

# **COMMISSIONING PLAN**

## **UBC BIOSCIENCES COMPLEX**

**Vancouver, B.C.**

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## 1.0 INTRODUCTION - LEED COMMISSIONING

Commissioning is the process of ensuring the various building systems are designed, installed, tested and operated in conformance with the owners requirements and the design intent. The goal of this Commissioning Plan is to guide the commissioning process and present the commissioning requirements to all parties including responsibilities, required documentation, etc to ensure the installation is complete and correct the first time. In this way “success” means both an effective and efficient process with minimal extra effort leading to a properly functioning facility.

Commissioning is to be provided throughout all stages of this project in accordance with the requirements of the Canada Green Building Council (CaGBC) Leadership in Energy and Environmental Design (LEED) NC 1.0 guidelines for Fundamental Building Systems Commissioning (EAp1) and Best Practices Commissioning (EAc3).

This Commissioning Plan is for the use by the Owner, the Design Consultants, the Commissioning Authority, the Contractor’s Commissioning Agents and all contractors and trades involved with commissioned systems.

LEED EAp1 Fundamental Building Systems Commissioning is a prerequisite for obtaining a LEED certification. Requirements to meet this are as follows:

1. Engage a commissioning authority
2. Develop the Owner’s performance requirements for energy, water and IEQ and review the basis of design to verify performance requirements will be met.
3. Incorporate commissioning requirements into the construction documents.
4. Develop and utilize a commissioning plan.
5. Verify the installation, functional performance, operator training and O & M Manual documentation.
6. Complete a commissioning report.

In addition to the above noted Fundamental Building Systems Commissioning requirements, the following will be required to comply with LEED EAc3: Best Practices Commissioning:

1. The Commissioning Authority conducts a review of the design prior to the construction document phase.
2. The Commissioning Authority conducts a focused review of the construction documents near completion and prior to issuing the contract documents for construction.
3. The Commissioning Authority reviews the contractor submittals relative to the systems being commissioned.
4. Information is provided to the Owner in a single document (manual) required to re-commission the building systems.

5. A contract is in place to review building operation with operating and maintenance staff, including a plan for resolution of outstanding commissioning related issues, within one year after construction completion date.

Upon completion of all of the fundamental commissioning the Commissioning Authority will submit signed LEED Letter Templates, certifying that the prerequisite and credit tasks have been successfully executed or alternatively, that these tasks will be implemented within one year from completion of the project.

## 2.0 INTENT OF COMMISSIONING PROCESS

The intent of this plan is to describe a commissioning process defined and monitored by an independently appointed Commissioning Authority and implemented by the Contractor.

The plan includes:

1. General requirements relating to the commissioning of the various components, equipment and systems
2. Details of scope, level of detail and standard of commissioning
3. Roles, lines of communication, and responsibilities of the Contractor, Design Team and independently appointed Commissioning Authority.
4. Deliverables
5. Acronyms:
  1. SM – Systems Manual
  2. Cx – Commissioning
  3. EMCS – Energy Monitoring and Control System
  4. O&M – Operation & Maintenance
  5. TAB – Testing, Adjusting and Balancing
  6. CA – Commissioning Authority
  7. CCA – Contractor's Commissioning Agent
  8. CBA – Contractor's Balancing Agent
  9. WHMIS – Workplace Hazardous Materials Information System
  10. MSDS – Materials Safety Data Sheets
  11. EIVF – Equipment & Installation Verification Forms
  12. PVF – Performance Verification Forms
  13. IST – Integrated Systems Testing
  14. OPRs – Owners Project Requirements

The general intent of the commissioning process is to ensure that each of the commissioned components and systems individually and collectively function effectively and efficiently in accordance with the design intent.

To achieve this objective, commissioning activities including document reviews, inspections, performance tests, system verifications and documentation will be completed by the Commissioning Team. Each member of the Commissioning Team will be assigned roles, responsibilities and objectives so that the overall goals of the commissioning process are met.

The following systems shall be commissioned as part of the project. Systems identified with asterisk (\*) are specifically required by LEED.

Site Services:

1. Hydro
2. Gas
3. Water, storm and sanitary
4. Phone and cable

Site Functions:

1. Storm water management
2. Irrigation system

Partitions:

1. Air tightness
2. Sound isolation
3. Interior doors and hardware
4. Fire rated assemblies and fire stopping

Transportation Systems:

1. Elevator

Envelope Systems

1. Water tightness
2. Air tightness
3. Thermal integrity

Active Fire Safety Systems:

1. Sprinkler, standpipe and extinguishers
2. Fire alarm

### Heating, Ventilating, and Air Conditioning Systems:

1. Hydronic distribution \*
2. Air distribution \*
3. Ventilation \*
4. Heat Exchangers \*
5. Pumps \*
6. VAV Terminal boxes \*
7. Fan Coil Units \*
8. Ductwork systems \*
9. Variable frequency drives \*
10. Controls \*
11. Glycol Systems \*
12. Heat Recovery Systems \*

### Plumbing Systems:

1. Storm water recovery system \*
2. Domestic hot water recirculation \*
3. Hot water generation and storage \*
4. Hot and cold water distribution \*
5. Fixtures \*
6. Tanks \*
7. Pumps \*

### Power Distribution System:

1. Wiring
2. Transformers
3. Switchgear
4. Switchboards
5. Breaker panels
6. Power factor correction
7. Grounding and lightning protection
8. Receptacles
9. Uninterruptible power supplies
10. Heating cables
11. Motor starters and MCC's
12. Transient voltage surge suppression
13. Contactors and disconnects

### Emergency Power Systems:

1. Generation
2. Distribution
3. Emergency lighting

4. Exit signage

Lighting Systems:

1. Interior
2. Exterior
3. Controls \*

Miscellaneous Electrical Systems (Telecommunication Systems):

1. Voice communications
2. Data
3. Electronic security
4. Clocks
5. Miscellaneous wiring
6. Electronic/Computerized equipment
7. Floor boxes
8. Communications conduit and outlet box wiring

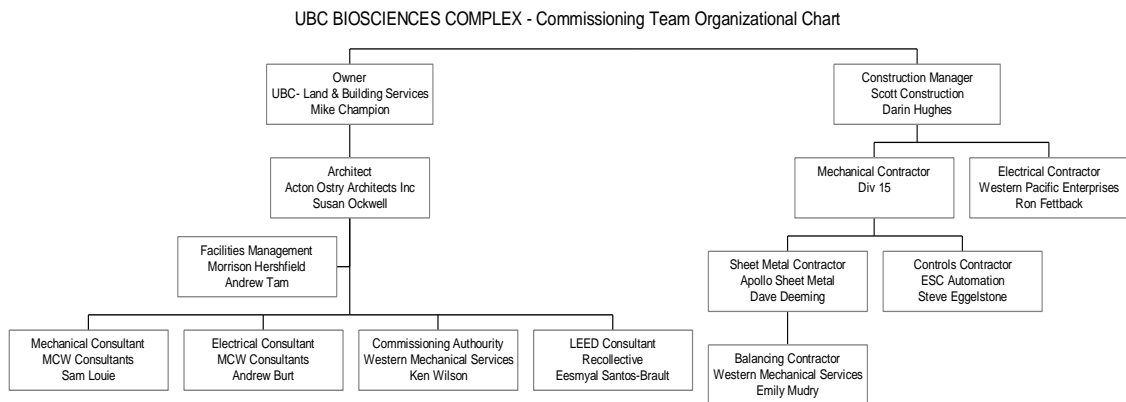
Miscellaneous:

1. Environmental Chambers

### 3.0 COMMISSIONING TEAM

The Commissioning Team is made up of the following main parties responsible for design and construction of the commissioned components and systems. The commissioning activities to be conducted by the various team members are coordinated by the Commissioning Authority.

Following is an organizational chart of the Commissioning Team Members



### 4.0 MANAGEMENT, COMMUNICATION AND REPORTING

The commissioning process that is successful requires coordinated inter-related tasks to be conducted in a focused manner. Coordination and communication is essential between all commissioning team members through commissioning meetings and correspondence that are well documented. Meetings will be held at a minimum every two weeks during the start up and testing phase of the project. The commissioning process is part of the project and is integrated into the over all project schedule.

#### Commissioning Meetings

Convene initial Cx meeting prior to any Cx activities to:

1. Review duties and responsibilities of the contractor, sub-contractors and specialist Cx and testing agencies.



2. Confirm lines of communication.
3. Confirm the degree of involvement of manufacturer's representatives in the Cx process.
4. Thereafter Cx meetings to be held regularly during the construction period.
5. Meetings to be chaired by the CCA who will record and distribute minutes.
6. CCA to ensure relevant Cx participants attend as required.
7. CA to attend and provide summary report of Cx activities at each Commissioning meeting.

### Commissioning Schedule

1. CCA to prepare a detailed schedule as part of construction scheduling activities.
2. Schedule shall identify all planned post occupancy Cx activities.
3. Submit for review following the start-up Cx meeting.
4. Accommodate changes as requested by the CA.
5. Update schedule as requested by the CA, or as necessary during construction.
6. Identify and allow time for all key Cx activities and milestones including but not limited to:
  1. CCA review of the commissioning plan and the specifications.
  2. Shop drawing submissions.
  3. Equipment installation verification and pre-start up checks.
  4. System installation verification.
  5. Start up of equipment and systems.
  6. System performance verification; TAB.
  7. Training materials preparation.
  8. O&M Manual delivery.
  9. As-built drawing delivery.
  10. Training.

## 5.0 OVERVIEW OF COMMISSIONING PROCESS

It is a planned program of tests, procedures and checks carried out systematically on components, systems and integrated systems undertaken throughout the construction delivery process and, where necessary, following building handover for the purposes of:

1. Verifying that installed equipment, systems and integrated systems operate in accordance with the owners project requirements, contract documents, design intent, and at maximum safety and efficiency satisfying all functional and operational requirements of the building under all normal occupancy and weather conditions.
2. Ensuring appropriate documentation is provided in the O&M Manuals.
3. Providing effective training of the owner's O&M staff.

4. Providing an effective means of communicating operational difficulties back to the design and construction teams.
5. Establishing baseline operating conditions against which ongoing building operation can be compared.

The commissioning plan may be updated during construction, if necessary to accommodate client program modification or approved design and construction changes.

The commissioning process is comprised of activities conducted by various commissioning team members that occur during the design, construction, acceptance and post acceptance phases of the project.

### Design

1. Review the design intent / owner's requirements and basis of design
2. Review the design to ensure the effectiveness, energy efficiency, maintainability of the installed equipment and components meet the owner's requirements.
3. Review of the construction documents prior to issuing for construction to verify that the requirements for commissioning is incorporated into the documents and the roles and responsibilities of all parties involved in the commissioning process are adequately specified.

### Construction

4. Review contractor's submittals including shop drawings, proposed testing criteria, start-up procedures and check sheets.
5. Hold regular commissioning meetings and issue minutes to all commissioning team members.
6. Pre-start and start-up inspections of all mechanical equipment and systems in a satisfactory manner utilizing manufacture / supplier representatives as required.
7. Verification of the control system sequences of operation.
8. Perform functional performance tests to ensure the results meet test criteria.

### Acceptance

9. Review the testing and balancing results.
10. Review operation and maintenance manuals for completeness and compliance with contract documents.
11. Provide demonstrations to the consultants and the owner and participate in operator instruction and training.

### Post-acceptance

12. Review seasonal testing.

13. Prepare and submit re-commissioning manual
14. Prepare a commissioning report in accordance with LEED requirements.
15. Provide a plan for warranty period resolution of commissioning related issues and carry out a warranty year end inspection and submit a report.

## **6.0 ROLE OF COMMISSIONING AUTHORITY**

The Commissioning Authority is an objective advocate during the commissioning process and provides coordination and general direction to Commissioning Team Members. The Commissioning Authority at their discretion witness tests being conducted by the contractor or will perform their own tests based on random samplings.

The Commissioning Authority's role is quality control and does not in any way relieve the contractor of any commissioning duties. Typical activities provided by the CA include:

1. Preparation of blank commissioning check sheets (EIVF and PVF).
2. Review of the contractor's Cx schedule.
3. Review of contractor shop drawing submittals for commissioned equipment and systems for assessment of their impact on the design intent and ability to be commissioned.
4. Review of construction meeting minutes.
5. Tracking commissioning progress.
6. Review of Requests for Information (RFI's), Site Instructions (SI's) and Contemplated Change Notices (CCN's) for assessment of their impact on the design intent and ability to be commissioned.
7. Review of submitted TAB reports, completed EIVF and PVF for completeness and acceptability.
8. Selective witnessing of testing in conjunction with the Design Team.
9. Review of the contractor's training materials and program.
10. Developing and compiling a re-commissioning manual.
11. Preparation of a warranty period User Issues & Response Plan.
12. Provision of a summary commissioning report at the time of substantial completion and a wrap-up report at the end of the warranty period. Report will include issues raised during the Cx and the contractor's responses and resolutions of these issues.

## **7.0 ROLE OF DESIGN TEAM**

The Design Team will be responsible for ensuring that equipment and systems are installed to satisfy the design intent as describe in their drawings and specifications including:

1. Review shop drawings for general conformance.
2. Attend Cx meetings when requested.
3. General review of construction and preparation of deficiency reports.

4. Selective witnessing of testing in conjunction with the CA.
5. Review of as-built drawings for accuracy.
6. Review of TAB reports.
7. Provide summary descriptions of each system for incorporation into the re-commissioning manual being compiled by the CA.
8. Description of emergency operating procedures for the building for incorporation into the re-commissioning manual.

## 8.0 ROLE OF CONTRACTORS

The contractor carries out the duties assigned in the contract documents and as directed by the commissioning authority.

The Contractor shall provide all labour, materials, tools and equipment necessary for Cx and shall be responsible for implementing all required commissioning activities including: but not limited to:

1. Preparation of a Cx schedule.
2. Submission of shop drawings.
3. Raising commissioning concerns to the CA.
4. Include an agenda item for Cx discussion for all construction meetings and include CA on the circulation list.
5. Attend all commissioning meetings.
6. Complete the equipment EIVF and PVF forms sheets prepared by the commissioning authority as specified for all features and systems requiring commissioning.
7. Submit the completed equipment EIVF and PVF forms to the commissioning authority and consultants for review.
8. All testing, adjusting and balancing.
9. Place all systems into operation and under control to permit functional testing by the commissioning authority.
10. Assist and cooperate with the commissioning authority during the verification of the functional performance of the systems.
11. Participate in troubleshooting those systems that do not meet the functional testing criteria and provide all necessary follow up testing and documentation.
12. Plan and execute all building operator training as set out in the specifications and commissioning plan with the assistance of supplier representatives as required. Prepare training materials and the training of facility O&M staff.
13. Preparation and submission of the O&M Manual.
14. Preparation of as-built drawings.
15. Re-testing and/or undertaking remedial works as deemed necessary by the Cx and/or to address occupant issues.
16. Fine tuning of system set points and operation prior to handover and during the warranty period.

## 9.0 ROLE OF CONTRACTOR'S COMMISSIONING AGENT

1. The contractor shall designate a Contractors Commissioning Agent (CCA) as a single point of contact for all administrative and co-ordination purposes.
2. The CCA shall have a minimum five (5) years experience managing commissioning activities for buildings of similar size and complexity.
3. The CCA shall co-ordinate activities of the construction team members, chair Cx meeting and provide minutes.

## 10.0 WORK PRODUCTS EXPECTED

Expected work products produced throughout the commissioning process and by various commissioning team members are as follows:

DOCUMENT	RESPONSIBLE PARTY
Schematic Design	Consultants
Schematic Design Review	Consultants & Commissioning Authority
Construction Documents	Consultants
Construction Documents Review	Consultants & Commissioning Authority
Construction Schedule	Contractor
Commissioning Schedule	Commissioning Authority / Contractors
Completed Pre Start-Up and Start-Up Check Sheets	Contractors
Shop Drawings	Contractors
Shop Drawing Review	Contractors, Consultants & Commissioning Authority
Minutes of Commissioning Meetings	Commissioning Authority
Air and Water Balancing Report	Contractor
Functional Performance Test Sheets	Commissioning Authority
Commissioning Report	Commissioning Authority
Other Test Documents	Contractor
As Built Drawings	Contractor
Operation and Maintenance Manuals	Contractor
Re-commissioning Manual	Commissioning Authority
Report of issues during first year of operation.	Commissioning Authority
LEED Commissioning Templates	Commissioning Authority

The Commissioning Authority provides blank itemized EIVF and PVF forms for the contractors use to document all relevant information related to the start-up and testing of equipment and systems. These are in addition to the manufacturer's start up check sheets for specialized equipment such as air conditioning units, chillers, boilers, variable speed drives, generators, etc. to be provided by the equipment supplier.

The Commissioning Authority will also provide the PVF forms with procedures proposed to demonstrate that the systems are functioning according to specified control sequences. These check sheets will be based on the sequence of operations specified for each system.

After the EIVF and PVF forms have been reviewed and accepted by the consultants and the commissioning authority, the respective team members proceed in a timely manner based on the commissioning schedule to complete the equipment and system start-ups. The check sheets are completed, along with any relevant information regarding equipment or control performance.

The commissioning authority reviews the completed forms with the consultants and coordinates follow-up actions with the contractor to resolve any issues and to re-verify system performance, conduct inspections and functional performance tests as required.

Results of the functional performance tests are documented to clearly indicate the specified control sequences and the actual performance under all operating conditions, including unoccupied and occupied operation, full heating, full cooling, morning warm-up, modulation within normal operating range, manual operation, alarm conditions, hard wired and software interlocks and emergency operation.

## EQUIPMENT AND SYSTEMS VERIFICATION

1. Contractor shall undertake a systematic verification procedure to ensure that:
  1. Equipment proposed is as specified or has been approved as an acceptable alternative by the Design Team.
  2. Equipment delivered and installed is as per reviewed shop drawings.
  3. Equipment is installed in accordance with all applicable codes, normal good practice, manufacturer's installation guidelines and requirements of these specifications.
  4. Equipment is safe to be started.
  5. Manufacturer's shop drawings, installation guide and O&M materials available for the Cx activities.
  6. As-built records correctly reflect any installation changes.
2. The contractor shall complete the EIVF commissioning check sheets in a timely manner and submit signed sheets in electronic and hard copy to the CA and CCA for review.
3. The EIVFs are provided in appendix, are provided for information and convenience to the Contractor and will not relieve the Contractor of responsibility for complete verification of components or systems not included on the check sheets.

4. The contractor may use their own check sheets, modified as necessary to include all the required checks described on the check sheets provided with substitutions subject to the approval of the CA prior to use.
5. Pre-start up checks must be completed before equipment start-up and systems performance verification.
6. The contractor shall re-submit any check sheets deemed to be incomplete or incorrectly completed and shall make good any equipment or systems installation deficiencies before proceeding with further Cx activities.
7. CCA and CA will sign check sheets, signifying they have been reviewed, and return to the Contractor for incorporation in the O&M Manuals.

## SYSTEM PERFORMANCE VERIFICATION

1. Contractor shall undertake a systematic verification procedure to ensure that equipment and systems operate safely, efficiently and in general conformity with the design intent.
2. Typical activities shall include:
  1. Verifying normal equipment operating conditions.
  2. Verifying proper operation of all safety devices.
  3. Verifying equipment delivery capacity.
  4. Pressure testing.
  5. Submission of TAB plan for review by the CA.
  6. Verifying air and water delivery meets design intent (review of TAB activities).
  7. Verifying hydronic system fluids are clean and treated as per specifications.
  8. Verifying control system operation.
  9. Verifying satisfactory equipment operating points (pumps and fans) and motor loading.
  10. Verifying linkage between interacting systems.
  11. Verifying electrical system parameters such as insulation resistance, phase voltages and currents.
  12. Responding in writing to all commissioning issues raised by the CA.
  13. Maintaining equipment in accordance with manufacturers' instructions from start up to handover.
3. The contractor shall complete the PVF commissioning check sheets in a timely manner and submit signed sheets in electronic and hard copy format to the CA for review as described in the PVF commissioning check sheets.
4. The contractor shall repeat certain tests, as identified in the PVFs, immediately prior to occupancy to verify operating conditions have not changed significantly since commissioning was first completed. Typical checks would include:

1. Pump heads.
  2. Filter and strainer pressure drops.
  3. Boiler, chiller, heat exchanger and AHU delivery temperatures.
  4. Electrical distribution system phase balance.
  5. EMCS alarm and warning messages.
  6. Selected room temperatures.
- 
5. Performance testing shall be undertaken to verify operation over the full range of operating conditions of the building necessitating some performance verification activities be undertaken following building occupancy. Systems should be verified as close to full load conditions as practical not withstanding systems should be commissioned to a degree necessary to ensure proper operation at the start of each change of season.
  6. The PVFs are provided in the appendix and are provided for information and convenience to the Contractor and will not relieve the Contractor of responsibility for complete verification of components or systems not included on the check sheets.
  7. The contractor may use their own check sheets, Statutory Authorities' check sheets, or check sheets prepared by equipment manufacturers, modified or supplemented as necessary to include all the required checks described on the check sheets provided; substitutions subject to the approval of the CA prior to use.
  8. Where specified start-up, testing or commissioning procedures duplicate verification requirements of the Authority Having Jurisdiction, arrange for authority to witness procedures so as to avoid duplication of tests and to facilitate expedient acceptance of facility. Submit certificates of approval with the associated completed commissioning check sheets.
  9. The contractor shall update and re-submit any check sheets deemed to be incomplete or incorrectly completed following a review and spot-checking on site by the CA.
  10. Contractor shall correct any equipment or systems installation deficiencies before proceeding with further Cx activities.
  11. The CCA and CA will sign check sheets, signifying they have been reviewed, and return to the Contractor for incorporation in the O&M Manuals.
  12. All performance testing shall be completed before handover where practical; all seasonal commissioning activities shall be completed within the warranty period unless other arrangements have been made and agreed upon in writing.



## MANUFACTURERS' INVOLVEMENT

1. Shall include as required by these specifications:
  1. Factory testing.
  2. Provision of written instructions for installation, operation and maintenance of equipment provided.
  3. On site pre-start up check.
  4. On-site performance verification.
  5. Training.
2. Requirements for factory testing and the need for witnessing are contained in the various technical sections of these specifications. Where factory testing and witnessing is specified, arrange for all testing and include all associated costs. Obtain CA's approval before shipping to site. Where factory tests specified do not require witnessing forward completed factory test forms to the Design Team before shipping equipment. Copies of factory test certificates should be submitted with the corresponding EIVF commissioning form.
3. Written instructions and recommendations for spare parts and special tools shall be provided for all equipment supplied. Note contractor's responsibility for the actual provision of spare part and special tools is limited to details provided in these specifications.
4. Requirements for manufacturers' pre-start up and performance verification are contained in the various technical sections of these specifications. Manufacturer's site representative shall have a minimum four (4) years experience with equipment of a similar nature and a minimum of one (1) years experience with the manufacturers' product or product line.

## MOCK-UPS

1. Where specifically requested in these specifications undertake Cx activities on mock-ups and obtain the consultants and CA's approval before proceeding with actual or further construction.

## MULTIPLE AND SAMPLE TESTING

1. Unless otherwise detailed in the various technical sections of these specifications, every component and system shall be commissioned regardless of the number of similar components involved.
2. Where sample tests are permitted Any fail requiring remedial measures and re-testing, the CA shall, at their discretion, order additional testing to that described in these specifications.

3. Sample testing shall be scheduled for the first completed installations and periodically through the installation process to check that installation standards are being maintained.
4. The extent of the additional testing shall depend upon the failure rate; testing of all components may be ordered when several consecutive tests fail to provide acceptable results.
5. Such additional work shall be undertaken by the contractor at no additional cost to the contract.

## START-UPS

1. Manufacturers or their agents to undertake equipment start-up where required by these specifications or where required by the equipment manufacturer as a condition of warranty.
2. The CCA shall ensure that a signed copy of manufacturer's test sheet and authority to start equipment is provided by the manufacturer and is attached to the corresponding EIVF commissioning sheet.
3. Where manufacturer not required to do start-up, carry out in accordance with manufacturer's written instructions.
4. Start-up shall not be undertaken until all pre-start up conditions have been satisfied as described in these specifications, included on the commissioning check sheets, or required by the manufacturer.
5. Failure to follow specified start-up procedures may result in re-evaluation of equipment by an independent testing agency.
6. Should the independent testing agency determine that failure to follow proper start-up resulted in damage to equipment, implement following:
  1. Minor equipment/systems: implement corrective measures approved by CA.
  2. Major equipment/systems: if evaluation report concludes that damage is minor, implement corrective measures approved by CA.
  3. If evaluation report concludes that major damage has occurred, CA shall reject equipment.
    - a. Rejected equipment to be removed from site and replaced with new.
    - b. Subject new equipment/systems to specified start-up procedures.
7. The Owner reserves the right to undertake independent performance testing. The Contractor shall co-operate with Owner to facilitate such testing. Such testing will

not relieve the Contractor from compliance with specified start-up and testing procedures.

#### WITNESSING AND VERIFICATION OF TESTING

1. CA or Design Team may witness all or any portion of testing at their discretion.
2. Contractor shall advise CA not less than five (5) days prior to undertaking start-up or verification procedures.
3. Contractor or CCA to be present at all tests performed by sub-trades, suppliers, equipment manufacturers and specialist testing organizations.
4. CA reserves the right to request testing (re-verification) where:
  1. The submitted commissioning check sheets are incomplete, inaccurate or the results deemed unacceptable.
  2. Tests were undertaken without advising the CA of their commencement.
5. CA reserves the right to request re-verification of up to ten percent (10%) of reported results, number and location to be at the discretion of the CA.
6. Perform additional commissioning until results are acceptable to the CA at no additional cost to the contract.
7. Contractor to assume costs incurred by CA for third and subsequent verifications where:
  1. Verification of reported results fail to receive CA's approval.
  2. Repetition of second verification again fails to receive approval.
  3. CA deems Contractor's request for second verification was premature.

#### INSTRUMENTS

1. Submit to CA for review and approval:
  1. Compile list of instruments proposed to be used.
  2. Include serial number, copy of current calibration certificate, calibration date, calibration expiry date and calibration accuracy
2. Use instruments installed under Contract for testing if:
  1. Accuracy complies with these specifications.
  2. Calibration certificates have been provided to the CA.

3. Calibrated EMCS sensors may be used to obtain performance data provided that sensor calibration has been completed and accepted.
3. Where practical, combined instrument and measurement tolerances for performance verification to be within +/- five percent (5%) between measured and actual values. Advise CA and note on commissioning check sheets where this accuracy is not practical and note best accuracy possible.

## OPERATIONS AND MAINTENANCE MANUAL

The contractor is to submit draft O&M manuals for review as specified in the specifications. The O&M manuals shall be organized and include contents as specified by discipline with separate binders being provided for each discipline as necessary.

## SYSTEMS MANUAL

The Systems Manual is compiled by the CA and includes the following components:

1. Final version of the Owners Project Requirements provided by the Owner and the Basis of Design provided by the design consultants.
2. The as-built sequence of operations for all equipment and systems provided by the contractors.
3. Operating instructions for all energy and water saving features and strategies.
4. Functional performance test results (benchmarks), blank test forms and recommended schedule for ongoing benchmarking.
5. Seasonal operational guidelines.
6. Recommendations for recalibration frequency of sensors and actuators by type and use.
7. Single line diagrams for each commissioned system.
8. Troubleshooting table for ongoing achievement of owner project requirements.
9. Guidelines for continuous maintenance of owners project requirements (operational requirements) and basis of design (basis of operation).

## 11.0 DEMONSTRATIONS AND BUILDING OPERATOR TRAINING

The contractor is responsible to provide adequate training for the owners building operations staff so that they become familiar with the various systems and associated controls. The demonstration shall also include advising and ensuring the operators understand how to operate, control, troubleshoot the systems, deal with any alarm conditions in an effective and efficient manner and are aware of all relevant health and safety issues associated with the systems. The operators are to be trained in the environmental aspects of the systems so they are able to operate the systems without unnecessary adverse environmental effects.

1. Demonstrate operation and maintenance and re-commissioning of all equipment and systems.
2. Co-ordinate with Owner to provide training for the owner's personnel. Provide schedule for training not less than two (2) weeks prior to the proposed start date. Training to be undertaken during normal working hours.
3. Demonstration and training to include both classroom tuition and field demonstration at each significantly different system or piece of equipment.
4. Demonstration and training to be completed no later than one (1) week before substantial completion and building hand-over with additional training as necessary after occupancy to demonstrate seasonal operating activities.
5. Keep record of date and time of training, attendees and instructors and forward to CA at completion of training.
6. The O&M manual shall be used as the basis of instruction, review contents of manual in detail to explain all aspects of O&M manual.
7. Provide participants with training evaluation sheets allowing space for participant to suggest need for additional or revised O&M material; review comments and make changes as appropriate. Circulate comment sheets to the CA.
8. Record training sessions for the purposes of future re-training.
9. Time allocations for training is to be coordinated with the CA and owner. Refer to the various technical sections of the specifications for allocations.

## **12.0 WARRANTY PERIOD COMMISSIONING ACTIVITIES**

Between the time of substantial completion and the expiration of the one year warranty period, the Commissioning Team provides technical expertise as required to ensure that warranty issues are dealt with in a timely manner by the responsible parties.

The Commissioning Authority makes one or more site visits as required during the warranty period after turnover to ensure that the operators are familiar with seasonal operating procedures during peak heating and cooling seasons and reviews the building mechanical system performance approximately one month before the expiration of the warranty to review any known commissioning related issues and to recheck systems as required to ensure that the mechanical and control systems are performing and being operated as per the design intent.

1. Activities not able to be completed before occupancy, remedial works and operational changes shall be undertaken and completed before the end of the

warranty period.

2. The CCA shall organize Cx meeting during this period:
  1. Periodically as required to address and update the status of remedial works and seasonal Cx activities.
  2. Two months prior to the end of the warranty period to address outstanding issues and their resolution.
  3. One week prior to the end of the warranty period to address any issues not satisfactorily resolved, agree on which, if any, of the outstanding issues are not warranty issues and to present proposals for the ultimate resolution of such issues.
  4. Meetings during the warranty period shall include the building's operations and maintenance personnel.
3. User feedback and complaints shall be communicated to the contractor only in writing; the CA will provide a reporting form. The contractor shall respond to the issues raised by correcting deficiencies and advising the owner by writing on the original complaints form of the remedial activities undertaken or proposed activities. Copies of the original complaints form and the contractor's response shall be copied to the CA who shall keep a running summary of remedial works and issues.
  1. A sample "Warranty Period: User Issues & Response Plan" is attached (Appendix C) and would be used for these activities subject to modifications as required and agreed between the Building Owner and the Contractor.
  4. CCA shall organize additional training sessions during the warranty period as necessary to cover operation of equipment not operating during the pre-occupancy commissioning period and/or address operational changes.
  5. Contractor to revise O&M as required that reflect changes undertaken during the warranty period and revise field setting markings as required, ensure all final markings are indelible.

**11.0 COMMISSIONING MILESTONES**

The key commissioning process milestones are as follows (future dates estimated):

<b>ACTIVITY</b>	<b>COMPLETION DATE</b>
Commissioning Authority Identified	May 2009
Compilation of Design Intent and Basis of Design	June 2009
Prepare Commissioning Plan	November 2009
Commissioning Requirements Incorporated into Construction Documents	Winter 2009
Shop Drawings Submitted and Reviewed	2010/2011
Installation of Systems to be Commissioned	2010/2011
Testing and Functional Performance Verification by Commissioning Team	Spring 2011
Commissioning & Balancing Reports and O&M Manuals Submitted for Review	Spring 2011
Deferred Seasonal Testing	Winter 2011
LEED Commissioning Template Submitted	Spring 2011
Warranty Year End Review	Spring 2012

**12.0 APPENDIX – EIVF and PVF Forms**

The final blank equipment EIVF and PVF forms will be provided by the Commissioning Authority and forwarded to the contractor for completion after the shop drawing submittals have been reviewed. Enclosed are sample forms.