as required for the execution of the commissioning program.

## **1.6 SPECIFIC GSAS AND/OR LEED REQUIREMENTS**

### **1.6.1 General**

- 1 The CONTRACTOR shall ensure that the requirements of the credits below are achieved, and shall undertake all activities necessary to do so as part of his CONTRACT. This shall include co-ordination with others, including the GSAS AND/OR LEED Service Provider, and the provision of all information, access and assistance required by the GSAS AND/OR LEED Service Provider to enable them to carry out their obligations under the GSAS AND/OR LEED criteria.



- 2 The CONTRACTOR should note that the specific GSAS AND/OR LEED® commissioning process does not address each and every requirement as required for the whole building commissioning process. The CONTRACTOR is required to allow for the total commissioning process as part of the CxA process as detailed in the respective parts of this document and other CONTRACT specific documentation.
- 3 The CONTRACTOR shall provide all documentation required by the GSAS AND/OR LEED for inclusion in the Systems Manual and GSAS AND/OR LEED Commissioning Report. Documentation shall be provided in a format and quantity as required by the GSAS AND/OR LEED Service Provider.

#### 1.6.2 Commissioning Plan

##### 1 Requirements

The following GSAS AND/OR LEED Commissioning Activities must take place:

- (a) Development of a plan that outlines the owner's commissioning goals and objectives
- (b) Development of a plan by the design team that delineates standards and descriptions for all commissioned systems
- (c) Inclusion of commissioning requirements within the construction documents
- (d) Review and verification of performance results of commissioned building systems, and completion of a summary commissioning report.

##### 2 Submittal Documentation

- (a) Owner's project requirements and design intent
- (b) Documents that identify essential elements of the commissioning plan that have been met
- (c) Documents that outline steps necessary for continued building commissioning during the construction and operations phases.

### 1.7 CONSTRUCTION PHASE COMMISSIONING

#### 1.7.1 Introduction

- 1 During the Construction Phase, the building shell is erected and the systems, components and equipment are installed and static tests are performed to show that construction meets the contract requirements.
- 2 The main focus of the commissioning efforts during the Construction Phase is to:
  - (a) Conduct the Kick-off meeting and all other Commissioning Meetings;
  - (b) Perform Site Observations (SO) - Site Observations are static inspections of all systems, components and equipment;
  - (c) Verify that the Pre-Functional Tests (PFT) are performed;
  - (d) Pre-Functional Performance Tests include installation verification and start-up tests;

#### 1.7.2 Construction Phase Responsibilities:

- 1 Commissioning Team Members - During the Construction Phase, the Commissioning team shall be comprised of representatives from:
  - (a) Owner
  - (b) Project Manager

- (c) Commissioning Agency (CxA) assigned by the Contractor as 3rd party (For all Contractor Works)
  - (d) Design professionals
  - (e) The Contractor
  - (f) Sub-contractor representatives
  - (g) Others as necessary
- 2 Commissioning Team Responsibilities - The Commissioning Team is responsible for verifying that the installed and operating systems, components and equipment will achieve the contract requirements.
- 3 Test procedures - Pre-functional tests (PFT) shall be completed by the Contractor during the construction phase. Functional performance tests (FPT) shall be completed during the acceptance phase. The total responsibility for creating, administering, performing, and observing the various activities of the tests is that of the main contractor and shall be as outlined in the Commissioning Plan. The CxA shall observe the PFT process and comment as appropriate.

### 1.7.3 Construction Phase Activities:

- 1 Commissioning Kickoff Meeting - The kickoff meeting should be the initial meeting with all members of the Commissioning Team for the Construction Phase. The CxA shall:
- (a) Create the agenda
  - (b) Attend and lead the meeting
  - (c) Review the Commissioning Plan with the Team Members
  - (d) Review the various commissioning activities and schedules
  - (e) Review documentation requirements
  - (f) Review communication and reporting procedures
  - (g) Prepare and distribute meeting minutes
- 2 Commissioning Meetings - The CxA shall conduct periodic commissioning review meetings throughout the construction phase to monitor the progress of the commissioning activities. The Contractors commissioning staff shall be appropriate in their approach. The CxA shall:
- (a) Create the agenda
  - (b) Attend and lead meeting
  - (c) Schedule and review the commissioning activities
  - (d) Coordinate with construction meetings and activities
  - (e) Prepare and distribute meeting minutes
- 3 Commissioning Activities Scheduled - The CxA shall verify that commissioning activities are incorporated into the Construction schedule; the Contractor shall provide full cooperation in this activity.
- 4 Approved Submittal and Shop Drawings - The submittals and shop drawings shall be reviewed by appropriate OWNER REPRESENTATIVE and the CxA. The CxA shall verify that the submittals conform to the contract requirements. The Contractor shall ensure that the CxA receives all documentation in a timely manner

- 5 Site Observation Inspections - Site observations are routine inspections that shall be performed by the CxA during the Construction Phase. The purpose of the inspections is to verify that the construction complies with the Contract Documents, the OPR and identify and document any quality issues that may lead to functional issues. Site observations are forwarded to the appropriate team member for their review and corrective action. Any site observation issues that are not automatically accepted and resolved shall be added to the Issue Log for resolution.
- 6 Pre-Functional Tests – the responsibility for creating, administering, performing, and observing the various activities during the Pre-Functional Tests are outlined in the Commissioning Plan and can be performed by different members of the Commissioning Team during the Construction Phase based on the type of technical activity of the test. The party responsibility to perform each task is as defined in the contract documents and the Commissioning Plan. The following activities shall be performed by the Commissioning Team as part of Construction Phase Commissioning:
- (a) Create and review test form;
  - (b) Review installation verification requirements with members of the Commissioning Team
  - (c) Review start-up requirements with members of the Commissioning Team
  - (d) Administer, perform and/or observe all PFT
  - (e) Report deficiencies on the Issues Log
  - (f) Distribute Issues Log to members of the Commissioning Team and manage the issue log for issue resolution
  - (g) Issues Log & Deficiency Resolution
- 7 The CxA shall report deficiencies from the PFT on the Issues Log and the log shall be distributed to the appropriate members of the Commissioning Team for resolution. The CxA shall work with the Commissioning Team Members to ensure that the issues are completely understood and the responsibilities for response or corrective action are completely understood. The Contractor must manage the issue log for resolution of all outstanding issues and the CxA shall assist as necessary to complete the issue log. After corrective action, retests shall be performed to verify conformance. When deficiencies are resolved, the issues shall be signed off on the Issues Log by the CxA and the appropriate Commissioning Team Member(s). All Issue Log items must be resolved or answered by the appropriate commissioning team member. Issues that are not properly resolved must be approved by OWNER REPRESENTATIVE.
- 8 Updating the Commissioning Plan, the OPR and the BOD – The CxA in conjunction with CxM shall update the OPR during the Construction Phase to incorporate any approved changes that may have developed due to changes, additions, deletions, or other modifications. The design professionals should update the BOD for all design related issues. The Commissioning Plan shall be updated and further defined to reflect any changes to the OPR, BOD or contract documents.
- 9 Construction Phase commissioning activities are complete when all construction installation inspections are complete.
- 10 Construction Phase Documentation Requirement
- Commissioning Meeting Minutes:
- (a) Submittal / Shop Drawing Evaluation Comments
  - (b) Site Observation Reports
  - (c) Pre-Functional Test Reports

- (d) Record Drawings Completed
- (e) Completed Operations & Maintenance Manuals
- (f) Updated Issues Log with noted corrections
- (g) Updated Commissioning Execution Plan

#### 1.7.4 Construction checklists

- 1 Construction checklists shall be developed by the Contractor and approved by the CxA, maintained by the CxA and used by the Construction Contractor and his sub-contractors.
- 2 The approach to the structure of the checklists shall be to keep them short and simple by focusing on key elements. Checklists span the duration from when equipment is delivered to the site until the point that the system/component is started up and operational. This includes testing, adjusting and balancing and control system tuning.
- 3 Construction checklists are tools for transferring the information contained in the contract documents (drawings and specifications) to the workers in the field. By completing the checklists, the workers are assured that requirements in the project documents are satisfied. Checklists generally fall into the following categories:
  - (a) Delivery & storage checks
    - (i) Document & track delivery of equipment & materials to site
    - (ii) Verify submittal information (avoid accepting & installing equipment which does not meet specifications)
    - (iii) Ensure equipment/materials remain free of contamination, moisture, etc.
  - (b) Installation and start-up
    - (i) Component-based checks
    - (ii) Systems-based checks
- 4 The development of the construction checklists will take close coordination between the OWNER Facility Management, OWNER Technical Experts, CxA, Contractor, and Designer.
- 5 Generally the checklists are developed as follows:
  - (a) CxA identifies components and systems for which checklists are required;
  - (b) CxA reviews Project Requirements for key success criteria;
  - (c) CxA reviews specifications and submittals for key requirements;
  - (d) CxA develops sample checklists for the OWNER REPRESENTATIVE's review;
  - (e) CxA provides sample checklists to CONTRACTOR for production of project specific checklists.

Implementation of site inspections conducted per the checklists will be periodically audited by the CxA.

## 1.8 COMMISSIONING EXECUTION PLAN

### 1.8.1 MANUAL

- 1 The CONTRACTOR (with input from the CxA) shall prepare a Commissioning Execution Plan and procedures that shall take into account the systems' design objectives and complexity.
- 2 The Commissioning Execution Plan shall include, without limitations, the following:
  - (a) General Project Information
  - (b) Overview and Scope of the Project Commissioning

- (c) Commissioning Protocols and Communications
  - (d) Identify all necessary site visits in order to observe component and system installations. Identify selected planning and job-site meetings in order to obtain information on construction progress.
    - (i) Commissioning Schedule;
    - (ii) Checklists listing each component or parameter that will be tested. Schedule shall incorporate all commissioning milestones;
    - (iii) The minimum number of hours that each system, operation, or parameter should be tested;
    - (iv) How each component or system should be tested (i.e., what measurements should be made). When developing the commissioning testing and inspection plans, the commissioning team should carefully review means and methods for testing and verification to determine any special testing. Examples of such special testing include thermo graphic (Infrared) scans of existing or new construction to identify envelope integrity, destructive testing of proposed assemblies to be commissioned (blast, wind, seismic), water penetration tests, Computational Fluid Dynamic (CFD) modeling of airflows, building pressurization tests, and the like.
  - (e) Testing appropriate to a facility should be designed along four hierarchal levels:
    - (i) Factory device testing;
    - (ii) Field component start-up;
    - (iii) System interface testing; and
    - (iv) Integrated system testing, which tests the overall facility resilience, under all probable risk scenarios, including failure mode.
  - (f) Designation of the initial systems and units to operated;
  - (g) Alternatives to deal with failed systems/equipment and emergency situations;
  - (h) Identification of regulatory authority operating permits and certificates;
  - (i) Definition of the O&M training requirements;
    - (i) Commissioning Documentation;
  - (j) Appendices;
    - (i) Testing and Inspection Plans;
    - (ii) Pre-Functional and Functional Test Procedures;
    - (iii) Construction Checklists;
    - (iv) Issues Logs;
- 3 The CONTRACTOR shall integrate commissioning activities into the overall construction schedule;, and to carry out site inspections with a focus on systems operations and maintenance.
- 4 The CONTRACTOR shall submit the draft Commissioning Execution Plan for OWNER REPRESENTATIVE and CxA review and agreement within 120 days of CONTRACT award.

## 1.9 PRE-FUNCTIONAL TESTS (PFT)

### 1.9.1 General

- 1 Pre-Functional Tests (PFT) shall include all tests and checks included in the Specifications, Codes and Standards listed in the Attachments or referenced in the Contract Documents, including the GSAS AND/OR LEED requirements.
- 2 The CONTRACTOR shall execute all WORK required for PFT i.e. all verifications required to demonstrate that each part of the WORKS is complete and ready for Commissioning.
- 3 The CONTRACTOR shall prepare plans and procedures for PFT at each stage of the WORKS.
- 4 The CONTRACTOR shall execute all PFT activities to demonstrate that each part of the WORKS is complete and ready for Commissioning.
- 5 All PFT activities and documentation shall be completed to the CxA's satisfaction prior to the start of Commissioning.

### 1.9.2 Contractor's General Duties

- 1 The CONTRACTOR shall:
  - (a) Provide a sufficient team of suitably experienced and qualified personnel to carry out all aspects of the PFT.
  - (b) Provide all necessary PFT spare parts.
  - (c) Provide all necessary PFT equipment, tools, instruments, and fluids/utilities, including but not necessarily limited to: fresh, clean, water; chemicals; temporary power; compressed air; nitrogen, and lubricant oils.
  - (d) Execute all scheduling, planning, and progress reporting procedures.
  - (e) Co-ordinate all activities of Suppliers and Vendors, and SUB-CONTRACTORS participating in the work and liaise with OWNER REPRESENTATIVE and CxA as and when required.
  - (f) Obtain all necessary Suppliers' and Vendors' documentation.
  - (g) Conduct work-planning meetings, in co-ordination with OWNER REPRESENTATIVE, CxA.
  - (h) Maintain all documentation and records.
- 2 All PFT operations shall be organised by system, following the pre-approved, Commissioning Execution Plan.
- 3 **PFT Activities:**

The PFT of the Building Services shall include, but shall not be limited to, the following:

  - (a) Systematic conformity checks, carried out on each part, item of equipment, and component, to visually verify the condition of the equipment, the quality of installation, compliance with drawings and Specifications, manufacturers' instructions, safety rules, codes, standards, and good workmanship.
  - (b) Pressure testing, cleaning and checking of all ductwork and air systems components.
  - (c) Continuity checks of cables.
  - (d) Installation checks and thermal scans of all electrical and instrumentation equipment.
  - (e) Installation and pre-testing of elevator components including hoist motors, hydraulic machines, elevator pit, elevator hoist way, controllers, signaling devices, door safety devices, cab interiors, video displays and emergency communication systems.
  - (f) Pre-testing and verification of all software and graphical interfaces



- (g) Static, de-energized tests of specific equipment to ensure the quality of a number of critical components. This cold-testing work shall apply all technical disciplines and shall cover activities such as calibration of instruments, stroking of valves, and testing of cable continuity.
  - (h) Submission of PFT section of the O&M/Commissioning Dossier complete with all red-line drawings and inspection records.
  - (i) Implementation of a water treatment regime as defined by the Water Treatment Specialist employed by the CONTRACTOR including all sampling, testing and other checks advised by the Specialist as necessary during PFT.
- 4 **Preparation Activities** – The CONTRACTOR's PFT preparation activities shall include, but not be limited to, the following:
- (a) Dividing the WORKS into systems and sub-systems that shall form the basis of the organisation of PFT activities
  - (b) Preparing and issuing marked-up, coloured P&IDs, Loop Diagrams, etc., showing the limits of the sub-systems.
  - (c) Compiling lists of items for all sub-systems.
  - (d) Preparing PFT plans and schedules and system handover sequences.
  - (e) Quantifying the work and preparing manpower histograms.
  - (f) Compiling all required engineering and manufacturers' documentation.
  - (g) Engineering and providing all required temporary facilities for the PFT.

### 1.9.3 PFT Checklists

- 1 The CONTRACTOR shall prepare and submit PFT Checklists that shall define the scope of work that shall be systematically performed on each selected item of equipment and shall also be used as a log to record the checks and tests made. Conformity checks shall be carried out in accordance with, and reported on.
- 2 One (1) PFT Check List shall be completed and signed for each system/sub-system and type of equipment. All contractors associated with each equipment or system shall have representative sign check list (Mechanical, Electrical, and Controls Contractors).

### 1.9.4 PFT Sheets

- 1 Static and de-energised tests shall be carried out in accordance with the relevant Specifications and reported by the CONTRACTOR on PFT Test Sheets.
- 2 One (1) PFT Test Sheet shall be completed and signed for each test performed. All other PFT activities such as piping and pipeline flushing and cleaning shall be supported by reports and drawings.

### 1.9.5 PFT Status Index

- 1 The PFT Status Index shall be an exhaustive list, arranged by system/sub-system, discipline, and type of equipment, for all equipment and materials subject to PFT operations.
- 2 The status of each PFT task shall be recorded on the PFT Status Index and used for following-up.

### 1.9.6 PFT Issue's Log

- 1 PFT shall be established by the CONTRACTOR for each system and sub-system being tested, for the purpose of recording all discrepancies, defects, damaged or missing equipment or parts, malfunctions, missing documents, and any and all deviations from the Drawings and/or the Specifications.



- 2 Issues Log Completion Status Report - From the start of PFT shall submit weekly a detailed written Issues Log Completion Status Report (in Microsoft Excel Format) which shall identify all outstanding Issues Log items and their timetable for completion. The Issues Log Completion Status Report shall be submitted in two (2) hardcopies and one (1) softcopy on the first day of the week, and shall be transmitted to OWNER REPRESENTATIVE electronically. The Issues Log items shall be organised by discipline, by system, by sub-system, by area, and by room.
- 3 Issues Log Categories shall be categorised as follows:
  - (a) Category A: Those Issue Log items which shall be addressed and remedied before proceeding any further with PFT activities.
  - (b) Category B: Those Issues Log items that can be addressed and remedied simultaneously with PFT activities.
  - (c) Category C: Those Issues Log items that shall be addressed and remedied after commissioning activities have been completed. However, these shall be cleared prior to demobilisation of the CONTRACTOR personnel.
- 4 The CONTRACTOR shall clear all Category "A" Issues Log items prior to applying to OWNER REPRESENTATIVE for the Ready-For-Commissioning Certificate for each system.

#### 1.9.7 PFT Dossier

- 1 The CONTRACTOR and CxA shall compile all documentation pertaining to the PFT activities in a Dossier arranged by system and sub-system, which shall contain all information required to demonstrate that such systems/sub-systems have reached the Ready-For-Commissioning status.
- 2 The PFT Dossier shall be submitted to the CxA once complete.
  - (a) The PFT Dossiers shall include, without limitations, the following:
  - (b) Updated Cleared Issues Logs.
  - (c) System description and marked up drawings.
  - (d) Specific procedures.
  - (e) Pre-commissioning Status Index.
  - (f) Pre-commissioning Check Lists.
  - (g) Pre-commissioning Test Sheets.
  - (h) As-Built drawings, route alignment drawings, pipeline profile drawings.
  - (i) Quality Control reports including non-destructive testing reports (flushing, pressure tests, etc.).
  - (j) CONTRACTOR's shop test reports.
  - (k) Supplier and Vendor documentation required for commissioning.
  - (l) Ready for Commissioning Certificate;
  - (m) Preservation Procedures;

## 1.10 FUNCTIONAL PERFORMANCE TESTING (FPT)

### 1.10.1 General

- 1 The Facility shall be fully commissioned by the CONTRACTOR after PFT in order to demonstrate the reliability, integrity, and performance of all equipment and systems in actual running and operating conditions. This requires the building interior and exterior to be substantially complete, free from dust, fumes and the finishes complete. Under no circumstances shall FPT be undertaken in a sectional manner. The CONTRACTOR's, SUB-CONTRACTORS', Vendors' and Suppliers' representatives shall (at no additional cost to OWNER REPRESENTATIVE) be present at the SITE and where necessary to assist in the Commissioning activities.
- 2 All PFT activities and documentation shall be completed OWNER prior to the start of the FPT activities.
- 3 FPT is the natural progression from completion of PFT of all systems to a point where they shall be considered fully operational and performing in the manner designed and effectively, efficiently, and economically fulfilling the tasks expected to the satisfaction of OWNER. Commissioning shall be inclusive of all witnessing, production of records and reports, etc. and the CONTRACTOR shall provide complete sets of test certificates duly signed by the CONTRACTOR, SUBCONTRACTORS, and OWNER.
- 4 The CONTRACTOR shall build in sufficient time in his schedule such that all PFT functions can be completed to the satisfaction of OWNER REPRESENTATIVE and the CxA.
- 5 The CONTRACTOR shall clear all Category "A" PFT Issues Log items prior to applying for the Ready-For-Commissioning Certificate for each system.

### 1.10.2 FPT Procedures

- 1 The CONTRACTOR shall prepare in conjunction with the CxA and submit to OWNER REPRESENTATIVE FPT Procedures for review and approval at least eight (8) weeks prior to the proposed start of FPT. The FPT Procedures shall indicate the following, as a minimum:
  - (a) FPT procedures and checklists based upon equipment manufacturers' and FPT procedures.
  - (b) Duration of FPT activities.
  - (c) Vendors' and suppliers' representative mobilisation notices.
  - (d) CONTRACTOR's requirement for workmanship assistance.
  - (e) Special tools and equipment to be supplied by the CONTRACTOR.
  - (f) Requirement for special products, consumables, lubricants, etc.
  - (g) Full method statements for all tests and associated activities .
  - (h) Details of all planned demonstrations to local, national and other authorities
  - (i) A schedule of dates for all tests and witnessing activities where external parties including OWNER REPRESENTATIVE and the CxA are expected to or may wish to attend. Dates must be confirmed to OWNER REPRESENTATIVE at least 15 days before each test.
- 2 Commissioning Team Meetings
  - (a) Regular Commissioning Team meetings shall be maintained throughout the construction phase in order to ensure the momentum of the commissioning process.

- (b) The schedule of meetings shall be defined, and should coincide with the monthly construction phase meetings. The typical agenda for construction phase Commissioning Team meetings shall include items such as previous action items, outstanding issues, schedule review, new issues, etc.
- (c) In addition to regular meetings, the CxA shall be responsible for preparing monthly Commissioning Process Reports during the construction phase. These reports shall include at a minimum the following information:
  - (d) Progress & status report along with look-ahead;
  - (e) Identification of systems or assemblies that do not perform in accordance with Owner's Project Requirements;
  - (f) Results from latest version of the Issues Log;
  - (g) Test procedures & data;
  - (h) Deferred & seasonal tests (and reason for deferring);
  - (i) Suggestions for enhancements which will improve the commissioning process and/or the delivered facility;
  - (j) The Commissioning Progress Reports shall be distributed to the entire Commissioning Team.
- 3 Retrofits and Modifications
  - (a) The CONTRACTOR shall record any retrofit/modifications on the newly installed equipment during and after commissioning and shall issue the relevant As-Built Drawings appropriately updated with new revision index.
  - (b) The CONTRACTOR shall allow for all adjustment of drives, belts, pulleys, sensors, impellers, electrical breaker settings, software adjustments and other parts during the commissioning as necessary to achieve the proper operation of the systems and equipment in accordance with the SPECIFICATIONS.
- 4 Replacement of Parts
  - (a) The CONTRACTOR shall replace any parts damaged or found unsuitable during Commissioning with new replacement parts at no additional cost to OWNER.
- 5 Final Commissioning Report
  - (a) The CONTRACTOR shall issue a Final Commissioning Report that shall include detailed status of equipment, notifications of SCHEDULED COMPLETION DATE, and a detailed list of all pending items.
- 1.10.3 Test Data**
  - 1 Test data records shall be completed by the Contractor and approved by the CxA which record outcomes of the FPT procedure; this will include the equipment and methodology, test data, observations and measurements.
  - 2 Data may be recorded using photographs, forms or other means appropriate for the specific test. Test data records shall include, but not limited to, the following information:
    - (a) Test reference (number, specific identifier, etc.)
    - (b) Date and time of test
    - (c) First test or retest following correction of an issue
    - (d) Identification of the systems, equipment and/or assemblies under test including location and construction document designation

- (e) Conditions under which the test was conducted (i.e. ambient conditions, capacity/occupancy, etc.). Tests shall be performed under steady-state and stable conditions
- (f) Expected performance
- (g) Observed performance including indication of whether or not this performance is acceptable
- (h) Issues generated as a result of the test
- (i) Dated signatures of those performing and witnessing the test.

#### 1.10.4 General Test Procedures

- 1 Testing shall be carried out in stages as follows:
  - (a) Preliminary Checks and Inspections.
  - (b) Units Functional Testing.
  - (c) System Operational Tests.
  - (d) Performance Tests.
  - (e) Continuous Operation Testing.
- 2 The CONTRACTOR shall not proceed from one stage of testing to the next without OWNER's written approval.
- 3 Consolidation of demonstration, testing, and instruction requirements; unit and system validation testing, commissioning and instruction of OWNER's personnel may be performed simultaneously.
- 4 CONTRACTOR shall allow for and make arrangements for the attendance of OWNER and other personnel nominated by OWNER at any time during the commissioning process.
- 5 CONTRACTOR shall allow for the attendance of and successful demonstration of systems to, the CxA in order to successfully close out the project's obligations under GSAS AND/OR LEED.
- 6 In general the CxA will require to:
  - (a) Witness HVAC piping pressure test and flushing, sufficient to be confident that proper procedures were followed. Include testing documentation in the Commissioning Record.
  - (b) Witness any ductwork testing and cleaning sufficient to be confident that proper procedures were followed. Include documentation in the Commissioning Record.
  - (c) Approve air and water systems balancing by spot testing and by reviewing completed reports and by selected site observation.
  - (d) Witness and document manual functional performance tests performed by the Construction Contractor for all commissioned systems and assemblies, except:
  - (e) Electrical equipment testing and regulated testing may be directed and documented by the Construction Contractor with only spot witnessing and report review by the Commissioning Agent.

#### 1.10.5 Preliminary Checks and Inspections

- 1 Prior to commencement of the FPT activities, the CONTRACTOR's commissioning team shall carry out Preliminary Checks and Inspections to verify that:
  - (a) All components, units, and complete systems conform to the SPECIFICATIONS, DRAWINGS and the approved working drawings, SAMPLES, construction manuals, material lists, and other approved SUBMITTALS.

- (b) All specified components and complete systems have been installed satisfactorily and are operable.
- (c) All installations are safe to use. Temporary access, covers, etc. will only be permitted if approved by OWNER.
- (d) All cleaning works have been completed.
- (e) All equipment is free from physical damage due to mechanical force, exposure to the elements, incorrect connection, etc.
- (f) Preliminary Checks and Inspections shall include, without limitations, thorough reviews of the PFT documents and physical checks of the WORKS.
- (g) Preliminary Checks and Inspections shall be carried out by technical discipline and shall be formalised on a specific report form.
- (h) PFT Issues Logs shall be updated following completion of the Preliminary Checks.

#### 1.10.6 Unit Functional Testing

- 1 The CONTRACTOR shall allow in the FPT schedule, time to facilitate and solve troubleshoot. As inspecting and testing proceed, if equipment or systems are found to be malfunctioning, these problems shall be documented and listed in the Issues Log for resolution. The Issues Log must be very clear about the test, system(s) involved, and tracking of the problem as it is corrected.
- 2 Unit Functional Testing is defined as tests on individual equipment, units such as pumps, compressors, blowers, fans, conveyors and all similar items of equipment. Tests may be performed simultaneously on groups of identical equipment, items, or groups of items supplied by one manufacturer, if practicable.
- 3 The functional testing shall include operating the system and components through each of the written sequences of operation, and other significant modes and sequences, including start-up, shutdown, unoccupied mode, manual mode, staging, miscellaneous alarms, power failure, security alarm when impacted and interlocks with other systems or equipment. Sensors and actuators shall be calibrated during construction check listing by the installing contractors, and spot-checked by the commissioning provider during functional testing. Analyse functional performance trend logs and monitoring data to verify performance. Coordinate retesting as necessary until satisfactory performance is achieved. Tests on respective HVAC equipment shall be executed, if possible, during both the heating and cooling seasons. However, some overwriting of control values to simulate conditions shall be allowed. Functional testing shall be done using conventional manual methods, control system trend logs, and readouts or stand-alone data-loggers, to provide a high level of confidence in proper system function, as deemed appropriate by the and OWNER REPRESENTATIVE.
- 4 The CONTRACTOR shall carry out Live Functional Tests on each item of equipment, instrumentation, or electrical system related to their given basic function.
- 5 Potable water shall be used to fill tanks, wells, piping, and systems that are to contain water, sewage, or sludge in normal operation. Where necessary, specified chemicals shall be used for chemical systems but shall not exceed in-service concentrations.
- 6 Tests shall show that all components, equipment, and units will operate with the quantities, efficiency, repeatability, tolerances, and accuracy specified.
- 7 Tests shall be carried out continuously for a minimum period of eight (8) hours, unless other periods are specified.
- 8 Separate Functional Test sheet forms shall be prepared for each type of functional test.

#### 1.10.7 System Functional Tests

- 1 Each system and sub-system shall be subjected to Functional Tests.
- 2 Functional Operational Tests shall not commence until Unit Functional Tests have been satisfactorily completed.
- 3 An Functional Test shall consist of bringing a given system into operation under the conditions as specified in the data sheets for the system/sub-system and verifying that all parts and the whole operate correctly in accordance with the Specification and data sheets. Functional Tests for utilities shall be as specified in CONTRACTOR's data sheets.
- 4 Each system Functional Test shall be carried out for minimum of twenty-four (24) hours, unless a longer time is required to prove the performance of the system.
- 5 The CONTRACTOR shall issue an Functional Test Certificate upon successful completion of the Functional Tests.

## 1.11 INTEGRATION AND OPERATIONAL TESTING

### 1.11.1 General

- 1 Integration and Operational Testing is only executed once all individual system testing is complete.
- 2 The testing is used to verify full project functionality as a prerequisite to project turnover to OWNER.
- 3 The testing is coordinated and performed by the CONTRACTOR for witnessing by OWNER, the PM and the CxA.

### 1.11.2 Integration Tests

- 1 Loss of Normal Power and Recovery – With the project operating in event mode normal power is de-energized to the project. The function of all systems on battery, standby, and emergency power is verified. Once this verification is complete normal power is energized and the return to normal operation is verified for all systems. Manual intervention shall not be required.
- 2 Simultaneous Loss of Normal Power and Generator Power – With the project operating in event mode the generators are disabled and then normal power is de-energized to the project. The function of all systems on battery power is to be verified. After a minimum of 120 minutes normal power is to be restored. The return to normal operation is verified for all systems. Manual intervention shall not be required.
- 3 Plumbing Flow Test – This test serves to simulate toilet use during the half-time of a football match. All individual toilets and urinals within the Stadium are to be flushed at thirty (30) second intervals for a period of fifteen (15) minutes and sixty (60) second intervals for the following fifteen (15) minutes. Inspectors are to be stationed throughout the Stadium along the routes of the waste water piping to document leakage, flooding, etc. That indicates the need for corrective work.



- 4 Fire Life Safety Integration Test – OWNER will randomly select eight (8) different emergency events from the Fire Life Safety Cause Effect Matrix that will be initiated across the WORKS. Reactions of all systems, including but not limited to, HVAC, Access Control, Lighting Control, Etc. shall be verified to be fully functional per the design requirements. Any failure of an emergency event test will result in corrective actions being completed and the test to be repeated. In addition, each failed event test will result in one addition emergency event to be added to testing program. Therefore, to successfully complete the Fire Life Safety Integration Tests, eight (8) tests must be successfully completed in sequence with no corrective works required.

#### 1.11.3 Operational Test

- 1 The Operational Test is defined as testing all the equipment and systems together under actual operating conditions using all the mediums used in actual operating conditions. The test consists of placing the WORKS into operation for a period of 96 hours. The WORKS must operate successfully for the full period without failure or alarm.
- 2 The test shall start in non-event mode and during the test period the Stadium is to be transitioned into cool-down and event modes twice.
- 3 A failure or alarm condition for a single component or piece of equipment will not fail the overall test, but will reset the test period to 96 hours for that item.
- 4 The Operational Test is complete once all components and equipment individual operate without fail for the 96 hour period.

### 1.12 DEFERRED TESTING

#### 1.12.1 General

- 1 Deferred tests include the Stadium Cool-Down Study, the Seasonal Performance Testing and any CONTRACT required testing that is approved by OWNER to be moved from the Construction and Acceptance Phases of the WORKS to the Warranty Phase of the WORKS. Deferral of any tests shall not result in any cost to OWNER.
- 2 The Contractor shall provide two (2) weeks written notification to OWNER prior to the execution of the deferred testing. Test events must be coordinated with the required participants from OWNER, the PM and the CxA.
- 3 Optimal sequence of operation of the stadium during 2022 World Cup Tournament (November/December) shall be considered as specified in the design requirements.

#### 1.12.2 Stadium Cool-Down Study

- 1 During the first summer season after the completion of the Acceptance Phase of the WORKS tests will be conducted by the CONTRACTOR to determine the optimal sequence of operation for the Stadium and Pitch Cooling Systems and the period of time required for the cooling of the Stadium prior to an event.
- 2 The study is to be scheduled by OWNER and the CONTRACTOR is to be notified in writing a minimum of one (1) month prior to the study's execution.
- 3 The CONTRACTOR shall take the Stadium from non-event mode to event mode a maximum of five (5) times to determine the minimum cool-down period required for the stadium without causing system failures, condensation problems, or other issues.



- 4 Initial testing will be done with the sequence required per the project design documents. Subsequent tests will be executed based on a modified sequence of operation as per the recommendation of OWNER and the CxA with concurrence by the CONTRACTOR.
- 5 Any modifications of the system sequence of operation shall be added to the O&M Manuals, Systems Manuals, Etc. A note is to be added to the Building Automation System Graphics that specifically states the time period required for stadium cool-down, and a count-down clock is to be provided based on that duration that is initiated when the system is commanded into cool-down mode.

### 1.12.3 Seasonal Performance Tests

- 1 During the first summer season after the completion of the Acceptance Phase of the WORKS tests will be conducted by the CONTRACTOR to verify that the entire project performs per the design requirements under maximum external heat load.
- 2 The Stadium Bowl cooling system requires testing under two (2) condition; #1 maximum external heat load with minimum human occupancy, and #2 maximum external heat load and full human occupancy.
- 3 The test is to be scheduled by OWNER and the CONTRACTOR is to be notified in writing a minimum of one (1) month prior to the tests execution.
- 4 The CONTRACTOR shall provide all necessary testing staff, operation personnel, security, and spectators for the tests.
- 5 The Building Automation System will be utilized to monitor temperature throughout the majority of the project.
- 6 The Stadium Bowl and Pitch will be required to be fully outfitted with a grid of temporary dataloggers spaced ten (10) meters on centre and at a height of 1.5 meters.
- 7 The CONTRACTOR is responsible for the provision of the temperature and humidity dataloggers and the downloading and compiling of their data into two dimensional temperature maps. Maps shall be provided from the start of the bowl cool-down period through one (1) hour after the completion of a theoretical football match. Maps shall be provided with a time frequency of no greater than 30 minutes during the cool-down period, and ten minutes during the event period.
- 8 The Temperature Maps shall be color coded appropriately for the depiction of the temperature variations and is to be determined during the development of the test plan. Sample maps shall be submitted in advance of the test for approval by OWNER. The maps shall include the following information:
  - (a) Time that data was recorded.
  - (b) Outside air temperature (degrees C, dry bulb) and relative humidity from a remote shaded location.
  - (c) Outside air windspeed from the roof of the stadium.
  - (d) Temperature in the Spectator Seating displayed in units for Standard Effective Temperature (SET). This will require calculation.
  - (e) Temperature on the Pitch displayed in units for wet-bulb temperature in degrees Celsius.
- 9 Any areas that exceed the design requirements shall be specifically highlighted.
- 10 Further details will be determined during the CONTRACTOR's development of the test plan.

### 1.13 READY-FOR-START-UP DOSSIER

#### 1.13.1 Manual

- 1 The CONTRACTOR shall handover only fully operable systems and facilities. The CONTRACTOR shall rectify any defects in workmanship, materials or construction and omissions or discrepancies which would impede the intended operation, at its own cost and expense.
- 2 The CONTRACTOR shall compile documentation of commissioning activities in a Ready-For-Start-Up Dossier arranged by system and sub-system, which shall contain all information required to demonstrate that sub-systems and systems have reached the Ready-for-Start-up stage.
- 3 The CONTRACTOR shall provide four (4) hard-copy sets and two (2) digital sets of the Ready-For-Start-Up Dossier.
- 4 The Ready-For-Start-Up Dossier shall include, without limitations, the following:
  - (a) Ready-For-Start-Up Certificate.
  - (b) Cleared Issues Logs.
  - (c) Basic Function list.
  - (d) Functional Test Sheets.
  - (e) Mechanical and Electrical reports.
  - (f) Manufacturers' and Vendors' reports.
  - (g) Leak tests and inserting reports.
  - (h) Marked-up, Ready-for-Start-Up, P&IDs, Hazardous Area Classification Drawings, Plot Plans, Cause & Effect reports, Single-Line Diagrams, Loop diagrams, etc.
  - (i) Any specific procedures.
  - (j) All relevant parts of Final Documentation.
  - (k) List of modifications and retrofits.
  - (l) Trip and alarm settings and system configuration details.
  - (m) Process and temperature parameters settings.
  - (n) Operational Test Procedures and Test Certificates.
  - (o) Performance Test Procedures and Test Certificates.
  - (p) As-Built Records and Drawings.
  - (q) Review of equipment warranties and a statement in regards of OWNER responsibilities
  - (r) Start-Up and Operating Manuals.
  - (s) Maintenance Manuals for each item supplied.

### 1.14 WARRANTY PHASE COMMISSIONING

#### 1.14.1 Introduction

- 1 The purpose of the Warranty Phase Commissioning effort is to insure that any warranty issues are resolved, deferred tests are performed and outstanding construction issues are resolved. Any operator issues that may have become apparent with building occupancy should be resolved during the warranty phase.

#### 1.14.2 Warranty Phase Responsibilities

- 1 During this phase, the Commissioning Team members shall be comprised of a representative from OWNER REPRESENTATIVE, the CxA, the Contractor and any team member who is involved with any outstanding issues.
- 2 Commissioning Team Responsibilities shall be to verify that the installed and operating systems, components and equipment will achieve OPR.

#### 1.14.3 Warranty Phase Activities

- 1 The CONTRACTOR is required as part of the Warranty Phase Activities to allow for the continued adjustment, optimization and modification of building systems to meet specified requirements.
- 2 The CONTRACTOR is required as part of the Warranty Phase Activities to resolve all outstanding issues.
- 3 Developing and issue a plan for re-commissioning the facility throughout its life cycle as part of the O&M Dossier.
- 4 Any Acceptance Phase testing that was deferred shall be performed during the Warranty Phase. The CxA shall verify and document that these deferred tests are performed by the responsible member of the commissioning team.
- 5 The CxA shall document any warranty issues and contractor call-backs. The CxA will be required to verify that the warranty issue has been resolved including retesting if required.
- 6 A Warranty Phase Commissioning Review Meeting shall take place during the Warranty Phase, facilitated by the CxA. The purpose of the meeting will be to:
  - (a) Perform operations review with owner and building operators;
  - (b) Provide documentation;
  - (c) Revise issue log if any deficiencies are found;
  - (d) Coordinate retests and verify any items identified as deficient are resolved;
- 7 The CxA shall coordinate any unresolved acceptance phase issues. The CxA will be required to verify that the issue has been resolved including retesting if required.
- 8 The CONTRACTOR and the CxA will be required to assist O&M staff with questions on O&M procedures during the warranty phase.
- 9 The CONTRACTOR and the CxA shall be required to:
  - (a) Coordinate and verify any required seasonal training;
  - (b) Perform training for equipment and systems that were not in operation at substantial completion.
  - (c) Review with OWNER the operators understanding of the training previously delivered and reinforce with more detailed training should this be required. This will not extend to the delivery of training to those operators who were not at the original training sessions.
- 10 The CxA shall conduct a "lessons learned" workshop with OWNER, PM/CM and operators to facilitate improvements to the owner's future building projects and commissioning efforts. The workshop shall include the following:
  - (a) A review of the results of commissioning for this project, its successes and its failures;
  - (b) A review of the functionality of the building;

- (c) A review of the buildings comfort level and its energy utilization;
- (d) Documented suggestions for improvement for inclusion into future projects OPR.

#### 1.14.4 Performance Review

- 1 At 10 months into the 12 month warranty period, the operation of all the systems and components shall be critically reviewed by CxA, OWNER and the Contractor to identify any items that must be repaired or replaced under the warranty.
- 2 The process will evaluate any discrepancies between predicted performance and actual performance and an analysis of any complaints received and logged by OWNER Facilities Management. The CxA shall document the results and forward recommendations to both OWNER and contractor for resolution.
- 3 Correct maintenance programs, training and familiarization of the systems by the OWNER Facilities management team is important in order to support Post-Construction commissioning. The CxA shall in conjunction with OWNER and the contractor agree a standard method of recording and responding to complaints.

#### 1.14.5 Warranty Phase Completion

- 1 The Warranty Phase in relation to the Commissioning is complete when:
  - (a) All warranty issues are corrected, or accepted by OWNER REPRESENTATIVE
  - (b) Final Commissioning Report with the warranty addenda is complete and accepted by OWNER REPRESENTATIVE;
  - (c) Lessons learned workshop and documentation is complete and approved;
  - (d) The reinforcement training sessions are complete and approved;
  - (e) Performance Review and documentation is complete and approved;

#### 1.14.6 Warranty Phase Documentation

- 1 Documentation Requirements shall include:
  - (a) Final Commissioning Report Warranty Addenda;
  - (b) Updated issue log if appropriate;
  - (c) Retest forms with deferred testing results if appropriate;
  - (d) Lessons Learned Workshop Report;
  - (e) Performance Review Report.

#### 1.14.7 Warranty Phase, Sectional Occupancy Handover

- 1 While the commissioning takes place during the beneficial occupation; the equipment warranties duly shall be initiated from the day following the issue of the Substantial Project Completion Certificate (regardless of any Partial or Sectional Occupancy Completion Certificate issued previously).
- 2 The specified warranty periods and the relevant project specifications are to exclusively include for the specified defect liability period(s) as defined within the Contract and project documentation.

- 3 Contractor is further responsible for all equipment, systems and installations, and is to warrant the same for the relevant period(s) from the agreed commissioning date / sectional completion dates through to the formal issue of the Certificate of Completion by the Owner. The warranties (and insurance coverage) are to commence from the point the whole of the project is handed over by the Contractor and that no partial handover or sectional completion allow for the warranties to commence prematurely or before the final completion certificate is issued by the Owner, thus no potential Variation shall be raised by the Contractor for any sectional occupancy milestones item in the programme.
- 4 The Contractor is to ensure all equipment and supplier warranties that are required shall be fully associated and aligned with the equipment / system manufacturer/supplier. Any non-compliance, failure or non-adherence to these warranties will be the Contractors exclusive obligation, liability and responsibility. The Contractor will provide warranty coverage from the date of final system commissioning. Therefore, if the commissioning takes place during the beneficial occupation, the warranty period takes effect from the whole of the works completion date only.

#### 1.14.8 Warranty Lists

- 1 This clause will be activated in the event that the Owner decides to appoint via the OM Contract document
  - (a) As detailed in (Table) attached to this section Commissioning and Start Up.
  - (b) The Contractor to submit at the end of Defects Liability Period (DLP) the remaining equipment/systems warranties as per Table to the Owner's representative for approval.

### 1.15 COMMISSIONING DOCUMENTATION

#### 1.15.1 General

- 1 The CONTRACTOR shall provide all required information to allow the CxA discharge their duties, this relates to all commissioning documentation. The purpose of the commissioning documentation is to record the standards of the building systems, and to verify that what has been designed and constructed meets the required standards.
- 2 As submittals for products and materials are received from contractors, copies of submittals critical to the commissioning process shall be forwarded to the CxA for review the following types of submittals.
  - (a) Coordination drawings
  - (b) Contractor start-up and checkout procedures
  - (c) O&M materials
  - (d) Redline As-builts
  - (e) Product data and key operations data submittals
  - (f) Systems manuals
- 3 This review allows the CxA to check the submittals for adherence to the Contract Documents. The CxA shall pay special attention to substitutions and proposed deviations from contract documents & the BOD.
- 4 The CxA shall only comment on submittals to the extent that there is a perceived deviation from the Contract Documents. All CxA comments shall be resolved by the commissioning team.

### 1.15.2 Commissioning Report

- 1 The Commissioning Reports shall be written in the following format:
  - (a) Report Title Page.
  - (b) Report Certification Page.
  - (c) Table of Contents .
  - (d) Executive Summary.
  - (e) Commissioning Plan.
  - (f) Final Issue Log.
  - (g) Completed Pre-Functional Test Forms And Check Sheets.
  - (h) Completed Functional Performance Test Forms And Check Sheets.
  - (i) Observation Reports.
  - (j) Training Verification Records.
  - (k) Copy of Final TAB Report.
  - (l) Commissioning Communications.
  - (m) Test Instrument Page.
- 2 The Report's Title Page shall include the following information:
  - (a) The heading: "Certified Building Systems Commissioning Report"
  - (b) Project Name / Project Address
  - (c) Owners Name / Address / Contact Numbers
  - (d) CxA Firm Name / Address / Contact Numbers / Certification Number
  - (e) Project and Design Professionals Names / Addresses / Contact Numbers
  - (f) General Contractor Name / Address / Contact Numbers
  - (g) HVAC Contractor Address / Contact Number Plumbing Contractor Name / Address / Contact Numbers
  - (h) Chemical Treatment Contractor Name / Address / Contact Numbers
  - (i) Electrical Contractor Name / Address / Contact Numbers
  - (j) Control Contractor Name / Address / Contact Number
  - (k) TAB Contractor Name / Address / Contact Numbers.
- 3 The Report's Certification Page shall include the following information:
  - (a) The stamp of the CxA Company. This stamp shall be signed or secure digital signature affixed as evidence that the CxA has reviewed and accepted the report. Signature stamps are specifically prohibited;
  - (b) Project Name;
  - (c) Certifying CxA Professional's Name;
  - (d) Firm Name; Certification Number; Expiration Date;
- 4 The Report's Table of Contents Page shall serve as a guide to the organisation of the report and shall include the sections with the associated page numbers.
- 5 The Report's Executive Summary and Remarks page shall include the following information:
  - (a) Review of the Commissioning Project Processes utilized;
  - (b) Review any deviations used;
  - (c) Review of each unresolved issue;



- (d) Review of each issue that was resolved in a manner that may still affect future system performance or creating future liability;
  - (e) Review of each deferred system test that is to be performed in the future;
- 6 The Owners Project Requirements (OPR) shall be provided if available, if not provided or there was insufficient information created in the programming stage, the CxA shall create an OPR in outline form for documentation of known project requirements. The OPR definition is a document that details the project requirements and the expectations of how the building and its systems will be used and operated. These include project goals, measurable performance criteria, value engineering/cost considerations, benchmarks, success criteria, and supporting information and should include:
- (a) Project Requirements;
  - (b) Building Requirements;
  - (c) Site Requirements;
  - (d) Sustainability;
  - (e) Energy & Efficiency;
  - (f) Accessibility;
  - (g) Safety & Security;
  - (h) Systems & Components;
  - (i) Operation & Maintenance;
  - (j) Level of maintenance anticipated per system or component;
- 7 The Commissioning Report shall include the final project Commissioning Plan which shall include the:
- (a) Commissioning Scope
  - (b) Commissioning Team
  - (c) Commissioning Team Member Responsibilities
  - (d) Phase information:
    - (i) Pre-Design Phase information;
    - (ii) Design Phase information;
    - (iii) Construction Phase information;
    - (iv) Acceptance Phase information and;
    - (v) Warranty Phase information;
  - (e) Normal channels of communication
  - (f) Commissioning Procedures Utilized
  - (g) Commissioning Check Sheets and Forms Utilized
  - (h) The commissioning schedule
  - (i) List or matrix of commissioning check sheets and forms and be inclusive for all phases included in the commissioning scope.
- 8 The Final Issue Log is a formal and on-going record of problems or concerns – and their resolution – that have been raised by members of the Commissioning Team during the course of the Commissioning Process. This information presented shall include all design phases from Pre-Design Phase, Design Phase, Construction Phase, Acceptance Phase and Warranty Phase and include the following information:
- (a) Issue Log Date

- (b) Issue Number
  - (c) Issue statement
  - (d) Date of Issue statement
  - (e) Person/Organisation making issue statement
  - (f) Issue statement answer
  - (g) Date of Issue statement answer/resolution
  - (h) Person/Organisation making issue answer/resolution.
- 9 All Completed Pre-Functional Check Sheets and Forms utilized on this project shall include the following information:
- (a) System or Component Name or tag number
  - (b) Description of item, condition or process to be verified
  - (c) Design Data for item, condition or process to be verified
  - (d) Observed state of item, condition or process to be verified
  - (e) Date of Observation or Verification
  - (f) Name of person & organisation providing the verification
  - (g) Name of person & organisation providing the witness.
- 10 All Completed Pre-Functional Check Sheets and Forms utilized on this project shall include the following information:
- (a) System or Component Name or tag number.
  - (b) Functional Test Design Parameters or description of item, condition or process to be verified.
  - (c) Design Data for item, condition or process to be verified.
  - (d) Approved trend or observed state of item, condition or process to be verified.
  - (e) Date of Observation or Verification.
  - (f) Name of person & organisation providing the verification.
  - (g) Name of person & organisation providing the witness.
- 11 Includes results of deferred Functional check sheets and reports.
- 12 The site observation (SO) reports shall include the following information
- (a) System or Component Name or tag number;
  - (b) Date of Observation;
  - (c) Observation Statement;
  - (d) Photographic report
  - (e) Relevant Data
  - (f) Recommendations
  - (g) Name of person & organisation providing the observation report
- 13 Training records shall be a comprehensive schedule of the training conducted for each and every training session and shall include:
- (a) Training Agendas for each training session;
  - (b) Training Schedule for all training sessions;
  - (c) Training Attendance Records and verification that each attendee has undergone and passed at an acceptable level the training provided;

- (d) CD of Video Taping of each training session;
  - (e) The Commissioning Communications section shall include all pertinent commissioning communications;
  - (f) Letters between the commissioning team members that are pertinent to the commissioning process performed or not performed for the project;
  - (g) Emails or other written documentation covering issues or issues resolution for the project;
  - (h) Commissioning Meeting Minutes;
- 14 The Test Instrument section shall include a complete schedule of all equipment used in e verification and witnessing of the process. The schedule shall include:
- 15 Model number and Serial number of each instrument;
- (a) Certification date of each instrument;
- 16 The Final Commissioning Report shall also include, but not limited to:
- (a) A statement that systems have been completed in accordance with the contract documents and that the systems are performing in accordance with OWNER Requirements document
  - (b) Identification and discussion of any substitutions, compromises or variances between the final design intent, contract documents and as-built conditions;
  - (c) Description of components and systems that exceed OWNER Requirements and those which do not meet the requirements and reasons why;
  - (d) Summary of all issues resolved and unresolved and any recommendations for resolution;
  - (e) Post-Construction activities and results including deferred & seasonal testing results, test data reports and additional training documentation;
  - (f) Lessons learned for future commissioning project efforts;
  - (g) Recommendations for changes to specified test protocols and/or facility/system design standards;
- 17 All report pages shall be clearly and easily identifiable with a unique designation.
- (a) The method of identification may use unique numbers, mechanical plans identification, or an appropriate narrative description;
  - (b) All pages shall contain the name of the project
  - (c) All pages shall be identified with a unique page number
  - (d) Each Pre-Function Test (PFT) or Functional Performance Test (FPT) form shall include the name of the responsible verifier and witness
  - (e) Pages may include a remarks section to record any information pertinent to the data reported on the data sheet.
- 18 The CONTRACTOR shall compile a Project Dossier arranged by sub-section, which shall contain all Operational and Maintenance (O&M) information for the WORK. The CONTRACTOR shall prepare the Project Dossier in accordance with the requirements and to the approval of OWNER, and in accordance with the requirements set forth in Attachment N° 7 to Part 1 of Scope of Works [Project Dossier Content List].

### 1.15.3 Report Distribution

- 1 The Commissioning Report shall be issued digitally to OWNER REPRESENTATIVE for OWNER REPRESENTATIVE's review and comments. The approval of the Commissioning Report is a prerequisite for project handover.
- 2 The CONTRACTOR shall submit a sufficient hard-copy sets and soft-copy sets of the Commissioning Report to OWNER for completing the project dossier requirement and the GSAS AND/OR LEED submission requirements for the project.

## 1.16 COMMISSIONING REQUIREMENTS/ OPERATION AND MAINTENANCE

### 1.16.1 Manual

- 1 This section sets forth the minimum requirements and guidelines for the commissioning services required during the development and handover of this project. The main objective of commissioning will be to confirm and document that the design and construction team fulfils the functional and performance requirements of the Owner, occupants, and operators. To reach this goal, it is necessary for the commissioning process to establish and document the Owner's criteria for system operation, performance, and maintainability; as well as, to verify and document compliance with these criteria throughout the design, construction, start-up, and the initial period of operation.
- 2 The Contractor will appoint or assign a Design Consultant who shall serve the project Commissioning Agency (CxA) if appropriately experienced in house staff can be utilised. If not, a separate CxA sub consultant can be retained. However, the sourcing of the CxA must be in agreement with the sustainability requirements of the project.
- 3 Standardized documentation will be issued by the CxA to serve as a project template.

### 1.16.2 Commissioning Process Overview

- 1 Commissioning (Cx) is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. This is achieved through a complete commissioning process; beginning at the design phase with documented design and operating intent and continuing through construction and acceptance phases, with actual verification of performance.
- 2 The Commissioning Process as described in ASHRAE Guideline 0–2013, ASHRAE Guideline 202-2013, ASHRAE Guideline 1.1-2007, NFPA 3-2015 or later editions shall be followed together with any other specific document required by the contract specifications in regards to specific elements. Specific elemental guidance is provided by learned institutions such as ASHRAE, CIBSE, BISRIA, ACG, etc, this guidance shall be considered as best practice.
- 3 The following is an outline of the commissioning process to be implemented by the project team.
  - (a) Design Phase:
    - (i) Commissioning objectives are defined and developed.
    - (ii) The design intent/basis of design is compiled.
    - (iii) A Commissioning Execution plan is finalised.
    - (iv) Design review of design development (DD) submittal.
    - (v) Commissioning specifications are created & incorporated into tender documents.
    - (vi) Design review of construction documents (CD) submittal.

- (b) Construction Phase:
  - (i) Commissioning scope meetings held.
  - (ii) Commissioning programme developed
  - (iii) Review of Method Statement (MS) and Inspection or Test Procedures (ITP)
  - (iv) Operation & Maintenance manual reviewed.
  - (v) Equipment submittals reviewed in parallel with project team (A/E)
  - (vi) Prefunctional/Startup documentation prepared by contractors.
  - (vii) Equipment needs incorporated into project programme (e.g. a section of the building is to be conditioned on a specific date, than the commissioning of all the pieces and the system must be listed as a predecessor to that date.)
  - (viii) Commissioning activities are reviewed in the project progress meeting. Separate commissioning meetings are scheduled with project team and contractors as required.
  - (ix) Site observations scheduled, focusing on prefunctional checklist.
  - (x) Startup request submitted by contractors.
  - (xi) Startups scheduled and witnessed.
  - (xii) Functional testing and verification procedures are developed and implemented as systems become ready for demonstration.
- (c) Acceptance Phase:
  - (i) Execution of remaining functional tests.
  - (ii) Training and orientation of Facilities Management personnel scheduled and conducted.
  - (iii) Systems are accepted and warranty period begins.
  - (iv) Turnover meeting held to transition responsibility of building operation from Construction Management to Facilities Management.
  - (v) Review and approve the final commissioning reports from the Contractor
- (d) Occupancy Phase (Post-Acceptance)
  - (i) Off-season functional testing is scheduled and is performed.
  - (ii) System performance monitoring takes place.
  - (iii) 10-month final walk-through held with Facilities management to coordinate any remaining warranty/construction items.
- (e) Commissioning activities during the design phase are intended to achieve the following specific objectives:
  - (i) Provide a plan for the implementation of the commissioning process, including the initial scope of systems to be commissioned for the project.
  - (ii) Ensure that the design and operational intent are clearly documented.
  - (iii) Provide a design review focusing on system performance, maintainability, and adherence to design intent.
  - (iv) Ensure that commissioning for the construction phase is adequately reflected in the tender documents.
- (f) Commissioning activities during the construction phases are intended to achieve the following specific objectives:
  - (i) Ensure the various members of the commissioning team clearly understand their responsibilities in their commissioning roles.

- (ii) Ensure the applicable equipment and systems are installed properly and receive adequate preoperational checkout.
- (iii) Verify and document proper performance of equipment and systems.
- (iv) Ensure that operation and maintenance documentation is provided for the continued management of the facility after the construction project is complete.
- (v) Ensure proper training of Facilities Management personnel.

### 1.16.3 Systems And Assemblies To Be Commissioned

1 The following is a subset of systems and assemblies that shall be addressed during the commissioning process. (This list is representative only. All systems as included in the Technical Specifications shall be commissioned unless otherwise stated by OWNER.)

- (a) HVAC Systems:
  - (i) Chilled water system  
Piping, pumps, heat exchangers, meters, fan coil units, metering, variable speed drives etc.
  - (ii) Heating hot water system  
Piping, pumps, heat exchangers, metering, variable speed drives etc.
  - (iii) Air distribution systems  
Air handling units, duct systems, VAV, boxes, fan coil units, air terminals etc.
  - (iv) Exhaust systems  
Fans, duct system, air terminals etc.
  - (v) Building management system  
Control devices, general building controls, energy management, system integration etc.
- (b) Fire alarm system
  - (i) Alarm panels, cabling, devices, interface with other systems (HVAC, Fire Suppression, Remote Monitoring), etc.
- (c) Emergency power system
  - (i) ATS, cabling,
  - (ii) UPS,
  - (iii) Generators.
- (d) Electrical Systems
  - (i) Lighting controls  
Cabling, dimming, scheduled controlled lighting systems etc.
  - (ii) Electrical power distribution system  
Cabling, meters, circuit breaker setting, transformers, inverters, etc.  
Protective device study
- (e) Communications & Technology Systems
  - (i) Security systems  
Card reader, devices, remote monitoring etc.  
CCTV
- (f) Emergency lighting
  - (i) Audio / Visual
  - (ii) Plumbing & Fire Suppression Systems



- (iii) Domestic water supply system (hot & cold)  
System pressure booster pumps, hot water heating generation, meters, etc.
- (g) Fire suppression systems
  - (i) Fire water pumps
  - (ii) Wet suppression systems
  - (iii) Dry suppression systems
- (h) Specialty Systems
  - (i) Swimming pool systems
  - (ii) Solar thermal Water heating, filtration and controls
  - (iii) Photovoltaic cells
  - (iv) General Building Systems
- (i) Vertical and horizontal transport
  - (i) Lifts, escalators, dumbwaiters.
- (j) Building Envelope Commissioning
  - (i) Whole building leakage testing
  - (ii) Façade sectional testing

#### 1.16.4 Codes And Regulations

- 1 Commissioning must be carried out in accordance with the authorities listed below or any other commissioning Standard or Code approved by OWNER.
  - (a) ASHRAE
  - (b) BSRIA
  - (c) CIBSE
  - (d) NFPA
  - (e) British Standards
- 2 All terminology used shall be as per ASHRAE or as defined by the OWNER standard contract documents.
- 3 If any of the above documents or references contradicts each other, the most stringent shall apply.

#### 1.16.5 Costs And Expenses

- 1 All costs and expenses associated with the commissioning process during the design, construction and defects liability periods of the project, including but not limited to the employment of specialist staff, as required by the Owner shall be deemed to have been included in the CONSULTANT's PRICE.

#### 1.16.6 General Roles And Responsibilities

- 1 CxA responsibilities from design stage for the commissioning process will include without limitation, the following and all other items detailed herein:
- 2 The CxA shall provide a CxA team with suitable commissioning experience as identified below. The CxA shall have experience providing commissioning reviews for all the design disciplines required. The CxA, and any staff performing the commissioning review, shall not have been directly involved with the design. OWNER shall have the right to approve all staff members, and OWNER shall have the right to seek the replacement of any staff members, if in OWNER's opinion, performance is unsatisfactory.

- 3 The CxA shall satisfy the following requirements:
- (a) Recent experience of commissioning at least one other project of similar scale;
  - (b) A minimum of 10 years commissioning experience on building services systems;
  - (c) Extensive experience in the operation and troubleshooting of HVAC systems, energy management control systems, security systems and the like;
  - (d) Detailed knowledge in building operation and maintenance and O&M training;
  - (e) Detailed knowledge in the test and balance of both air and water systems;
  - (f) Experienced in energy-efficient equipment design and control strategy optimization;
  - (g) Direct experience in monitoring and analysing system operation using energy management control system trending and stand-alone data logging equipment;
  - (h) Experienced in authoring Commissioning Plans, method statements, and execution programmes;
  - (i) A professional certification in building commissioning is required for a minimum of one member of the staff conducting the commissioning review. The following certificates are acceptable:
    - (i) Building Commissioning Association (BCA) – Certified Commissioning Provider (CCP)
    - (ii) Commissioning Specialist Association (CSA) – Grade 6 Accreditation;
    - (iii) American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) – Commissioning Process Management Professional (CPMP);
    - (iv) National Environmental Balancing Bureau (NEBB) – Building Systems Commissioning Certification (BCS);
- 4 A minimum of a Bachelor's degree in Mechanical/Electrical or Building Services Engineering together with P.E. /C. Eng. certification is desired; however, other technical training, past commissioning and field experience will be considered.
- 5 Commissioning Responsibilities
- (a) The following is a listing of commissioning responsibilities. The list is not intended to capture all the tasks of the project team; just the tasks associated with commissioning. The list should serve as an example and is by no means complete.
- 6 OWNER Representative's Responsibilities:
- (a) The OWNER Representative will review the Basis of Design, Design Intent, Commissioning Execution Plan, and Design Review Documentation. They may review and provide direction on any submittal during the execution of the program.
- 7 Project Manager (PM)
- (a) Works with the CxA to determine the level of commissioning required for the specific project.
  - (b) The PM distributes DD & CD plans and specifications to key personnel for review comments. The PM tracks the review comments so that the "reviewers" are informed as to the status of their comments.
  - (c) The PM and GC provide the CA with information regarding substitutions, change orders, RFI's and any instructions that may affect commissioning.
  - (d) Conveys to the A/E their commissioning requirements. This includes defining the deliverables.

- (e) The PM is responsible for budget and scheduling; therefore, any suggested change to the budget or schedule brought about from the commissioning activities must be approved by the PM.
  - (f) Negotiating fees.
- 8 Commissioning Agent (CxA): Execution/Monitor
- (a) The CxA develops the commissioning plan.
  - (b) The CxA develops the project specific functional performance testing procedures and forms.
  - (c) Works with A/E & PM to get commissioning requirements into specification
  - (d) The CxA reviews and comments on DD & CD plans and specifications.
  - (e) Presents design intent to FM/OM personnel that will be involved in commissioning on this project.
  - (f) The CxA Reviews the final commissioning report as developed by the CONTRACTOR.
  - (g) Make site visits to assure that installation of wide spread systems (i.e. duct work, conduit, wiring, and piping) are meeting contract requirements.
  - (h) Witnesses functional testing along with the involvement of FM/OM personnel.
  - (i) Review and comment TAB specification.
  - (j) Review TAB services contractors
  - (k) Manage TAB contractor.
  - (l) Coordinates FM/OM training and spare material turnover Communicates Cx status to construction and commissioning team
  - (m) Communicate all discrepancies found during commissioning activities to PM. Attends progress meetings to discuss commissioning issues as needed.
- 9 Architect and Engineer (A/E)
- (a) Provides design intent documents.
  - (b) Provides design intent clarification to CxA as needed.
  - (c) Provides written responses to design review comments
  - (d) Generates TAB specification
  - (e) Provides support to insure adherence to the design intent described in the specification and drawings:
    - (i) The services intended to be the A/E's commissioning responsibility are to verify on site that a piece of equipment is installed in accordance with specifications and manufacturers recommendations prior to startup.
    - (ii) Method - The CxA will contact the A/E when a startup request is submitted for the first piece of equipment in an equipment type group. The CxA and A/E will inspect together with the possible inclusion of FM/OM personnel. Any discrepancies will be reported to the PM for resolution.
  - (f) Provide consultation for the CxA when a situation arises to where the design intent is unclear.
  - (g) Make site visits to assure that the installation of systems (i.e. duct work, conduit, wiring, and piping) meet contract requirements.
  - (h) Provide electronic specifications to the CxA for use in PFC and FPT development.
  - (i) Witness functional testing.

- 10 Contractors (GC, MEP, FPC)
  - (a) Contracts a third party to perform commissioning duties (TAB). The third party will be independent of the MEP and works with the CxA.
  - (b) Modifies the pre-functional checklist provided by the CxA to make them project specific.
  - (c) Accumulates all the manufactures startup procedures for the procured equipment
  - (d) Assembles, in an orderly fashion, a startup binder that would include the PFC and manufactures startup procedure for each piece of equipment provided.
  - (e) Provides assistance during FPT of systems provided (as indicated on Commissioned Equipment Listing)
  - (f) Provides training of FM/OM as specified. Training sessions to be scheduled through the CxA.
  - (g) Provides trend data to CxA to demonstrate functionality of system. The CxA will transmit trend requirements to the MEP.
- 11 Testing and Balancing Contractor (TAB)
  - (a) Reports directly to CxA, GC and MEP.
  - (b) Performs task and generates reports as listed in TAB specification:
    - (i) Weekly status report including any discrepancies found that degrade the system.
  - (c) Works with CxA during FPT to collect data for reports (i.e. static profile of an AHU).
  - (d) Spot check equipment with CxA for deviation from original calibration.
- 12 Facilities Management Personnel (FM/OM)
  - (a) Assist CxA in the completion of the PFC
  - (b) Attends contractor training sessions.

#### 1.16.7 Commissioning Process

This section sequentially details the commissioning process by task or general activity.

- 1 Design Phase:
  - (a) Commissioning (Cx) is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. This is achieved by documenting the design and operational intent during the design phase and continuing through construction and acceptance with the actual verification of performance.
  - (b) Commissioning during design is intended to achieve the following specific objectives:
    - (i) Provide commissioning focused design reviews
    - (ii) Ensure the design and operational intent is clearly documented.
    - (iii) Ensure that commissioning for the construction phase is adequately reflected in the tender documents.
- 2 Commissioning Plan
  - (a) The CxA develops the project specific commissioning plan based on budget and input from the PM.
- 3 Design Intent and Basis of Design Documentation

- (a) The design documentation differs from traditional specifications in that it provides a more narrative description of the building systems. In general, specifications detail what is to be done on a component level, while design documentation explains why something is done and, in general terms, how design and operating objectives will be accomplished. Design documentation consists of two dynamic components: design intent and the basis of design.
- 4 Design Intent
- (a) The design intent is a dynamic document that explains the ideas, concepts and criteria that are considered to be very important to the owner. It is initially the outcome of the planning stage of the project and will be provided by the A/E before the completion of the concept design phase.
- 5 Basis of Design
- (a) The basis of design document is the primary thought processes and assumptions behind the design decisions made to meet the design intent. The basis of design describes the systems, components, conditions and methods chosen to meet the intent. Some reiterating of the design intent may be included. This document will be completed and provided from by the A/E at the completion of the design documentation phase.
- (b) The design intent narrative and basis of design documentation should cover the following, for each system, major component, facility and area:
- 6 General Construction:
- (a) Energy performance
  - (b) Applicable codes and standards
  - (c) Glazing fraction, U-value and shading coefficient
  - (d) Objectives and functional use of the system, equipment or facility
  - (e) Occupancy, usage, and schedule assumptions, all seasons.
  - (f) Building envelope assumptions
  - (g) Floor load assumptions and calculations
  - (h) Vibration assumptions and calculations
  - (i) Noise criteria and acoustic assumptions and calculations
  - (j) Fire and life safety considerations
  - (k) Fire zoning rationale
  - (l) Smoke control rationale
  - (m) Life safety operations modes and sequences
  - (n) GSAS AND/OR LEED goals
  - (o) Cost considerations and design compromises
  - (p) Restrictions and limitations of system or facility
- 7 Mechanical:
- (a) Indoor and outdoor design conditions, all seasons
  - (b) Indoor "heat to" temperatures, general and specific
  - (c) Indoor "cool to" temperatures, general and specific
  - (d) Indoor humidity, general and specific
  - (e) Equipment sizing criteria and calculations
  - (f) Diversity used in sizing

- (g) Occupant density and function
- (h) Air quality criteria
- (i) Air distribution zoning rationale
- (j) Ventilation requirements and calculations
- (k) Occupied and unoccupied operation modes, all seasons
- (l) Steam distribution and condensate recovery rationale
- (m) Chilled water distribution rationale
- (n) Life safety operation modes
- (o) For individual systems, sequences of operation, set points, and dead-bands
- (p) For interactive systems, sequences of operations
- (q) Metering and sub metering requirements

8 Electrical:

- (a) Lighting requirements and calculations
- (b) Lighting zone assumptions
- (c) Outdoor lighting control
- (d) Fire and life safety considerations
- (e) Fire alarm zoning rationale
- (f) Equipment load assumptions and calculations
- (g) Energy conservation intentions and calculations
- (h) Life safety operations modes
- (i) Occupied and unoccupied operation modes, all seasons
- (j) Equipment sizing criteria and calculations
- (k) Emergency power and what equipment is connected
- (l) Metering and sub metering assumptions

### 1.16.8 Design Development Review

The design development review is documented in writing and submitted to the PM by the CxA. The PM will compile any comments/corrections to the documentation and forward them to the A/E. The architect distributes the comments to the design team members. The team members respond to the architect who provides a written response to the PM and CxA. The final draft of the design intent and basis of design documentation will be available at the end of construction documents design phase.

#### 1 Commissioning Specification Development

The commissioning specifications, for inclusion in the construction tender documents, are developed by the A/E and members of the design team and reviewed by the CxA as part of the commissioning process during design.

#### 2 Purpose

The specifications provide detail so that the contractor on the project can clearly understand how the commissioning process works and specifically what role they have in the process.



### 3 Specification Content

The commissioning specifications will provide the contractor a clear description of the extent of the verification testing required, including what components and systems will be tested and the documentation, reporting and scheduling requirements. Details of the extent of testing and who is responsible for writing tests, executing tests, witnessing and signing-off on tests shall be included. The relationship between and requirements for start-up, prefunctional checklists, manual functional performance tests, control system trend logs and stand-alone data logging shall also be given. Example tests will also be provided. The specifications will also detail the operator training and the O&M documentation and any O&M plan requirements. Any specific program of tasks focusing on indoor air quality will be included in the specifications.

#### 1.16.9 General Review of Drawings and Specifications

1 Drawings and specifications are reviewed throughout the design process. As a minimum, the documents are distributed at the end of schematic design, at the end of design development, and at 50% & 95% construction documents. The commissioning review of the plans and specifications is in addition to any traditional review process.

#### 2 Purpose

- (a) Provide contractor with additional information on existing conditions (if required)
- (b) Make sure that the standards are maintained in the construction documents
- (c) Make sure the commissioning requirements are incorporated
- (d) Verify the design intent is maintained
- (e) Maintainability
- (f) O&M requirements
- (g) Devices present for proper balancing
- (h) Training requirements
- (i) Equipment spare requirements

#### 3 Construction Phase

This section details the commissioning process and activities during the construction phase.

#### 4 Construction Phase Commissioning Activities

The following is an outline of commissioning activities during the construction phase. The topics are described in detail in this section.

- (a) Kickoff Meeting
- (b) Submittal Review
- (c) Pre-functional Checklist and formal startups
  - (i) Contractor commissioning meeting
  - (ii) Startup Request Forms
  - (iii) A/E site inspections
  - (iv) PM, CxA, FM/OM site inspections
- (d) Tracking of deficiencies
- (e) Commissioning Progress Reporting
- (f) Testing And Balancing
- (g) Functional Performance Testing

5 Submittal Review

- (a) The CxA will conduct reviews of contractor submittals of equipment to be commissioned. The A/E will provide the CxA with specific submittals as requested by the CxA. This review will not take the place of the A/E submittal review process, but will be completed in parallel. Any comments by the CxA will be forwarded to the A/E.
- (b) The CxA submittal review process is done for two reasons. One is to gather additional information not in the O&Ms to use in pre-functional inspections and functional performance testing. The other reason is to assure that the submitted equipment meets the specifications.

6 Pre-functional Checklist and formal startups

- (a) Prefunctional checklists (PFC) are important to ensure that the equipment and systems are connected and operational and that functional performance testing may proceed without unnecessary delays. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g. oil levels, fan belt tension, labels affixed, gages in place, sensor calibration, etc.). However, some prefunctional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). Prefunctional checklists augment and are combined with the manufacturer's start-up checklist.

7 Contractor commissioning meeting

- (a) A commissioning scoping meeting is planned and conducted by the CxA. This will be arranged with each of the prime contractors commissioning representative. The contractor will be given generic prefunctional checklist templates (electronically) if necessary. The contractor will create a form for each piece of equipment from the templates, with equipment specific information filled in (e.g. Equipment Tag, location, manufacturer, model number, serial number, horsepower, voltage, gpm, cFM/OM, etc.). These forms will be placed logically into 3 ring binders. The contractor will then compile manufacturer recommended startup procedures and place this documentation into the binders in the appropriate sections. This binder will be submitted to the CxA for approval. Once approved, a copy will be generated. One copy will be given to the CxA and one will be maintained on the job site by the field commissioning representative, as appointed by each contractor. The contractor will initial and date the items on the prefunctional checklist and manufacturer startup forms as they are completed.
- (b) The completed contractor commissioning binder will be submitted to the CxA once all equipment startup has been completed. This binder will include all the "signed off" prefunctional checklist, manufacturer startup forms, and startup request forms.

8 **Start-up Request Forms**

- (a) Each contractor will be given an electronic version of the Equipment Startup Request Form along with the PFCs. The contractor is required to submit a signed Startup Request Form a week in advance prior to equipment startup. The signature on the Startup Request Form is to indicate that all of the prefunctional requirements for that equipment have been accomplished. The equipment that will require an official scheduled startup will be designated in the "Equipment to be Commissioned" listing. All startups and testing must be witnessed by the CxA and/or the PM.
- (b) Equipment started up for temporary cooling/heating will be done in a formal matter. The equipment will be inspected so that all safeties and filters are in place. This will not take the place of the official startup for that equipment, but in addition to.

## 9 A/E site inspections

The applicable party on the A/E team will be notified when a startup request form has been submitted the first time for each different type of equipment. The A/E will schedule a site visit with the CxA to verify that all requirements specific to that type of equipment has been completed.

## 10 CxA, FM/OM, site inspections

- (a) The CxA will schedule site inspections with FM/OM personnel that are on the commissioning team. The focus of these inspections will be on equipment that is scheduled to be operating, as determined by the commissioning programme.
- (b) The team will meet with the contractors commissioning team to discuss project progress and to get a startup schedule look ahead.
- (c) The A/E's representative and FM/OM personnel will perform site inspections. The field inspectors will refer to the prefunctional checklist but will not be responsible for "signing off" on them. This is the contractor's responsibility. The field inspectors will focus on equipment that is schedule to be started in the near future in order to make the construction team aware of any deficiencies prior to the startup date. The field inspectors will also focus on systems that are installed over a large section of the schedule, like ductwork, piping, terminal units, insulation, and conduits. The objective is to highlight deficient installation issues before they are repeated.

## 11 Tracking of deficiencies

- (a) Any deficiencies (deviations from the plans and specifications) found during commissioning activities will be forwarded to the PM for tracking and resolution. The CxA will log these issues and resolutions for inclusion in the final Cx report.
- (b) Any other issues found during Cx that are not considered deviations from the tender documents, but none the less affect the performance of a system will be championed by the CxA. This will include maintainability issues, differences in design intent interpretations, or systems not performing up to design criteria. These type issues will be resolved through a collaborative effort of the CxA, PM, Contractors and A/E. These issues will be tracked on a commissioning log, distributed periodically, and included in the final commissioning report.

**1.16.10 Commissioning Progress Reporting**

1 The CxA regularly communicates with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling issues through progress reports, and commissioning status summary sheets. At the beginning of construction, the CxA provides monthly commissioning progress reports. Thirty (30) days prior to the startup of the first piece of major equipment, the frequency of progress reports is increased to twice per month, until startup is completed. The CxA & PM may adjust the reporting frequency as needed. The progress reports contain: a two week look ahead for commissioning activities, a list of new and outstanding deficiencies and description of commissioning progress.

## 2 Testing and Balancing

- (a) The testing and balance work will be performed by the TAB contractor. The CxA and PM will manage the TAB contractor throughout the construction process. The TAB contractor is an integral part of commissioning.

## 3 Functional Performance Testing

- (a) Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g. all hot water pumps and hot water converters will be looked at simultaneously for temperature control, pressure control, staging and lead/lag rotation). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all of the control system's sequences of operation and components are verified to be responding as the sequences state. The commissioning agent develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor.
  - (b) It is imprudent to assume that all the functional performance testing will be completed during the construction phase of a project. Having all the systems in a building complete and demonstrated to FM/OM prior to occupancy. If FPT is to be carrying on during post-occupancy, this will be done with as little disruption to the occupants as possible.
- 4 Acceptance Phase
  - (a) The following section describes the commissioning activities that occur during the acceptance phase.
- 5 O&M Documentation
  - (a) The A/E will forward all submitted O&Ms to the CxA for review. The CxA will review the O&Ms in assure that the information contained within will provide adequate direction to the FM/OM department over the life of the building and systems within. If the documentation is inadequate, it will be noted as such and returned to the A/E for resubmittal from the contractors.
- 6 Turnover Meeting
  - (a) Purpose: To officially transfer the responsibility of maintaining the facilities from the contractors to FM/OM. Attendees will be the PM, CxA, A/E and appropriate FM/OM personnel.
  - (b) The CxA will schedule and lead meeting. The following is a basic agenda for the turnover meeting.
    - (i) As-built drawing status – PM to provide copy of field prints if the final as built are not available at this time
    - (ii) O& M Manuals
    - (iii) Equipment spares
    - (iv) Keys / Access
    - (v) Contractor contact listing and the work they performed
    - (vi) Warranty start/finish dates consolidated listing
    - (vii) Training – what's been completed and what's remaining
    - (viii) Commissioning status -Remaining functional performance testing schedule
    - (ix) Open punch list of deficiencies / Commissioning Issues Review - Creating an action plan and assigning a champion for any open items
- 7 System Warranties
  - (a) System warranties will not take effect until successful functional testing is complete and the system is accepted by the CxA and PM. Warranty periods and requirements will be described in the project contract specifications.

- (b) During the warranty period, seasonal testing and other deferred testing required will be completed according to the Specifications. The CxA will coordinate these activities with Contractor. Systems requiring seasonal testing during the warranty period will have the warranty start date adjusted if the system does not initially pass functional testing, regardless of the initial acceptance of the system at the end of the Acceptance Phase.
- 8 Off-season Functional Testing
- (a) Due to the nature of HVAC systems operation, performance of the systems cannot all be evaluated for performance during one season of the year. It is anticipated that the performance of the systems will require evaluation during all seasons of the project completion year. The system will also require functional testing during the two peak seasons, cooling and heating, to complete the commissioning of these seasons. The CxA will work with FM/OM to accomplish the seasonal testing. Any deficiencies will be taken directly to the contractor as a warranty call.
- 9 Performance Monitoring
- (a) During the warranty period of the building FM/OM personnel will evaluate the HVAC systems through performance monitoring using the Building Management System. The CxA will assist FM/OM in this task.
- 10 Ten (10) Month Final Walk-Thru and System Review
- (a) Ten months into the warranty period, the CxA, PM and FM/OM will meet and discuss any remaining outstanding operational issues and review the performance of each system. Any remaining open contractor issues will be processed at this time.
- 11 Recommissioning Management Manual
- (a) The CxA will provide FM/OM blank functional test forms and information on the equipment provided on the PFC by the contractors. FM/OM will use this information and forms for their preventative maintenance / recommissioning program for the equipment provided under this project.
- 12 Commissioning Report
- (a) The CxA will issue a final summary report. The report will include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each system commissioned equipment, the report will contain the disposition of the Commissioning Agency regarding the results of the commissioning work.
  - (b) The results of commissioning each system will include as summary identifying the;
    - (i) Equipment met the owner's design intent
    - (ii) Equipment met the specification requirements
    - (iii) Equipment has been installed properly
    - (iv) Functional performance status of each system
    - (v) As-built documentation, and
    - (vi) Operator training was completed.
  - (c) Any non-compliance issues remaining will be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented.
  - (d) Appendices will contain logs, meeting minutes, progress reports, deficiency lists, site visit reports, findings, unresolved issues, communications, etc. Pre-functional checklists and functional tests (along with blanks for the operators) and monitoring data and analysis will be provided in a separate labeled binder.

- (e) The commissioning plan, the pre-functional checklists, functional tests and monitoring reports will not be part of the final report, but will be kept on file by the cxa

END OF PART