



Construction Phase Commissioning Plan

Project Name

SABS Labs Treatment Building

Project Number

16429

Date Submitted

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Overview

The purpose of this Commissioning Plan is to provide the Project Team with guide documentation to navigate through the commissioning process. The commissioning process provides a benefit to the owner by ensuring that systems are working according to the design intent of the Architect and Engineering Team. The commissioning documentation is intended to validate proper system operation.

This Commissioning Plan is a living document and will be updated according to the needs of the Owner and Contractor as Commissioning progresses throughout the project.

There are generally two phases to the commissioning process - the design phase and the construction phase. This document addresses only the construction phase.

In the construction phase, the commissioning process begins with the Commissioning Authority(CxA) working with the construction team to verify that a quality control process is being used to ensure all of the proper parts and pieces are installed and the equipment is started up according to the manufacturer's recommendations. The documents used as part of this quality control process are called the **equipment checklists** and the **start-up reports**. The mechanical contractor and, depending on the commissioning scope of work, the electrical contractor has primary responsibility during the pre-functional and start up verification process.

Also in the construction phase, the Commissioning Authority is responsible for reviewing the design documents and developing procedures to test the functionality of the system components, as well as developing performance tests with pass/fail criteria. This project has specified **functional-performance testing** of various systems that are incorporated into the Commissioning Plan. These tests are designed to verify that the systems operate as intended. The Contractors are responsible for successfully executing these tests and the CxA is responsible for directing this work and documenting the results. The Contractors execute the tests on their own as part of their checkout process. This book is turned over to the Owner at project completion. After the Contractors have completed the tests successfully on their own, and an acceptable TAB report has been provided, the CxA schedules the **functional-performance test witnessing**. At the direction of the CxA, the Contractors execute the tests with the CxA witnessing and with the expectation that the observed results will match the previously submitted Contractor completed tests. Although it varies with project scope and is determined by the CM/GC, the BAS contractor and the TAB contractor typically have primary responsibility during functional-performance testing. The completed documentation is included in the Cx book

The construction phase also includes review of the contractor supplied **Operation and Maintenance Manuals** as well as review of the **Owner training** provided by the contractors. The CxA reviews the O&M's and comments on whether the information provided is sufficient enough to allow the Owner to operate and maintain the equipment and also whether the information is specific to the equipment actually installed on site. Contractors are responsible for preparing and submitting training plans to the Commissioning Authority.

The post-occupancy phase consists of deficiency follow up. It is inevitable that deficiencies will be discovered during the commissioning process. These are listed in the **Commissioning Issues Log**. The contractors are responsible for correcting all deficiencies. Contractors are expected to report to the CxA that issues have been resolved and outline the steps taken in the resolution.

Project Description

The Biocontainment Lab at SABS is a disease lab which works with aquatic pathogens in a flow through system. The effluent water must be treated to kill pathogens before it is released back to the sea.

The purpose of the project is to provide a new building to cover the chlorination treatment component of the Biocontainment system to meet the CFIA Level of AQC3 certification. The chlorination system is located at the southern end of the SABS facility near the rear parking area and is easily accessible.

The chlorination system will be in use throughout the construction phase. DFO/PSPC staff will relocate existing chlorine dosing equipment to the main lab temporarily and strip the existing chlorine monitors, controllers, and sample pumps out of the chlorine huts. DFO will rely on manual chlorine measurements for the duration of the project.

As part of the project, controls and equipment reinstalls and/or upgrades to the existing Delta control system, including fibre connection to the network, will occur. Work will involve hook up to the new and existing controls for: chlorine monitors, controlled power for existing secondary dosing pump, new HVAC controls, new UV system controls. Mechanical systems designed and installed in accordance with CFIA Containment Standards for Facilities Handling Aquatic Animal Pathogens. DFO/PSPC will reinstall existing chlorine sample circulation pumps and chlorine monitors and chlorine dosing pumps.

Abbreviations

A/E	Architect / Engineer
BAS	Building Automation System
BOD	Basis of Design
CM	Construction Manager
Cx	Commissioning
CxA	Commissioning Authority
EC	Electrical Contractor
FPT	Functional Performance Test
GC	General Contractor
MC	Mechanical Contractor
O&M	Operation and Maintenance Manual
OPR	Owner's Project Requirements
PFC	Pre-Functional /Equipment Checklist
PM	Project Manager
TAB	Test, Adjust and Balance

Commissioning Team Members and Their Roles and Responsibilities

The following table lists the roles that are members of the Commissioning Team. If there is information missing it should be filled in at the Cx Kick-off Meeting.

Team Member	Company and Contact Name	Phone	E-mail
Owner		Tel:	
Commissioning Authority		Tel:	
Construction Manager		Tel:	
Architect		Tel:	
Mechanical Engineer		Tel:	
Electrical Engineer		Tel:	
General Contractor		Tel:	
Mechanical Contractor		Tel:	
Electrical Contractor		Tel:	
BAS Contractor		Tel:	
UV System Manufacturer		Tel:	
Chlorine Pump Manufacturer		Tel:	
TAB Contractor		Tel:	

Tasks in the Commissioning Process

CxA tasks include the following:

- Perform submittal reviews
- Prepare Cx plan
- Prepare Equipment Checklists (as necessary)
- Prepare FPT's
- Revise FPT's (as required) based on Cx Team feedback
- Conduct site visits as necessary for site verification
- Review the Contractors' equipment and start-up quality control procedures
- Observe and document FPT results for commissioned systems
- Identify and log deficiencies and commissioning issues
- Reviews staff training requirements and verifies completion
- Prepare Final Cx Report

A/E tasks include the following:

- Provide clarifications to design intent as requested
- Participate as needed in commissioning issue resolutions

Contractor tasks include the following:

- Review Cx Plan
- Review FPT's to ensure they are applicable, can actually be performed, and will not damage equipment
- Complete Equipment Checklists (as necessary)
- Document start-up process
- Execute FPT's in presence of CxA
- Resolve commissioning issues
- Conduct Owner Training

Responsibility Matrix

	Cx Authority	Owner A/E	CM/GC	MEP/TAB Contractor	Equipment Representative
Cx Kickoff Meeting. - Early to mid construction phase.	Lead	Attend	Attend	Attend	Attend
Write FUNCTIONAL-PERFORMANCE tests - After shop drawings have been reviewed.	Write				
Review and refine tests.	Refine	Review	Review	Review	Review
Cx Authority Site Visits to Review -use of Equipment Checklists -start-up procedures -start-up documentation	Observe / Review	Review	Discuss / Correct	Discuss / Correct	Discuss / Correct
System and Equipment Start-up. - Submit documentation for record.	Review	Review	Schedule	Execute	Execute
FUNCTIONAL-PERFORMANCE Tests	Observe / Document	Observe	Schedule	Execute	Execute
Commissioning Issues Log	Write	Review	Verify Completion	Correct	Correct
Systems Operations Manual	Write	Review			
Final Cx Report	Write	Review			

Project Schedule

The table below lists the major commissioning tasks in the construction phase and the beginning and ending dates for each task. If not already filled in, the dates should be filled in at the Cx Kickoff meeting. The majority of the information should be provided by the CM/GC. The CxA will provide the specific commissioning dates once the overall project schedule is understood.

The CM/GC is responsible for keeping the CxA informed on all scheduling changes. The CM/GC is also responsible for incorporating the Cx effort into the master project schedule so the proper sequencing of effort and adequate time for Contractor checkout, TAB and CxA witnessing can occur.

Depending on the commissioning scope and the phasing of the project, a more detailed schedule may be required that shows dates for specific equipment.

Table 1 Commissioning Schedule Overview

Item #	Task	Begin	End
1	Cx Kickoff Meeting		
2	Equipment Checklist Phase		
3	Equipment Start Up Phase		
4	TAB		
5	Contractor Pre-Testing		
6	Witnessing of Functional-Performance by CxA		
8	Substantial Completion Date		

For this Project:

1. The CM/GC is expected to provide CxA the most recent copy of the project schedule or, at the very least, the beginning and ending dates for items 2,3,4,5,7 and 8.
2. CxA will then provide beginning and ending dates for items 1 and 6.
3. The CM/GC is expected to regularly update CxA on project schedule changes and copy CxA on all revised project schedule distributions.

Cx Kickoff Meeting

A Commissioning Kickoff meeting is scheduled by the Commissioning Authority at approximately 30% construction progress, but before equipment that is to be commissioned has arrived on site. This is so the full benefits of the Equipment Checklist process can be realized.

In attendance are the members of the commissioning team which include representatives from the GC, PM, A/E, MC, EC, BAS Contractor and TAB Contractor. The objective of the meeting is for all parties to achieve an increased understanding of the Cx process. A **Cx Kickoff Meeting Agenda** and **Sign-in Sheet** are provided in Appendix D of this document.

The purpose of the meeting, which is led by the CxA, includes the following:

- Share and explain the Commissioning Plan for the project
- Help the construction team understand how the forms are used
- Estimate time frames for events
- Address any process questions the commissioning team members may have
- Determine the lines of reporting and communication
- Develop a preliminary schedule
- Review the roles and responsibilities of each Cx team member.

The members of the commissioning team are strongly encouraged to ask any questions they may have about the commissioning process and their involvement.

Equipment Checklists

Equipment Checklists (or pre-functional checklists) are intended to document the quality control process used on the project as it relates to installed equipment. This process applies to both large and small equipment and is targeted at the equipment that is to be commissioned.

The equipment checklist process is designed to make sure that the following is addressed for each piece of equipment:

- Equipment is of the correct make and model number.
- Equipment is not damaged - either when received on site or anytime thereafter.
- Equipment is protected while on site waiting to be installed.
- Location where the equipment will be installed is ready.
- Equipment gets installed per the manufacturers' instructions.
- Equipment has all the accessories required by the construction documents.

Failure in any one of these will result in re-work and extra costs for the installing contractor and potentially delaying the project. Most contractors estimate doing things once. This process is designed to help the contractors achieve that goal.

Equipment checklists typically have two parts, a pre-installation section and an installation section. The pre-installation section is intended to make sure that before the equipment is off-loaded from the delivery truck, that it is the proper make and model number and is not visibly damaged. This simple check can prevent installing the wrong piece of equipment and wasting installation resources and valuable checkout time, especially if the problem is discovered after hours of troubleshooting to determine why the equipment does not perform as intended. The checklist process can also help the installing contractor verify that they are not receiving a damaged piece of equipment.

The installation section is intended to assist the contractor with both the installation of the equipment (according to the contract documents) and the documentation to demonstrate equipment is ready for start up. It is important to make sure the electrical service to the equipment is proper to prevent damage. It is equally important to make sure that the systems served by the equipment are also ready.

Most installing contractors have a quality control process, but unfortunately few of them document this process. A requirement of commissioning is to document this quality control process through the use of equipment checklists.

If the installing contractor has their own equipment checklists, CxA will review these documents, and, if it appears that these checklists adequately ensure the quality of the installation, the installing contractor's documents can be incorporated into the Commissioning Book.

If the installing contractor does not have their own equipment checklists, CxA will work with the installing contractors to develop them by providing generic forms. The contractor is responsible for modifying the forms (as needed) to match the equipment specific to this project.

The installing contractor, not the CxA, is ultimately responsible, for the proper checkout of the equipment and is viewed as an expert as it relates to this equipment. If the CxA or any other individual makes a recommendation that the installing contractor feels may cause damage to the equipment, the installing contractor should inform that party of their concern and only continue with the procedure they determine acceptable.

Primary responsibility for documenting the equipment checklist phase resides with the installing contractors. CxA verifies that a documented process is being used by observing the contractors using the process in the field. All equipment checklists are turned into CxA for inclusion in the Cx Book. On

projects where the equipment quantity is large and thus the amount of checklists numerous, CxA may suggest an alternative approach.

For this Project:

1. Each contractor is responsible to prepare checklists for the equipment and systems they will be installing. These checklists shall be submitted to the CxA for review prior to the equipment being delivered to site. The CxA will then review and approve the checklists for content and completeness prior to use. Ultimate responsibility for completing the checklists resides with the installing contractor. Refer to the Test Manager Matrix for a list of equipment requiring checklists.
2. The CxA will request all completed checklists prior to functional-performance testing. Completed checklists will be incorporated into Cx Book.

Equipment Start-Up

Start-up records are intended to document the process used to prepare a piece of equipment for operation. It is a systematic logical process whereby equipment is transitioned from its shipping and installation state to full operation according to the manufacturer's specifications. Proper start-up is important to make sure the equipment is not damaged at the onset of its use which could result in any of the following:

- Premature failure
- Inefficient operation whereby wasting energy
- Failure to meet design capacities.

The start-up of equipment should be done in accordance with the manufacturer's start up procedures and performed only by individuals with sufficient experience and training on the specific equipment. This process applies to both large and small equipment and is targeted at the equipment that is to be commissioned.

Most installing contractors have start-up procedures, but unfortunately few of them document this process. A requirement of commissioning is to document this quality control process through the use of start-up records.

The installing contractor is not always the contractor responsible for documenting the start-up process. The CM/GC is responsible for determining who is responsible for start-up for each piece of equipment.

The contractor responsible for the start-up is responsible for obtaining the manufacturer's start-up process or developing one on their own. The responsible contractor is asked to submit a start up process to the CxA through the CM/GC and Owner for each unique piece of equipment prior to commencing the start up process. The CxA will review the process to assess its general adequacy and provide comments back to the responsible contractor through the Owner and CM/GC. The contractor, not the CxA, is ultimately responsible for the proper start-up of the equipment and is viewed as an expert as it relates to this equipment. If the CxA or any other individual makes a recommendation that the responsible contractor feels may cause damage to the equipment, the responsible contractor should inform that party of their concern and only proceed with the start-up procedure they determine acceptable.

The responsible contractor is expected to follow every step on the start-up checklist, sign and date it upon successful completion, and provide the CxA a copy for inclusion in the Cx Book.

The CxA may witness the start-up process for selected pieces of equipment at their discretion. The CxA initially provides a list of equipment to the CM/GC that requires documenting of the start-up process. The CM/GC then informs the CxA of the date and time of the start-up for each piece of equipment with sufficient notice so that the CxA can make arrangements to get to the project site if necessary.

For this Project:

1. Refer to the Test Manager Matrix for a list of equipment requiring start-up documentation.
2. The construction team is asked to submit to CxA, via the CM/GC and Owner, their proposed start-up procedures for each piece of equipment listed in the matrix. CxA will review and provide comments if necessary.
3. The CM/GC is expected to inform CxA of the date and time such equipment is scheduled to be started up.
4. Upon successful completion of the start-up procedures, the responsible contractor informs the CM/GC and provides CxA a copy of the completed start-up record(s) for inclusion in the Cx book.

Functional-Performance Testing and Witnessing

Systems are typically made up of many separate independent components which must work as stand-alone control loops. An air handling unit is an example of a system that has many independent components such as control valves, control dampers and sensors that all must work properly for the whole system to work properly. Functional-Performance testing is a process that starts at individual component level, proceeds to the system level and then to the inter-system level.

Verification of the individual components of a system is often referred to as the functional checkout portion of the Functional-Performance test. The functional checkout tests the individual components of a system to make sure the wiring, setpoints, and locations are acceptable. Most independent pieces of equipment will have functional tests. Examples of functional tests for an air handling unit are:

- 1) Verifying that the outside air damper closes when the unit is shut off
- 2) Verifying sensor location and calibration for sensing effectiveness.

Once the proper operation has been verified for all of the individual components, then, and only then, can all of the components be checked to see if they work together as a system. Even though the individual components or pieces of equipment may operate properly, the whole system may not be performing as intended, or the system capacity may not be as high as the design documents imply. This is typically accomplished by witnessing the system execute every line of the sequence of operation. Verification that all of the individual components work together as designed is usually referred to as the performance checkout of the Functional-Performance test. Examples of performance tests for an air handling unit are:

- 1) Verifying the compressors stage on and off to maintain unit supply temperature in a stable manner.
- 2) Verifying correct unit interlocks with other equipment.
- 3) Verifying the scheduled unit operation in occupied and unoccupied mode.

In addition to verifying the sequence of operation, the performance section also tests to verify that the equipment can achieve design capacities, such as cooling, heating and airflow. This testing is typically done by the Mechanical contractor with some help from the TAB contractor.

All Functional-Performance testing is done with simple pass/fail criteria. If a piece of equipment or system fails any individual step of the Functional-Performance testing, the CxA may assist the contractors with investigating and solving the deficiency in the spirit of keeping the testing moving forward. Deficiencies that cannot be resolved within a reasonable time frame are noted on the Issues Log, and the test canceled for that piece of equipment until the responsible contractor has corrected the deficiency.

The CxA will create a Functional-Performance test for each piece of equipment to be commissioned. The tests are then turned over to the construction team for execution. The responsible contractor performs the Functional-Performance test and documents the results as part of their checkout. The contractor then submits the completed Functional-Performance test to the CxA for review and eventual turnover to the Owner. The receipt of the test, coupled with the **Commissioning Test Request Form** (provided in Appendix A) is received as notification by the contractor that the equipment is complete and ready for verification by the CxA.

The CxA will witness the proper operation of equipment as the responsible contractor executes the Functional-Performance test. The CxA will have the contractor's completed Functional-Performance test and will expect to witness the results documented by the contractor. The CxA may choose to sample equipment and not witness each and every piece of equipment. Refer to the Sampling Section of this plan for the sampling strategy for this project. Regardless of whether the CxA utilizes a sampling strategy, the contractors are responsible for ensuring all equipment and systems operate as intended.

The CxA will schedule, through the CM/GC, the Functional-Performance test witnessing. The contractor is expected to supply the necessary labor, tools, and instruments needed to execute the test. The CxA will direct the test, witness the performance, and document the results.

Functional-Performance test witnessing will only be done after TAB is completed for that equipment and system.

The equipment and systems that require functional-performance testing are listed in the Test Manager Matrix.

For this Project:

1. CxA identifies the equipment and systems that require Functional-Performance testing in the Test Manager Matrix.
2. CxA prepares the Functional-Performance tests and distributes to the contractors for review.
3. The responsible contractors review the tests to make sure they are applicable, can be performed, and are not damaging to the equipment.
4. The responsible contractors complete the tests as part of their checkout process.
5. Upon receipt of the preliminary TAB report and the contractor completed Functional-Performance tests, CxA can then, through the CM/GC, schedule Functional-Performance Test witnessing.
6. Upon successful completion of each and every step in the test, a copy will be included in the Cx Book.

Mechanical Contractor

The mechanical contractor is typically responsible for completing the majority of Functional-Performance tests because it is their programming that is responsible for the proper and efficient operation of the equipment. Emphasis is placed not only on execution of the sequences of operation but on the stability of control, rate of response, set points, and other components that affect building occupant comfort and energy usage.

Included in the functional-performance testing of many systems is verification of the controls operation including verification that proper time of day schedules exist and adjustable set points can be easily adjusted. For this reason, it is important that all stand alone controllers have been properly set up.

TAB Contractor

The testing Adjusting & Balancing (TAB) of the systems is vital to the systems achieving occupant comfort, energy efficiency, and design capacity. For this reason, the TAB is included in the Functional-Performance Test witnessing.

The TAB contractor is expected to submit a copy of the preliminary TAB report to the CxA. After review and approval, the CxA can then, through the CM/GC, schedule Functional-Performance Test witnessing. Typical tests include sampling the following:

- 1) Verification of airflow at the diffuser level.
- 2) Adjustment of critical devices such as outdoor air dampers.
- 3) Verification of system level airflows.

The CxA will have a copy of the preliminary TAB report and will expect to find the same results as documented in the report.

Deficiencies and Non-conformance

Throughout the course of the construction and post-occupancy phase, the CxA will be making observations of the system installations that are in progress and of those that are complete. If the CxA identifies an item that does not conform to the project specifications or documents, the CxA will list that item in the **Commissioning Issues Log**.

The CxA will update the Issues Log after each commissioning field visit and submit it to the Owner and CM/GC for review and distribution to the construction team. The CM/GC is responsible for making sure each issue is addressed by the appropriate contractor and notifies the CxA when the issue has been addressed. The CxA then updates the Issues Log with the date the issue was corrected as well as the action taken to correct the issue.

The Commissioning Issues Log does not provide authorization for additional work, change orders, or project extensions. If any item in the Issues Log is viewed by a contractor as outside of or in addition to their contracted scope of work, the contractor is requested to respond stating this and seek direction from the Owner. In addition, the Issues Log does not provide authorization to perform work nor is it intended to contradict the contract documents. If any item in the Issues Log is viewed by a Contractor to contradict the contract documents, the Contractor is requested to notify the CxA of such conflict.

It is very likely that Functional-Performance Test witnessing will be delayed until all identified issues for that equipment or system have been reported back by the contractors as corrected. It is important that the contractors make every attempt to correct the issue because if the CxA returns to the site and determines that a reportedly corrected issue is not corrected, the contractor is at risk of being back-charged for the CxA visit or a portion thereof.

The method of communicating identified issues and their resolution will be discussed and agreed upon at the Cx Kick-off meeting. A sample of the Cx Issues Log format is shown below for reference.

Item No.	Date Posted	Equip. Tag or Location	Comment	Date Addressed	Resp. Party	Initials	Actions Taken	Status
1	4/1/10	AHU-1	Failed freezestat	4/8/10	MC	JJS	Replaced freezestat	Closed

Occupancy Phase Training

Part of the mission of commissioning is to give the Owner the best chance of sustaining the high performance, energy efficient building systems turned over to them at substantial completion. If this high level of efficiency is to be sustained over the life span of the systems, knowledge of the systems design intent and proper operation and maintenance must be conveyed to the facility staff.

For this Project:

1. The CxA will prepare a Systems Operation Manual for the Owner/Managers of the facility.
2. The systems operation manual is intended to be used by the operations & maintenance staff as a companion to the O&M manuals to help guide the proper operation of the systems over their entire life span.
3. This document will be provided to the Owner in electronic format.

Appendix A
Cx Test Request Form

Commissioning - Test Request Form

Project Name:

Date:

To:

FAX:

From:

Subject:

Contractor shall fax this form to CxA to schedule the commissioning authority to visit the site to execute the Functional-Performance Tests. A prerequisite for Functional-Performance Testing is that the systems are started-up and operating according to the parameters listed in the Functional-Performance Tests provided to the contractors during the Commissioning Kickoff Meeting.

The contractors are encouraged to self-perform the Functional-Performance Tests **prior** to field verification by the Commissioning Authority. The contractor may be liable for the Commissioning Authority's labor and material costs if the Functional-Performance Tests cannot be performed due to contractor's uncompleted work.

The Contractor is to fill in the following information and fax to CxA to authorize travel to the site for the purpose of Functional-Performance Testing.

Equipment has been started up by the manufacturers on date: _____

TAB was/will be completed on date: _____

Controls were/will be completed on date: _____

Request Commissioning Authority on-site starting date: _____
(Requires mechanical and controls sub-contractor on-site)

Statement of Readiness: _____
(Name)

(Company)

(Date)

Appendix B Equipment Checklist Process

The construction manager determines which subcontractor is responsible for the equipment checklist process for each type or specific equipment listed in the table below. The construction manager instructs the responsible contractor to prepare and submit their equipment checklist procedures to CxA for review and comment. Each equipment checklist must have a date and signature block for the start-up technician to fill out upon successful completion of the process.

The CM/GC is responsible for managing this process.

Step 1: CxA identifies in Column 1 the equipment name or type for which the equipment process is to be documented and submits the document to CM/GC.

Step 2: The CM/GC indicates in Column 2 the responsible Contractor and provides the responsible contractor(s) and CxA a copy of this document.

Step 3: The CM/GC records in Column 3 the date documentation is submitted to CxA for each piece of equipment.

Step 4: The CM/GC records in Column 4 the date documentation is returned by CxA to the CM/GC. Upon CxA review of the start-up checklist, the CM/GC can then schedule start up of the piece of equipment.

Column 1 Equipment Name or Type	Column 2 Responsible Contractor	Column 3 Submitted to CxA (Date)	Column 4 Reviewed and Returned by CxA (Date)
UV Pumps	Mechanical		
UV Pump VFDs	Mechanical		
250A Feeder – SABS Wet Lab to Greenhouse	Electrical		
200A Feeder – Greenhouse to SABS Quarantine	Electrical		
Power Distribution – SABS Quarantine Electrical Room	Electrical		
Power Distribution – Greenhouse Electrical Room	Electrical		
Power Distribution – SABS Wet Lab	Electrical		
Branch Circuit Wiring	Electrical		
Network Fiber Converter	Electrical		
Communication Systems	Electrical		
Electric Unit Heaters	Electrical		
Lighting and Lighting Controls	Electrical		
Emergency and Exit Lighting	Electrical		
Access Control	Electrical		
Fire Alarm	Electrical		
Chlorination System	Owner		
Dechlorination System	Owner		
Chlorine sampling pumps	Mechanical		

Eye Wash Station	Mechanical		
Eye Wash Station Mixing Valve	Mechanical		
UV Sterilizers	UV System Manufacturer		
Sand Filters	Manufacturer's Rep		
Level Sensors	Controls		
Water flow meters	Mechanical		
Chlorine Monitors	Owner		
Domestic Cold-Water Supply	Mechanical		
Hot Water Distribution	Mechanical		
Air Dampers	Mechanical		
Hand Wash Sink	Mechanical		
Make-Up Air Unit	Mechanical		
Heating Coil	Electrical		
Make-up Air Unit VFD	Mechanical/TAB		
Thermostats	Controls		
Hot Water Tank	Mechanical		
Supply fans	Mechanical		
Exhaust Fans	Mechanical		
Controls	Controls		
TAB	TAB		
HEPA Filtration Equipment	Mechanical		

Appendix C

Equipment Start-Up Documentation and Witnessing

The CM/GC reviews the list below and determine which subcontractor is responsible for the start-up process for each type or specific equipment listed. The CM/GC then instructs the responsible contractor to prepare and submit their start up procedures to CxA for review and comment prior to the start-up of any equipment listed below. Each start-up checklist must have a date and signature block for the start-up technician to fill out upon successful completion of the start-up process.

The CM/GC is responsible for managing this process.

Step 1: CxA identifies in Column 1 the equipment name or type for which the start up process is to be documented and submits to CM/GC.

Step 2: CxA indicates in Column 2 the equipment for which the start-up process requires witnessing. The CM/GC notifies the CxA when each specific or type of equipment listed is scheduled for start-up with enough notification so the CxA can reasonably make accommodations to be on site. CxA will sample witness.

Step 3: The CM/GC indicates in Column 3 the responsible Contractor and provides the responsible contractor(s) and CxA a copy of this document.

Step 4: The CM/GC records in Column 4 the date documentation is submitted to CxA for each piece of equipment.

Step 5: The CM/GC records in Column 5 the date documentation is returned by CxA to the CM/GC. Upon CxA review of the start-up checklist, the CM can then schedule start up of the piece of equipment.

Column 1 Equipment Name or Type	Column 2 Responsible Contractor	Column 3 Submitted to CxA (Date)	Column 4 Reviewed and Returned by CxA (Date)
UV Pumps	Mechanical Contractor		
UV Pump VFDs	Electrical Contractor		
250A Feeder – SABS Wet Lab to Greenhouse	Electrical Contractor		
200A Feeder – Greenhouse to SABS Quarantine	Electrical Contractor		
Power Distribution – SABS Quarantine	Electrical Contractor		
Power Distribution – Greenhouse	Electrical Contractor		
Power Distribution – SABS Wet Lab	Electrical Contractor		
Branch Circuit Wiring	Electrical Contractor		
Network Fiber Converter	Electrical Contractor		
Communication Systems	Electrical Contractor		
Electric Unit Heaters	Electrical Contractor		
Lighting and Lighting Controls	Electrical Contractor		
Emergency and Exit Lighting	Electrical Contractor		
Access Control	Electrical Contractor		

Fire Alarm	Electrical Contractor		
Chlorine Dosing Pumps	Mechanical Contractor		
Dechlorinator Dosing Pumps	Mechanical Contractor		
Eye Wash Station	Mechanical Contractor		
Eye Wash Station Mixing Valve	Mechanical Contractor		
UV Sterilizers	UV System Manufacturer		
Sand Filters	Manufacturer's Rep		
Level Sensors	Controls Contractor		
Water flow meters	Mechanical Contractor		
Chlorine Monitors	Mechanical Contractor		
Domestic Cold-Water Supply	Mechanical Contractor		
Hot Water Distribution	Mechanical Contractor		
Air Dampers	Mechanical Contractor		
Hand Wash Sink	Mechanical Contractor		
Make-Up Air Unit	Mechanical Contractor		
Heating Coil	Electrical Contractor		
Make-up Air Unit VFD	Electrical Contractor		
Thermostats	Controls Contractor		
Hot Water Tank	Mechanical Contractor		
Supply fans	Mechanical Contractor		
Exhaust Fans	Mechanical Contractor		
Controls	Controls Contractor		
TAB	TAB Contractor		
HEPA Filtration Equipment	Mechanical Contractor		

Appendix D
Cx Kickoff Meeting Agenda & Sign-in Sheet

Commissioning Kickoff Meeting Agenda

Project Name:

Date:

Owner
Engineer
Mechanical Contractor
Electrical Contractor
Controls Sub-contractor
TAB Sub-contractor

Attendees:

Project No.

Commissioning

Authority:

1. Introductions.

Fill in Sign-In sheet.

Determine level of commissioning experience with attendees.

2. Commissioning Overview.

Commissioning (Cx) helps improve the quality of the construction process. The commissioning forms provide guidance to the installing contractors to better understand the basis of design of the systems so the systems are installed and set-up properly. The commissioning team will help the contractors optimize the system set-up to maximize capacity and minimize the owner's energy costs.

The commissioning process is intended to *verify* that the contractor's have installed, set-up, and optimized the systems. The Cx team has spent a lot of time developing the Cx forms to provide basis of design information for the benefit of the contractors. The contractors are to use the forms for guidance, fill them out during setup, and review them with the commissioning agent during the verification process.

3. Commissioning Book.

The commissioning book contains the following important documents for the contractors:

Commissioning Plan – defines the Cx process

Test Manager Matrix – tracking form for all checklists, forms and tests

Equipment Checklists – verification of proper equipment and installation; these documents can be provided by the installing contractor, subject to CxA review, prior to use.

Functional-Performance Tests – verification of correct component function and overall equipment sequences and capacities

4. Commissioning Schedule

On-going construction site-visits by CxA
Contractors complete equipment (pre-functional) checklists.
Contractors complete start-up of equipment and document using their own forms.
Substantial completion
TAB completion
Controls completion
Functional-Performance Tests performed by contractors and witnessed by CxA

If Owner move-in is a priority, some of the functional-performance tests can happen during move-in or early in occupancy.

5. Deficiencies

Deficiencies and any recommendations for improvement from the CxA will be tracked in the Cx Issues Log. Items that fail to comply with the project documents are deficiencies. It should be noted that the Construction Administration and Cx field staff specialize in different areas. CA focuses on construction; Cx focuses on operation, performance, comfort, and energy consumption. CA and Cx will keep track of deficiencies separately. Contractors are expected to sign-off and fax back the Cx Issues Log when deficiencies are completed.

6. Responsibilities

CM	Manage the process and track progress of subs
Electrical	Complete respective portions of checklists, provide early power, coordinate generator testing
Plumbing	Complete associated equipment checklists, require mfr's start-up of major equipment and document completion
Mechanical	Complete associated equipment checklists, manage mfr's start-up and document, assist with controls
Controls	Complete programming early, test and calibrate all devices
TAB	Follow specifications closely, provide TAB report to CxA

7. What to Expect During the Process

Functional-Performance Tests – mostly controls, recommend as much programming completed off-site
TAB – will use final TAB report and flow hood to verify accuracy

Appendix E
Sample Commissioning Checklists



Project Name: SABS BUILDING
Date of Site Visit _____
By : _____
Discipline : Mechanical

Commissioning Checklist

The following is a checklist of items that will be inspected and commented on.

1	PLUMBING - SANITARY SEWER SYSTEM
	Sanitary Sewer System is installed a minimum of 1.0 meter outside the building foundation?
	Excavation elevation and bedding elevation are acceptable prior to pipe installation (Y/N)
	Pipe and fittings are clean of debris and water before installation (Y/N)
	Pipe is installed in accordance with manufacturer's recommendations (Y/N)
	All required pressure-testing is complete (Y/N)
	All applicable coatings and wrappings are applied to piping system (Y/N)
	Backfill and compaction of sanitary sewer. Proper materials are placed and compacted as per the specifications and drawings.
	Engineer sign-off of new piping prior to hydrostatic pressure tests (Y/N)
	Pressure gauge accuracy verified by comparison with calibrated test instruments (Y/N)
	After accuracy verified, conduct full scale tests at max. flow rates, operating temperatures and pressures for continuous 2 hours. Passed? (Y/N)
	All floor drains and clean-outs accessible and clear of debris? (Y/N)
	Deep seal p-traps installed on drain lines? (Y/N)
	Additional Comments / Observations



3	PLUMBING - DOMESTIC HOT WATER SYSTEM
	DHW Tank & Ancillaries Installed as per drawings & specifications (Y/N)
	Installed as per manufacturer's recommendations (Y/N)
	Tank is level (Y/N)
	Specification plate is visible (Y/N)
	Poly sump installed beneath tank (Y/N)
	All piping is as per drawings, identified, and insulated (Y/N)
	Pressure Relief valve installed on tank and pipped to drain? (Y/N)
	Air vent installed at highest point in system (Y/N)
	Check valves installed (Y/N)
	Shut off valves installed (Y/N)
	Vacuum breaker installed (Y/N)
	All piping supported (Y/N)
	Operated for 12 hours continuously (Y/N)
	No leakage from mechanical seals (Y/N)
	Thermometer installed on inlet and outlet of DHW tank (Y/N)
	Hot water delivered to system (Y/N)
	Additional Comments / Observations



4	HVAC - FANS (Supply and Exhaust)
	Installed as per drawings & specifications (Y/N)
	Installed as per manufacturer's recommendations (Y/N)
	Fan bearings lubricated (Y/N)
	Fan rotation correct (Y/N)
	Fan casing cleaned (Y/N)
	Duct geometry correct (Y/N)
	Exhaust Fans come complete with VFDs where indicated (Y/N)
	Exhaust Fans EF-1 and EF-2 and supply fan SF-1 come complete with vibration isolators (Y/N)
	Spare parts: Matched set of belts, bearings and seals, addresses of suppliers, list of specialized tools necessary for adjusting, repairing or replacing of each piece of equipment (Y/N)
	In addition to filters installed immediately prior to construction acceptance by Owner, one additional set of filters for each system provided? (Y/N)
	Additional Comments / Observations



5 MAKE-UP AIR HANDLER
Installed as per drawings & specifications (Y/N)
Installed as per manufacturer's recommendations (Y/N)
Lamacoid nameplate labels affixed to unit (Y/N)
Casing condition good: no dents, door gaskets installed (Y/N)
No holes in the unit, i.e. missing screws or caps (Y/N)
Access doors close tightly, and open easily (Y/N)
Factory disconnect (Y/N)
Unit complete with starters? (Y/N)
Unit complete with BACNet compatible control panel? (Y/N)
Filter frame made of expanded metal? (Y/N)
Filters installed, and clean (Y/N)
Spare parts: 1 spare set of filters? (Y/N)
Additional Comments / Observations



6	AIR DISTRIBUTION SYSTEM
	Installed as per drawings & specifications (Y/N)
	Installed as per manufacturer's recommendations (Y/N)
	Quality of duct construction?
	Wall penetrations sealed? (Y/N)
	Access for inspection and servicing of dampers/actuators/etc? (Y/N)
	No cracks around damper frames?
	Balancing damper blades close fully/seal tightly? (Y/N)
	Motorized dampers stroke fully open to fully closed? (Y/N)
	Damper accessible and identified? (Y/N)
	Actuator not in air stream?
	Flexible connectors installed at inlet & outlet of each fan/air handler, and tested to ensure adequate pressure (after seals have cured) (Y/N)
	Performance verification of ducted air systems to be performed by same certified TAB agency as approved to undertake TAB on this project. Results acceptable within tolerances?
	Additional Comments / Observations



7	CONTROLS
	Commissioning of system(s) to be in accordance with specifications
	Sequence of operation checked with schematic? (Y/N)
	Test each DI, DO, AI, AO to ensure proper operation of controlled devices. Issues?
	Test software and provide samples of logs/commands. Issues?
	Strobe and horn to indicate ventilation system failure activating upon unit shutdown? (Y/N)
	Differential pressure sensors maintaining appropriate airflow direction? (Y/N)
	Inward directional airflow verified? (Y/N)
	Sequence of operation & verification report provided? (Y/N)
	All controls devices installed and wired? (Y/N)
	All devices labeled? (Y/N)
	Pulse width modulating solid state relay for unit heater installed as per drawings? (Y/N)
	Tamper locks installed on breakers of circuit panels for Operator Work Station(s), peripherals, controllers as per specifications? (Y/N)
	Primary Operator Work Station PC Components: Two spare expansion slots in system provided for PWGSC's use (Y/N)
	Field mounted panels, transmitters, sensors, etc. supported on pipe stands/channel brackets? (Y/N)
	Thermowells installed for piping applications? (Y/N)
	Occupancy sensors installed within each space? (Y/N)
	Confirmation of unoccupied vs. occupied sequence activation upon trigger of occupancy sensor? Verify with TAB report (Y/N)
	Graphics on center PC in main DFO facility updated to reflect renovations/additional equipment and tested for functionality? (Y/N)
	Demonstration of operation of system (including sequence of operations under normal and emergency conditions) to departmental representative in accordance with specifications. Issues?
Additional Comments / Observations	



Project Name: SABS BUILDING
 Date of Site Visit _____
 By : _____
 Discipline : Process Equipment

Commissioning Checklist

The following is a checklist of items that will be inspected and commented on.

1	CHLORINATION SYSTEM
	Ultrasonic Transducer on top of in-use chlorine barrel connected to Delta Controls system? (Y/N) Issues?
	Transducer tied in to transfer pump? (Y/N) Issues?
	Chlorine dosing pumps to be tested as per manufacturer's start-up procedures. Issues?
	Chlorine dosing pumps connected to influent flow meter(s)? (Y/N) Issues?
	Chlorine dosing pumps connected to Delta Controls system? (Y/N) Issues?
	Chlorine pumps, flow meters, and analyzers calibrated and work as a complete system (Y/N). Issues?
	Level switch installed in spare chlorination tank connected to transfer pump for shut-off and to Delta Control system for alarm? (Y/N) Issues?
	Equipment alarms operational? (Y/N)
	All equipment pertaining to this system installed as per drawings (Y/N)
	Spare Parts: One Flow Indicator per panel (total of 3 required) (Y/N)
	Each pump supplied with two repair kits, one spare pump heads and one injector lance (Y/N)
	Additional Comments / Observations



2	UV SYSTEM
	UV Sterilizers and panel to be tested by Manufacturer's rep. (Emperor Aquatics). Issues?
	UV Pumps to be tested by mechanical engineer in accordance with manufacturer's recommendations. Issues?
	UV Pumps operating and connected to level pressure sensor and controlled by VFDs? (Y/N) Issues?
	Sand filters to be installed and tested bas per manufacturer's start-up procedures (Pentair). Issues?
	All equipment pertaining to this system installed as per drawings? (Y/N)
	Are power enclosures (typical 2) for UV system installed as per drawings and functional? (Y/N) Issues?
	Temperature alarm for UV system linked to Delta Controls System? (Y/N) Issues?
	Bulb failure alarm for UV system linked to Delta Controls System? (Y/N) Issues?
	Ultrasonic Transit Time Flowmeter (clamp-on style) installed on UV system piping and operational as per manufacturer's requirements? (Y/N)
	UV system to be functional as a complete unit as per process drawings and specifications (Y/N). Issues?
	Spare Parts for Pumps: one set of packing, one casing joint gasket, one glass for each gauge glass, one filter cartridge or set of filter media for each filter/filter bank in addition to final operating set. Included? (Y/N)
	Spare Parts for System: 8 UV Lamps, 8 Quartz sleeves, 8 Sleeve Holder Seals (Y/N)
	Additional Comments / Observations



3	DECHLORINATION SYSTEM
	Ultrasonic Transducer on top of in-use dechlorination chemical barrel connected to Delta Controls system? (Y/N) Issues? Transducer tied in to transfer pump? (Y/N) Issues?
	Dechlorination chemical dosing pumps to be tested as per manufacturer's start-up procedures. Issues?
	Dechlorination chemical dosing pumps connected to influent flow meter(s)? (Y/N) Issues?
	Dechlorination chemical dosing pumps connected to Delta Controls system? (Y/N) Issues?
	Dechlorination chemical pumps, flow meters, and analyzers calibrated and work as a complete system (Y/N). Issues?
	Level switch installed in spare dechlorination chemical tank connected to transfer pump for shut-off and to Delta Control system for alarm? (Y/N) Issues?
	Equipment alarms operational? (Y/N)
	All equipment pertaining to this system installed as per drawings (Y/N)
	Spare Parts: One Flow Indicator per panel (total of 3 required) (Y/N)
	Additional Comments / Observations



4	CHLORINE SAMPLE PUMPS (WATER CIRCULATION PUMPS)
	Water loop pumps (three total) to be tested as per manufacturer's start-up procedures. Issues?
	Sample lines off pump discharge installed and working correctly to feed analyzers (Y/N) Issues?
	Chlorine analyzers to be tested as per manufacturer's start-up procedures. Issues?
	Pressure gauges installed at suction and discharge of pumps? (Y/N)
	Water loop pumps and analyzers calibrated and work as a complete system (Y/N). Issues?
	Equipment alarms operational? (Y/N)
	All equipment pertaining to this system installed as per drawings? (Y/N)
	Spare parts provided? (Y/N)
	Additional Comments / Observations



5 FLOWMETER	Ensure line and working environment clean during installation (Y/N)
	Is the associated instrumentation compatible with flow meter output (i.e. pulse or analog?, voltage or current? PNP or NPN? frequency range?) (Y/N) Issues?
	Flowmeter connected to Delta Controls system? (Y/N)
	Is the flow meter installed in the correct orientation? (Y/N)
	Has flow meter been calibrated as part of manufacturer's specifications? (Y/N)
	Functionality verified as per manufacturer's specifications including, but not limited to, display and totalizer? (Y/N)
	Additional Comments / Observations



6 GENERAL	Instrument type and class as per drawings and specifications? (Y/N)
	Instrument tag(s) installed and correct? (Y/N)
	Wiring of all devices, equipment, etc. correct? (Y/N)
	Connections secure? (Y/N)
	Is all Process equipment make/model an acceptable manufacturer as per specification(s)? (Y/N) If no, explain why.
	Drawings marked up as-built? (Y/N)
	Testing and witnessing of system/sub-systems completed as per Cx Plan? (Y/N)
	Additional Comments / Observations



Project Name: SABS BUILDING
Date of Site Visit _____
By : _____
Discipline : Electrical

Commissioning Checklist

The following is a checklist of items that will be inspected and commented on.

1	MAIN SABS WET LAB ELECTRICAL ROOM TO GREENHOUSE ELECTRICAL ROOM FEEDER - 250A FEEDER
	Are Conductors Labeled and Color coded?
	Are Duct/Conduits Sealed at penetrations?
	Additional Comments / Observations

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2 GREENHOUSE ELECTRICAL ROOM TO SABS QUARANTINE LAB ELECTRICAL ROOM FEEDER - 200A FEEDER

Are Conductors Labeled and Color coded?

Are Duct/Conduits Sealed at penetrations?

Additional Comments / Observations

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3 POWER DISTRIBUTION - SABS QUARANTINE LAB ELECTRICAL ROOM		
Is the System Energized?	Yes	No
Are typed panel directories present, circuit numbers identified? If No Identify:	Yes	No
Are Conduits and Conductors Labeled and Color coded?		
Are lamicooids installed on panelboards, disconnect switches, starters, contactors, cabinets and transformers?	Yes	No
Is the system grounded?	Yes	No
Are the proper grounding connectors used (compression or thermit)?	Yes	No
Panel	Spare Breakers	Spare Spaces
6E1A 600V/225A		
2E1A 120/208V/225 A		
Are Lock On devices for breakers installed and are there spares?		
Are the Breakers all the same KA rating? If no Identify:		
Are the panels load balanced?		
Are all Panel feeders Meggered (provide report) ? (Y/N)		
Is Transformer, TX-2E1A, Grounded (45 kVA, 600-120/208V)?		
Transformer has adequate clearance for ventilation? (Y/N)		
Additional Comments / Observations		



4	POWER DISTRIBUTION - GREENHOUSE ELECTRICAL ROOM		
	Is the System Energized? Yes No		
	Are typed panel directories present, circuit numbers identified? Yes No If No Identify:		
	Are Conduits and Conductors Labeled and Color coded?		
	Is lamicaid installed on panelboard? Yes No		
	Is the system grounded? Yes No		
	Are the proper grounding connectors used (compression or thermit)? Yes No		
	Panel	Spare Breakers	Spare Spaces
	6LPA1 600V/400A		
	Are the Breakers all the same KA rating? If no Identify:		
	Are the panels load balanced?		
	Are all Panel feeders Meggered (provide report) ? (Y/N)		
	Is Transformer, TX-2E1A, Grounded (45 kVA, 600-120/208V)?		
Transformer has adequate clearance for ventilation? (Y/N)			
Additional Comments / Observations			



5 POWER DISTRIBUTION - SABS WET LAB ELECTRICAL ROOM		
Is the System Energized?	Yes	No
Is the 250A-3P breaker in switchboard 'DP-WIAE1' programmed, tested and commissioned by an I-Gard manufacturer's representative? Provide test results:	Yes	No
Are the zero sequence current sensors installed?	Yes	No
Is the feeder module installed?	Yes	No
Shunt-trip unit on 250A-3P breaker operates correctly?	Yes	No
Are lamicroids installed on switchboards to indicate panelboard being fed? If no identify:	Yes	No
Are the Breakers all the same KA rating? If no Identify:		
Are all Panel feeders Meggered (provide report) ? (Y/N)		
Additional Comments / Observations		



5 Branch circuit wiring	
Are Conduits and Conductors Labeled and Color coded?	
Test voltage drop at each receptacle. Provide test results.	
Are Spare Conduits Installed c/w Fish Wires?	
Conduit and Cable Installation	Installed straight and true
	Properly Supported
	Workmanship neat
Are PVC expansion Joints Installed?	
Are Conduits sealed at both ends and penetrations?	
Are conduits more than 40% full?	
Additional Comments / Observations	



6 Communication systems including additional data		
System in Operation?	Yes	No
Have all network cables been verified with tester? Provide test results.	Yes	No
New Network Ties in to Existing Fibre Switch?	Yes	No
Network Cables Identified	Yes	No
Fiber optic Cables Identified	Yes	No
Cables neatly bundled within data rack with Velcro or supported by cable managers?	Yes	No
UPS provided with data rack?	Yes	No
Spare Cables Coiled and Identified	Yes	No
Harness Slack in Cables	Yes	No
Are Duct/Conduits sealed at penetrations?	Yes	No
Additional Comments / Observations		



7	Electric Unit Heaters
	Installed as per manufacturer's installation instructions and specifications? (Y/N)
	Test fan delay switch to assure dissipation of heat after element shut down. Results:
	Heaters and controls operate correctly? (Y/N)
	Additional Comments/Observations

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10	Access Control
	Samples for each component proposed included in system (Y/N)
	Verification certificates signed by manufacturer submitted? (Y/N)
	Test and evaluation reports from testing laboratories submitted (Y/N)
	Operation and Maintenance data including functional description of equipment and instructions of operation of equipment submitted (Y/N)
	Recorded system pretest measurements and pretest certification submitted? (Y/N)
	All system manuals, as-built drawings submitted (Y/N)
	Electrical power circuits for system are properly labeled, wired, phased, protected, grounded (Y/N)
	Conductor ends are protected by heat shrink wrap; audio spade lugs, barrier strips and punch blocks are used (Y/N)
	Equipment properly labeled? (Y/N)
	Equipment identified in system's equipment list are in place and properly installed? (Y/N)
	Equipment fastened properly? (Y/N)
	Inclusion of all accessories? (Y/N)
	ULC decals applied to equipment? (Y/N)
	Operational testing of each subsystem and overall system conforms to spec? (performed by access control equipment manufacturer) (Y/N)
	Additional Comments/Observations



11	Fire Alarm System
	System manufacturer present to perform tests as per specification and system installation instructions? (Y/N)
	15 spare glass rods for manual pull box stations provided as per specification?
	Lectures and demonstration by fire alarm equipment manufacturer to train operational personnel in use and maintenance of fire alarm system (Y/N)
	Detectors mounted more than 1 m from air outlets? (Y/N)
	At least 600 mm radius clear space on ceiling, below and around detectors (Y/N)
	Ensure no splices are present.
	Ensure wiring is free of opens, shorts, grounds before system testing.
	Additional Comments/Observations