FACILITIES & OPERATIONS
ARCHITECTURE, ENGINEERING AND CONSTRUCTION
UNIVERSITY OF MICHIGAN

Generic Sample

Commissioning Plan

Building Name: _____

Project Name: _____

U-M Project No._____

U-M Building No._____

Editor's Notes:

11/26/01: Revised Training and added O&M under part 1.4.

5/22/12: Revised the Progress Check Sheet sample to the condensed version. Changed all references from "Commissioning Agent" to "Commissioning Authority".

9-1-14: Revised title to Commissioning Plan" instead of "Commissioning Manual" and other minor changes to align better with ASHRAE Standard 202-2013. D. Karle for CPR dept.

3/23/16: Minor terminology changes and spec check.

7/01/16: Significant update to improve plan content, formatting, and Section 1.4. 1.6, and 1.7 by D. Karle.

Commissioning (Cx) Plan Index

Tab 1 - Introduction

- **1.1 Introduction to Cx and Intent of the Commissioning Plan**
- **1.2 Breakdown of Commissioning Responsibilities**
- **1.3 Commissioning Team (& List of Sub-Contractors)**
- **1.4 General Cx Procedures**
- **1.5 Sample Progress Check Sheets**
- **1.6 Sample Order and Timing List**
- **1.7 Standardized Cx Forms: Pre-Installation Check Sheet, Training, Duct Leak Testing, Pre-Start Check Sheet (sample)**
- **1.8 Fundamental Cx Requirements for All Projects**
- **1.9 Operation and Maintenance Manual Check List**

Tab 2 – General Commissioning Documentation

- **2.1 List of Systems and Components to be Commissioned**
- **2.2 Commissioning Status Check Sheets**
- **2.3 OPR/BOD Requirements**
- **2.4 Order and Timing List**
- **2.5 Water Treatment/Flushing and Cleaning Reports**
- **2.6 AHJ Approval Documentation**
- **2.7 Commissioning Meeting Minutes**
- **2.8 Commissioning Reports**
- **2.9 Transmittal Records**
- **2.10 Record of O&M Manual Submittals**
- **2.11 Record of Test and Balance Activities**
- **2.12 Mechanical Test Reports**
- **2.13 Electrical Reports**
- **2.14 Owner Training Record**

Tab 3 – Commissioning Documentation Specific to Equipment and Systems

3.1 [System Title]

3.2 [System Title]

3.3 [System Title]

3.4 [System Title]

ETC.

1.1 Introduction to Cx and Intent of the Commissioning Plan

Definition of Commissioning (Cx)

For purposes of this project, Commissioning is defined as a Quality Assurance Process designed to ensure buildings are designed to meet the needs of the user, and built and operated as intended by the design team and users. Commissioning is a team effort that requires the coordination and cooperation of all members of the Cx Team.

Commissioning for this Project

Commissioning activities are the shared responsibility of the Commissioning Team. The team shall consist of the Owner's Commissioning Authority, the University, the Architect/Engineer, and the Contractor (and his suppliers). The Commissioning Plan is the vehicle by which the Cx process is planned and documented. The draft version of the Cx Plan for this project was produced by the Commissioning Authority (CxA). The Owner's Commissioning Authority and the Contractor are responsible for developing the final Commissioning Plan and executing all commissioning activities. The Contractor is responsible for obtaining all documentation related to the commissioning effort, and submitting same to the Commissioning Authority for approval. Commissioning activities shall be conducted by the Contractor, and witnessed by the Commissioning Authority or a designated University representative.

1.2 Breakdown of Commissioning Responsibilities

Note - this is an overview and is not meant to list all necessary duties each party must fulfill during the process.

General Contractor/Construction Manager:

- Responsible for assuring Contractors fulfill all project Commissioning requirements
- Organize Contractors relative to the Commissioning Process
- Assist CxA in scheduling Cx meetings. Invite appropriate parties to Cx meetings. Attend all such meetings.
- Assist the CxA in validating the Cx Process
- Assist in development of the Commissioning Plan
- Maintain up to date field copy of the project Cx Plan during construction.
- Assist in development of order and timing
- Integrate order and timing into the project schedule
- Obtain paperwork for inclusion in the Commissioning Plan
- Schedule start-ups and other events. Insure system is ready for start-up.
- Oversee the coordination drawing process
- O&M Manuals.

Contractors:

- Attend meetings
- Invite appropriate parties to meetings
- Provide paperwork for inclusion in the Commissioning Plan
- Assist in development of order and timing
- Assist in development of the Commissioning Plan
- Follow the Cx Status Check Sheet and be ready for Start-Ups, Functional Tests, and other commissioning events
- Conduct pre-start checks
- Organize vendor check/test/starts
- Attend/conduct start-ups
- Functionally test systems, with Commissioning Authority witnessing
- Attend/conduct training

- O&M Manuals

Commissioning Authority (CxA):

- Write commissioning meeting minutes
- Review shop drawings in parallel w/AE of record
- Develop order and timing (lead)
- Develop and update the project Commissioning Plan (lead)
- Schedule meetings
- Write Commissioning Reports
- Witness/Commission
- Coordinate UM personnel relative to commissioning
- Trouble shoot in cooperation with engineer of record
- Enforce commissioning process
- Review and approve O&M Manuals

1.3 Commissioning Team

The following list includes names of individuals and organizations involved directly or indirectly in the Cx process for this project:

Owner and Design Team

(Name/Role)

U of M User/ Owner	**Phone**	**E-Mail**
Architect/ Engineer	**Phone**	**E-Mail**
U-M Project/Construction Managers	**Phone**	**E-Mail**

General Contractor/Construction Manager

Name/Role	**Phone**	**E-Mail**

Commissioning Authority

Name/Role	**Phone**	**E-Mail**

Contractor:

Construction Manager -
Project Manager
On Site Foreman
Commissioning Lead

Mechanical & Piping -
Project Manager
On Site Foreman
Commissioning Lead

Fire Protection
Project Manager
On Site Foreman
Commissioning Lead

Sheet Metal
Project Manager
On Site foreman
Commissioning Lead

Controls
Project Manager
On Site foreman
Commissioning Lead

Test and Balance
Project Manager
On Site foreman

Electrical -
Project Manager
On Site Foreman
Commissioning Lead

Suppliers/ Manufacturers

Air Handling Units:
Manufacturer:
Supplier/contact/phone:

Return Fans
Manufacturer:
Supplier/contact/phone:

Exhaust Fans
Manufacturer:
Supplier/contact/phone:

Heat Exchangers
Manufacturer:
Supplier/contact/phone:

Humidifiers:
Manufacturer:
Supplier/contact/phone:

Variable Frequency Drives
Manufacturer:
Supplier/contact/phone:

Condensate Pumps:
Manufacturer:
Supplier/contact/phone:

Grilles/registers/diffusers
Manufacturer:
Supplier/contact/phone:

VAV Boxes
Manufacturer:
Supplier/contact/phone:

Radiant Ceiling Panels
Manufacturer:
Supplier/contact/phone:

R.O. Water System
Manufacturer:
Supplier/contact/phone:

Fire Alarm System
Manufacturer:
Supplier/contact/phone:

Security (Card Reader)
Manufacturer:
Supplier/contact/phone:

[ADD OTHERS AS NECESSARY]

1.4 General Cx Procedures

Commissioning is the responsibility of the Contractor, with the cooperation and assistance of the University's Commissioning Authority (CxA). The following information outlines the procedures and defines the minimum requirements for commissioning the project. The procedures and the forms that document the Cx activities shall be developed by the Commissioning Authority with the assistance of the Commissioning Team.

The typically required documentation for commissioning includes but is not limited to the list below. Copies of this documentation must be collected by the Contractor and inserted in the Commissioning Plan.

- Installation Sequences
- Manufacturer's Factory Testing Certificates
- Cx Status Check Sheets
- Pre-Installation Check Sheets
- Pre-Start Checklists
- Manufacturer's Check, Test and Start Forms/Field Reports
- Functional Test Forms
- Performance Test Data/ Report
- Cx Order and Timing, integrated into the Project Schedule
- Duct Leakage Testing
- Training Plan/Attendance Sheets/Reports
- Pipe Flushing and Cleaning Plan
- Water/Water Treatment Reports
- AHJ Approval Documentation
- Lube/Filter/Maintenance Reports
- Various Project Specific Certifications/Field Test Reports
- Cx Meeting Minutes
- Cx Reports
- Transmittal Record

The activities recorded by the above documentation and the minimum responsibilities of Commissioning Team members are described below.

Explanation of Responsibilities and Terms used in the Commissioning Process

Owner's Project Requirements (OPR) and Basis of Design (BOD)

The OPR is a detailed description of the Owner's goals and requirements for the project, and the Owner's expectations on how the project will be used and operated.

The BOD is a detailed description of the Design Team's concepts, assumptions, calculations, decisions, product selections and operating conditions to meet the Owner's project requirements and to satisfy applicable codes, standards and guidelines.

These two documents, prepared by the Architect/Engineer, are the benchmarks by which the completeness, adequacy and acceptability of the project is judged. Therefore they provide fundamental goals the commissioning process must verify.

The CxA reviews the OPR/BOD and extracts the requirements pertinent to the Cx process. These requirements are then summarized in Section 2.3 of the Commissioning Plan.

Commissioning Plan

The Cx Plan (this document) outlines the project specific requirements and responsibilities of the Cx process. The Cx Plan also stores all validating documentation related to the Cx process in a hard cover 3 ring binder with a table of contents and tabbed sections. For large projects 3 separate binders may be required: Architectural, Mechanical, and Electrical. When possible however it is desirable to combine all systems into one binder. At minimum two copies of all binders shall be maintained, one by the Commissioning Authority, and a field copy by the General Contractor (GC) (or the Construction Manager (CM)). It is the responsibility of the Contractors to provide, through the GC (CM), all commissioning documentation, for insertion in the master Commissioning Plan, which will be held by the Commissioning Authority. The GC (CM) shall maintain a parallel field copy of the Commissioning Plan. Once all project commissioning activities are complete including the resolution of issues, the Commissioning Authority shall transmit the completed Commissioning Plan to the U-M Architecture, Engineering, and Construction Facilities Information Center (FIC) for archiving.

Communication

The commissioning process shall follow the same communication procedures established for the balance of the project.

Installation Sequence

The installation sequence is a written plan developed by the installing Contractor for completing the installation of the system. It may be required where phasing of the installation is critical, and when delivering and rigging are especially sensitive. Installation sequences are required at the discretion of the CxA.

Coordination Drawings

Coordination drawings are required on many projects, especially where spatial constraints make installation difficult. Coordination drawings are addressed in the specification. The coordination drawing process is orchestrated by the GC (CM) , with the cooperation and participation of all Contractors. The Commissioning Authority shall be invited to all coordination meetings. The Commissioning Authority will typically attend the first few coordination drawing meetings and thereafter at his/her option.

Manufacturer's Factory Testing Certificates

Testing certificates of factory tested systems (air handlers, boilers, etc.) or components. Testing may consist of functional testing, performance verification, acoustic testing

vibration testing. etc. Certificates shall be retained in the related equipment or system Part 3 section.

Commissioning Status Check Sheets

Check sheets, organized in a summary basis, that track the progress of equipment and systems, from submittal phase, through installation, pre-start tests, start-up, functional testing, and ultimately final acceptance. Also tracks select commissioning activities, such as O&M Manuals. Reviewed and updated during Cx meetings. A sample can be found in Section 1.5.

Pre-Installation Check Sheet

All materials and equipment shall be inspected for damage, compliance to the approved submittal, etc. upon arrival from the supplier. Certain materials or equipment identified in the Commissioning Status Check Sheets or as otherwise required by the CxA shall be certified as examined via a standardized "Pre-Installation Check Sheet" form (see Section 1.7). Equipment manufacturers often have a pre-installation checklist used to make sure installation will go according to plan. In such cases, this form shall be filled out and submitted with the standardized form. Check sheets are completed by the appropriate Contractor foreman and submitted to the CxA.

Pre-Start Checklists

A pre-start form developed by the Commissioning Authority, required for all major equipment. Verifies such items as nameplate clean-up, clean filters installed, etc. has occurred before official start-up and/or Functional Testing can commence. When a manufacturer includes a pre-start form or procedure, this must be part of the prestart checklist. These checks must be performed and documented by the Contractor, and a copy of the document provided for the Cx Plan. Pre-Start Checklists shall include date and name/affiliation of the individual completing the check list. A sample pre-start check list can be found in Section 1.7.

Manufacturer's Check, Test and Start

If specified or otherwise agreed to by the commissioning team, a manufacturer's technician will check, test, and start (CTS) a piece of equipment related to a system (such as a pump) or an entire system (such as an R.O. System). Whenever a manufacturer's technician performs a CTS, a form documenting the CTS, along with the technician’s name, affiliation, date, equipment name and serial number, and actions taken, must be provided for inclusion in the Cx Plan. The Commissioning Authority must be invited to all CTS'.

Functional Test (and Procedure)

"Official" start-up and commissioning of the equipment and/or system, witnessed by the Commissioning Authority. Occurs after all pre-functional Cx activities (completion of related pre-start checklists, manufacturer's CTS, etc.) have been successfully completed. Functional testing often consists of two parts. The first is the actual start-up, where it is demonstrated that the equipment/system functions with no apparent problems. The second

part is detailed testing, normally associated with controls verification, to assure that the system works correctly under all operating modes or situations.

The CxA will develop, in cooperation with the Contractor, functional test procedures and forms that document the functional testing.

In the case of controls, in addition to a testing procedure for verification of each step of the controls sequence of operation, the Contractor shall also provide a detailed check list to verify proper function of every control point installed.

Functional testing is done to ensure that various components of systems, especially controls, work in conjunction with one another, as intended by the manufacturer and the system designer. Functional testing demonstrates all interlocks and safeties, valves, dampers, and motors operate and also verifies control logic, etc. Portions of functional testing may be covered during the manufacturer's CTS. However, detailed functional test procedures specific to the particular equipment and systems shall be used to comprehensively validate that the design document and OPR/BOD requirements have been met. Functional testing is the responsibility of the Contractor, with the cooperation and assistance of the CxA.

Functional test procedures and forms shall in all cases be developed by the Cx Team prior to equipment start-up. Activities must be scheduled to allow the Commissioning Authority to participate and/or observe.

Performance Testing

Performance testing is conducted to ensure that equipment capacity scheduled and submitted is being attained by the equipment as installed. Performance testing is not typically required, although it is specified for some equipment such as cooling tower installations (CTI testing). Accurate and meaningful performance testing is often difficult to achieve in the field, in that installation conditions and ambient conditions are difficult to control. Consequently, performance testing plans must be carefully developed by the Contractor, submitted and approved prior to conducting tests. Where required, performance testing is the responsibility of the Contractor, with the cooperation and assistance of the Commissioning Authority. Activities shall be scheduled to allow the Commissioning Authority to participate and observe.

Order and Timing

Commissioning shall occur as project construction progresses, it cannot be left until the end of construction. Order and timing is a list of each commissioning activity including duration, sequenced in an order that permits commissioning to proceed logically. Once developed by the CxA, each activity shall be integrated into the project construction schedule by the GC (CM). For example, an air handler serving VAV boxes must be commissioned before the VAV boxes. A sanitary pump serving a back-washed filtration system must be commissioned before the filtration system. A heating system may need to be commissioned before the heating season to allow architectural finish work to occur. The

CxA often uses the order and timing list to track the progress of commissioning. A sample order and timing list can be found in Section 1.6

Duct Leakage Testing

Duct leakage testing is typically conducted by the Sheet Metal sub-Contractor or a Test and Balance Contractor. A duct leak test plan must be submitted at least 2 weeks in advance of any tests. This plan shall indicate how the duct will be sectionalized for testing and the amount of duct surface area in each section under test. The plan shall include sheet metal layout drawings with dimensions that will allow a cross-check of the surface area calculations to be made. All ductwork must be leak tested and accepted prior to insulating. The Contractor should make preliminary tests (and repairs) before the Commissioning Authority witnesses tests. Submit a record of all acceptance tests to the Commissioning Authority for inclusion in the Commissioning Plan. See sample form, Section 1.7.

Operation and Maintenance (O&M) Manual

Detailed O & M Manuals are required for all projects. Normally a minimum of 3 separate types of O&M manuals are required: architectural, mechanical, and electrical. The minimum content of O&M manuals shall be per the project's specifications and as outlined in Section 1.9 "O & M Manual Checklist." A draft copy of each O&M manual type must be submitted for CxA approval via the project's normal submittal review process, prior to submitting 4 copies of each type for final review. Do not submit draft or final O&M Manuals that do not comply with the requirements of the O&M Manual checklist. Final O&M Manuals must be submitted at least 2 weeks prior to training.

Training

Training is required for most equipment and systems. The Commissioning Authority will develop an "overview" style training document(s) that generally describes design intent, performance specs, area served, etc., for inclusion in the project O&M. The Commissioning Team will jointly develop an *integrated* training plan: topics, dates, durations, etc. At each training session, the Commissioning Authority will provide "overview" training (based on the overview training document) and the Contractor will provide equipment specific training and/or other training as per the Specifications. The CxA and Contractor shall document each training session (attendance and brief report, which shall be inserted in the Cx Plan). See sample form, Section 1.7. Store training session sign-in attendance lists in Section 2.14.

The final project O&M must be submitted at least 2 weeks prior to training. The training report form shall be included in the Cx Plan to document each training event.

Pipe Flushing and Cleaning Plan

A plan developed by the sub-Contractor and reviewed by the Commissioning Authority to assure thorough and complete flushing and cleaning of all piping systems. Flushing and cleaning shall not occur until the plan is approved. Flushing and cleaning activities shall be scheduled to allow the Commissioning Authority to participate and observe.

Water/Water Treatment Reports

All water treatment activities shall be validated with reports as described in the project water treatment specifications. Copies shall be retained in the Cx Plan in Section 2.5

Other reports regarding water properties, such as reports validating lab RO/DI or boiler feed-water quality, shall be retained in the related equipment or system Part 3 section.

Note that piping system pressure tests and potable water sterilization reports are retained by the U-M AHJ and are not required to be retained in the Cx Plan.

AHJ Approval Documentation

The CxA will collect up various documentation from AHJs. Copies of this documentation shall be retained in the Cx Plan in Section 2.6

Test and Balance (TAB) Activities

The CxA and the contractors shall convene a pre-balance conference to assess readiness for TAB activities, to coordinate TAB activities with commissioning activities (e.g. Functional Tests), and to review the methodology the TAB Contractor proposes to test and balance the various systems. Any concerns identified shall be resolved prior to TAB activities commencing.

The CxA will monitor the project TAB activities and shall be provided TAB data before the TAB Contractor leaves the work site each day. Any significant deficiencies shall be reported to the CxA at that time. The CxA will assess the impact of such deficiencies on the ability of the project to be successfully commissioned by Substantial Completion and will notify the Architect/Engineer and U-M Project Manager as concerns emerge.

Temporary Service Cx Requirements (Lube/Filter/Maintenance Reports)

Systems and equipment that will be used for temporary service shall undergo preliminary Prestart Checks and Functional Testing to the extent deemed appropriate by the CxA, to assure damage-free and insignificant wear while in service. Such equipment and systems shall re-undergo Functional Testing prior to Owner acceptance. The contractor shall maintain equipment and systems in temporary service in full accordance with the manufacturer's and generally accepted maintenance recommendations, including performing lubrication, filter change and other maintenance activities validated with logs as deemed appropriate by the CxA. The contractor shall submit these logs weekly for inclusion in the Cx Plan. Logs shall be retained in the related equipment or system Part 3 section.

Project Specific Certifications and Field Test Reports

The contractor shall provide certifications and field reports required by the project documents, any provided by manufacturer start-up or trouble shooting technicians, and any other incidental certification or field reports generated during the project and deemed

appropriate by the CxA, for inclusion in the Cx Plan. These reports shall be retained in the related equipment or system Part 3 section.

Commissioning Meeting Minutes

The CxA will generate commissioning meeting minutes and minutes of special commissioning meetings. Copies shall be retained in the Cx Plan. (Section 2.7)

Commissioning Reports

The CxA will generate periodic commissioning reports summarizing commissioning progress, impediments, issues, and resolutions, and a final commissioning report. These reports shall be retained in Section 2.8 of the Cx Plan.

Transmittal Record

Copies of all transmittals related to commissioning shall be retained in Section 2.9 of the Cx Plan.

1.5 Sample Commissioning Status Check Sheet

Project specific "Commissioning Status Check Sheet(s)" shall be developed to track the progress toward final CxA sign-off , which shall cover each system to be commissioned as well as certain commissioning activities. A sample page from a check sheet follows. Typically multiple pages are required for a project.

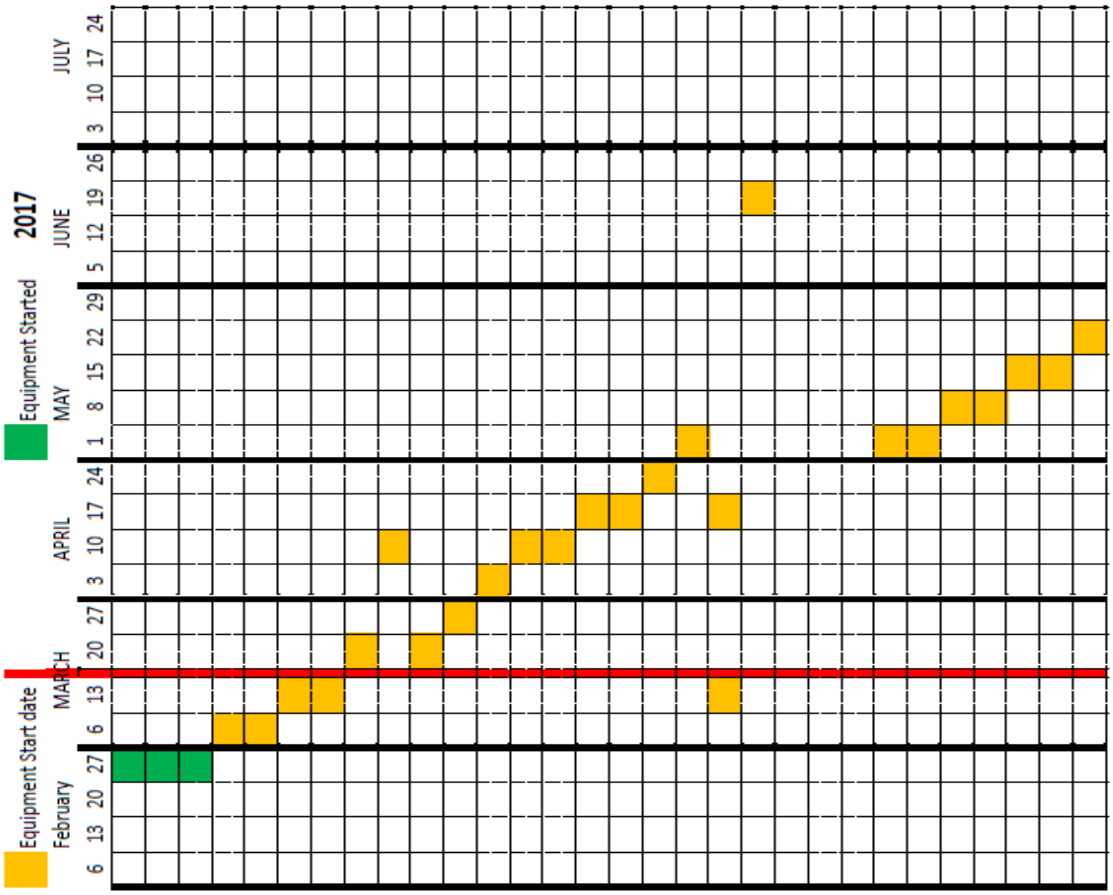
Cx Status Check Sheet (SAMPLE):

Building: **Project:**

Cx Plan Tab	System	Submittals Approved	Installation Manual Submitted	Equipment Delivered	Pre-install Check Sheet Submitted	Mfg. C/T/S Report Submitted	Field Test Reports Submitted	Pre-start Sheet Submitted	Functional Test Passed	All Issues Resolved	Reports/ Manuals Submitted	Training Complete	CxA Sign-off
4	**General**												
	Draft O&M Manual										O		
	Final O&M Manual										O		
	Pre-Balance Conference										O		
	Final Balance Report										O		
	Final Acoustic Testing										O		
	Final Vibration testing										O		
5	**Domestic Water Systems**							O	O	O		O	O
	Water Heater IHW-1	O	O	O	O	O							
	Recirc Pump DHWRP-1	O	O	O									
	Pipe Flushing and Sanitization						O						
	Testing and Balancing						O						
	Plumbing Fixtures	O		O									
6	**Chilled Water System**							O	O	O		O	O
	Tertiary Loop: Pump TCHWP-1	O	O	O	O	O							
	VSD TCHWP-1	O	O	O	O	O							
	Pump TCHWP-2	O	O	O	O	O							
	VSD TCHWP-2	O	O	O	O	O							
	Chilled Beam Loop: Pump CBP-1	O	O	O	O	O							
	VSD CBP-1	O	O	O	O	O							
	Pump CBP-2	O	O	O	O	O							
	VSD CBP-2	O	O	O	O	O							
	Pump Factory Test Reports Submitted										O		
	Pipe Flushing and Cleaning						O						
	Testing and Balancing						O						
	Vibration Testing						O						
7	**Heating Hot Water System**							O	O	O		O	O
	Pump HHWP-1	O	O	O	O	O							
	HHWP-1 VSD	O	O	O	O	O							
	Pump HHWP-2	O	O	O	O	O							
	HHWP-2 VSD	O	O	O	O	O							
	HX-1	O	O	O	O								
	HX-2	O	O	O	O								
	HX-3	O	O	O	O								
	Expansion Tank ET-1	O	O	O	O								
	Flow Meter	O	O	O	O								
	Pump Factory Test Reports Submitted										O		
	Pipe Flushing and Cleaning						O						
	Testing and Balancing						O						
	Vibration Testing						O						

Required: O Completed: O Deleted: O

1.6 Sample Order and Timing List



SPC Lower Level	Equipment	Primary Responsible	Startup (date by contractor)
Area 5 Substation	DTE 15kV Switch & Metering	TC	2/27/17
	15kV Service Feeders	TC	2/28/17
	FP Sprinkler Press test	WFP	3/1/17
	Energize Unit Substation	TC	3/9/17
	Panel PP2-B490-1	TC	3/10/17
	Vent Fan VF-1-02	S & Z	3/13/17
Area 5 - Chiller Plant	CH-1 Sec Feed Meters	TC	3/13/17
	Switchboard MSB1-B484	TC	3/20/17
	Ltg Panel LP1-1498	TC	4/12/17
	Panel DP1-B484 + Xfmr	TC	3/22/17
	Recept Panel RP1-B484-4	TC	3/27/17
	Refrigerant Monitor	JCI ?	4/6/17
	Vent Fan VF-1-01	S & Z	4/12/17
	Exhaust Fan EF-1-01	S & Z	4/12/17
	Air separator AS-1-02	BD	4/19/17
	Expansion Tank ET-1-02	BD	4/19/17
	CHWP-1-01 to CHWP-1-02	BD	4/26/17
	Chilled water pipe flush	BD	5/15/17
	DDC control	JCI	3/6/17
	Chiller CH-1	BD	6/19/17
	UH-1-07	BD	
	Laundry exhaust EF-1-02	S & Z	
	Laundry exhaust EF-1-0?	S & Z	
SPC - Condenser water	CWP-1-01 to CWP-1-02	BD	5/1/17
	Chemical Feed & blowdown	BD	5/1/17
	Condenser water flush	BD	5/8/17
	Dirt separator AS-1-03	BD	5/8/17
IDT - Condenser water	Switchboard MSB2-1130	Conti	5/15/17
	Panel PP2-1378	Conti	5/15/17
	Cooling Tower CT-1	BD	5/22/17

1.7 Standardized and Sample Cx Forms

The following forms are included:

- Pre-Installation Check Sheet
- Equipment/ System Start-Up Notification
- Training Plan/ Sign-In
- Duct Leak Test Report
- Pre start check list (sample)

Pre-Installation Check Sheet

Equipment: _____ **Page**:____/____

Building:_____ **Project:**_____

List the Tag # followed by the corresponding data. Up to five equipment Tag #'s may be listed if they are part of the same system. For equipment that includes pumps, fans, motors, VSDs, coils, humidifiers, or control panels, list the equipment Tag # in the first column for overall review and each component in a separate column for component review. For capacity use gpm for pumps, cfm for fans, HP/Voltage/Phase for motors & VSD's, Btu's/Hr for Coils, and Lbs/Hr for Humidifiers. Strike out (---) space if no information is found. Write "NA" if it does not apply.

Tag # or Component					
Submittal Mfg.					
Nameplate Mfg.					
Submittal Model #					
Nameplate Model #					
Serial #					
Submittal Capacity					
Nameplate Capacity					
Date Delivered					
Location Stored					

Check off each item below if acceptable or complete. Enter note number if deficient.

Undamaged					
Clean and Dry					
All Parts Provided					
Riggable for Site					
Fits Final Location					
Installation/ Operation/Maint. Manual Retained					
Photos Taken					
Protected					

List note number with deficiency description:_____

_____

_____

Signed By (Print): _____Company:_____

Signature: _____ Date:_____

Equipment/ System Start-Up Notification

Project Name:_____

Project Number: _____

Equipment/ System to be started: _____

Notification Date: _____ Start-up date and time:_____

Start-Up will be conducted by:

Name:_____

Firm:_____

The following individuals/ firms have been notified and will be in attendance:

_____ General Contractor _____

_____ Mechanical/ Piping _____

_____ Sheet Metal_____

_____ Controls_____

_____ Electrical Power_____

_____ Electrical Control_____

_____ Manufacturer Representative_____

_____ _____

_____ _____

Pre-Start Requirements:

____ Installation is complete and ready for start-up

____ Start-up technician has reviewed start-up procedure

____ Start-up report draft has been submitted and approved by Commissioning Authority

Signed:

Name: _____ Title: _____

Date:_____ Company: _____

Training Plan/ Sign-In:

Note: Approved O&M Manuals must be received 2 weeks prior to final scheduling of training.

Project Name: _____

Project Number: _____

Date:_____ **Time:**_____

Equipment/ System: _____

_____

Training Conducted By (name(s) and firm(s)): _____

_____

_____

Training Location:_____

Agenda:_____

_____

_____

_____

Training Sign-In Sheet:

Name (print) Department/ Firm Phone

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Duct Leak Test Report:

Test #: _____

Project Name: _____

Project Number: _____

Date:_____ **Time:_____**

Test Equipment:_____

Type of Test:

___ Actual Leak Rate **___ Audible/Visual**

Duct System Description(s):

1. Supply/ Return/ Exhaust ductwork
   located_____
   served by fan _____. Allowable leakage Class: _____
2. Supply/ Return/ Exhaust ductwork
   located _____
   served by fan _____. Allowable leakage Class: _____
3. Supply/ Return/ Exhaust ductwork
   located _____
   served by fan _____. Allowable leakage Class: _____

System Data/Test Results:

Sys. No.	Sq. Ft.	Test pressure	Allowable (cfm)	Actual (cfm)	pass/ fail
1.					
2.					
3.					

Testing Conducted By (name/firm/date):

_____

Testing Witnessed By (name/firm/date):

_____

SAMPLE
PRE-START CHECKLIST - 23-29 – CHILLED WATER SYSTEM

Project Name: _____ **U-M Project No:** _____

This document shall be filled out by the contractor and provided to the UM Commissioning Authority in advance of the actual equipment start-up. Note "NA" for not applicable or "NO" for problem or non-compliance. This document is to be used in conjunction with the manufacturer's pre-start checklist.

Tag No.	Model No.	Serial No.

Item	Check	Comments/Date Completed
Additional Forms (Have the Following Forms Been Completed and All Issues Resolved?)		
1. Pumps (Hydronic Pump Pre-Start Form)	**Y☐ N☐ N/A☐**	
2. Variable Frequency Drives (VFD Pre-Start Form)	Y☐ N☐ N/A☐	
3. Flushing and Cleaning (Flush-Clean and Treat Certification Form)	Y☐ N☐ N/A☐	
4. Condenser Water (Condenser water Pre-Start Form)	Y☐ N☐ N/A☐	
5. Refrigerant monitor (Refrigerant Monitor Pre-start form)	Y☐ N☐ N/A☐	
6. Functional test refrigerant monitor (Refrigerant Monitor Functional Test form)	Y☐ N☐ N/A☐	
General		
7. Nameplate and system labels for the expansion tank, air/dirt separator and plate/frame heat exchangers are secure, complete, legible and undamaged	**Y☐ N☐ N/A☐**	
8. Data label info matches approved submittal for the expansion tank, air/dirt separator and any plate/frame heat exchangers	Y☐ N☐ N/A☐	
9. Electrical complete (power to all components complete, etc.)	Y☐ N☐ N/A☐	
10. Controls complete and maintains setpoint	Y☐ N☐ N/A☐	
11. Equipment clean	Y☐ N☐ N/A☐	
12. Check piping and valves for leaks. Open and close valves to check for proper operation	Y☐ N☐ N/A☐	

13. Conduit/Flex connections correctly installed	Y☐ N☐ N/A☐
14. Reviewed and approved bolts and gaskets are installed and bolts properly torqued	Y☐ N☐ N/A☐
15. Piping vibration isolators (aligned, weight even distributed, free floating)	Y☐ N☐ N/A☐
16. Gages positioned to be readable	Y☐ N☐ N/A☐
17. Gage scale ranges reasonable (spec./submittal)	Y☐ N☐ N/A☐
18. Chilled water makeup complete (PRV, BFP and gauges, etc.) PRV Set?	Y☐ N☐ N/A☐ Record PRV Setting:
19. Relief valves installed on the chilled water piping	Y☐ N☐ N/A☐
20. Chilled water through the chiller balanced	Y☐ N☐ N/A☐
21. Condenser water through the chiller balanced	Y☐ N☐ N/A☐
22. Condenser water through the cooling tower balanced	Y☐ N☐ N/A☐
Expansion Tank	
23. Required Pre-charge (not "factory" charge)	_____ **psig** _____
24. Verify pre-charge pressure (tank shall be isolated from system and drained to verify pre-charge pressure. Do not assume/use factory pre-charge)	Y☐ N☐ N/A☐ _____ psig _____
25. Pre-charge pressure marked on tank	Y☐ N☐ N/A☐
26. Tank connection off side of pump suction pipe (If off bottom, dirt leg and blow down valve installed)	Y☐ N☐ N/A☐
27. Minimum 1" pipe size is connected to main	Y☐ N☐ N/A☐
28. Air vent at top of 1" connection if connection rises above tank inlet	Y☐ N☐ N/A☐
29. Tank connected as close as possible to pump suction	Y☐ N☐ N/A☐
Air Vents General (all locations on system)	
30. Installed at all system high points	**Y☐ N☐ N/A☐**
31. Correct types installed manual and auto vents	Y☐ N☐ N/A☐
Drains (all locations on system)	
32. Drains: at all low points	**Y☐ N☐ N/A☐**

	33. Correct type ball valves with hose connection	Y☐ N☐ N/A☐
Insulation		
	34. Complete	**Y☐ N☐ N/A☐**
	35. Correct label nomenclature	Y☐ N☐ N/A☐
	36. Correct arrow directions	Y☐ N☐ N/A☐
Chiller		
	37. Factory performance test report provided	**Y☐ N☐ N/A☐**
	38. Factory vibration readings provided	Y☐ N☐ N/A☐
	39. Field vibration testing scheduled (vibration is check through entire operation range)	Y☐ N☐ N/A☐ Scheduled Date:
	40. Chiller manufacturer prestart requirements complete	Y☐ N☐ N/A☐
	41. Chiller Manufacturer Check Test and Start Sheet Submitted to U-M Cx	Y☐ N☐ N/A☐
	42. Unit is level and vibration isolation is installed	Y☐ N☐ N/A☐
	43. No insulation damage on the chiller and all field insulation is complete	Y☐ N☐ N/A☐
	44. Chiller refrigerant safety relief valves piped to the outside	Y☐ N☐ N/A☐
	45. Flow sensing devices are within the evaporator and condenser isolation valves to allow for maintenance	Y☐ N☐ N/A☐
	46. Flow sensing devices pre-tested	Y☐ N☐ N/A☐

Completed by (print): _____ **Company:** _____

I certify the above checks have been made:

Signed: _____ **Date:** _____

1.8 Fundamental Cx Requirements for all Projects

1. Provide at least 2 weeks' notice prior to manufacturer's check-test-start. Commissioning Authority MAY attend.
2. Provide duct leak test plan at least 2 weeks prior to each test, Commissioning Authority to witness.
3. Provide 2 weeks' notice prior to functional testing, duct leak testing, and flushing and cleaning.
4. Provide 2 weeks' notice prior to each training session.
5. Fax or e-mail all notifications directly to the Commissioning Authority.
6. Hydronic flushing plans must be submitted and approved by the Commissioning Authority 2 weeks prior to the actual flushing. Commissioning Authority to witness.
7. All required forms must be collected and provided for the Commissioning Binder by the Contractor.
8. Provide brief agenda for each training session with the 2 week notification.
9. Check, test, start and DEBUG all equipment before commissioning. If system "fails" commissioning or debugging becomes necessary during commissioning, commissioning shall be rescheduled.
10. Provide adequate maintenance clearance around all equipment or the equipment will "fail" commissioning.
11. Install all equipment per manufacturer's recommendations or the equipment will "fail" commissioning. If a conflict arises, mfg. versus specification requirements, ask before you install.
12. Do not schedule training until commissioning has been successful, all punch-list items relative to that system have been corrected, and all tests are completed and test results resolved (example: vibration testing).
13. Review and comply with the "O&M Check-List" before submitting draft O&M Manuals for review.

1.9 O & M Manual Checklist

Do not submit O & M Manuals for approval that do not meet the following basic requirements. One draft O & M should be formally submitted "for approval" via the project' submittal review process.

1. Must be in 3-ring binder, with table of contents, and tabbed sections. 4 copies will be required for final approval.

2. Building name, project title, UM project number, Contractor name, Contractor project number, must appear on **BOTH** the front and spine of the binder.

3. Provide a copy of the valve tag schedules at the front of the O & M binder.

4. Except for minor equipment, provide complete nameplate data at the front of the O & M. Include all data including serial numbers as well as the complete motor nameplate data of the associated motor.

5. Provide a sheet at the beginning of the O& M listing equipment and the local supplier (with address and phone number) of that equipment.

6. For all equipment with warranties in excess of one year (example: VSDs), include extended warranty information in front of binders, i.e. a specific manufacturers document indicating the length of the extended warranty.

7. All information must be project specific. Do not submit generic vendor O & M manuals that cover multiple model numbers of equipment. Edit vendor O & M manuals to reflect exact equipment supplied. Cross out extraneous information not applicable to the specific equipment provided. Highlight applicable information.

8. For each piece of equipment, provide complete data relative to make/model number, size, capacity data, manufacturer name and address, accessories included, etc., i.e. provide complete information that would allow ordering the exact piece of equipment supplied. To accomplish this, including *portions* of the approved submittal for the piece of equipment is permitted. **Do not** include extraneous submittal information that doesn't facilitate actually ordering a piece of equipment.

9. If a piece of equipment contains multiple subassemblies provided by different manufacturers, include make/model number, size, capacity data, etc. to allow ordering an exact replacement. For example, for an air handler, provide information for each coil, filter, dampers, fan(s), etc.

10. Job specific, *as-built*, wiring diagrams, piping diagrams, etc. must be supplied for all equipment. All external connections must be shown on these diagrams. Example #1:

for VSD drives, terminal strip numbers where external control signal is landed must be indicated. Example #2: A piece of equipment is supplied with controls that interface with the university DDC system. Wiring diagram must be project specific and indicate interface with University DDC system. Example #3: (piping) reverse osmosis system, sand filter system, etc.

11. For all pumps, include pump curves.

12. For all flow elements (pitot tubes, triple duty valves, circuit setters, etc.) provide flow curves.

13. For all fans, include fan curves.

14. For all fans, include sound power data (normally this was included as part of the fan submittal).

15. For all filters, clean and dirty filter pressure drops must be included.

16. Provide manufacturers recommended spare parts list for all major equipment.

17. Provide information for all equipment provided. In other words, if a reheat coil is provided, a lighting fixture, etc., and no O & M is provided by the manufacturer, at minimum, include the installation instructions and model/capacity data. *As a final cross-check, check the design drawing schedules to assure you have included O & M information for all equipment scheduled.*

18. Provide an approved copy of water and air balance reports in the O & M.

19. Provide an **as-built** copy of the project control drawings in the O & M, along with installation and maintenance information on individual control components.

20. Provide a copy of the equipment vibration test report in the O & M.

21. For equipment requiring a factory start-up, a start-up report is required for the O & M.

Tab 2

General Commissioning Documentation

[Sample]

2.1 List of Systems and Equipment to be Commissioned

Architectural Systems:

1. **Automatic Doors**

2. **Door Hardware**

3. **Wheel Chair Lifts**

4. **Motorized Projection Screens**

5. **Elevator**

6. **Cold Room**

7. **Fume Hoods**

Mechanical Systems:

1. **Storm Water System**
   Piping
2. **Sanitary Drainage System**
   Piping
   Domestic Water System
   Piping.
   Mixing Valve Station Return Pump P-3
   Return Heat Exchanger HX-5
   Controls
3. **Natural Gas System**
   Piping
4. **Compressed Air System**
   Piping- 90# and 40#
   Refrigerated Air Dryer
5. **Dental Systems**
   Piping – Oxygen
   Piping - Nitrous Oxide

Piping – Suction
Piping - Vacuum

6. **Reverse Osmosis System**
   Piping
   Reverse Osmosis System

7. **Fire Suppression Systems**
   Piping
   Valves, Accessories

8. **Hot Water Heating System**
   Heat Exchanger HX-1
   Pumps P-1 and P-2
   Expansion Tank
   Air Separator
   VFD 5, VFD 6
   Controls

9. **Steam System**
   Piping
   Condensate Return Units 1-2 and 3-4

10. **Chilled Water System**
    Piping
    Interface with Dental Secondary CHW Pumps/VFDs

11. **Air Handling System**
    Air Handling Unit AHU-1 including supply fan, heating and cooling coils, filters
    Return Fan RF-1
    AHU-1 (VFD-1)/RF-1 (VFD-2)
    Duct Work
    Controls

12. **Terminal Units**
    VAV Boxes
    Radiant Panels
    Controls

13. **Humidifiers**
    Humidifiers and associated steam/water pan type heat exchangers
    HUM-1/HX-2
    Controls

14. **Misc. Fan Systems**
    Fans, related controls, and relief hoods:

SF-1/EF-1/ EF-2	Atrium Supply and Exhaust
SF-2/EF-8/RH-1	Penthouse Supply and Exhaust Fans and Relief Hood

EF-3	Toilet and Janitors Closet Exhaust
EF-4	Telephone Equipment and Janitors Closet Exhaust
EF-5	Room G061 Servery Exhaust
EF-6	Lab and Dark Room Exhaust, 1st. Floor.
EF-7	Toilet 2075T
EF-9	Existing Gas Storage Room
RH-2	Existing EF-7
RH-3	Existing EF-6

15. **Unit Heaters**
    CUH-1
    CUH-2
    UH-1-9 (hot water)
    UH-10 (steam)

16. Testing and Balancing

Electrical Systems:

1. **Electrical Power**
   Distribution and Motor Control Equipment
   Automatic Transfer Switch

2. Grounding System

3. Fire Alarm System

4. **Electrical Lighting**
   Light Fixtures
   Emergency Lights
   Dimming System

5. Card Access and Intrusion Detection System

6. Sound System

7. Electrical Testing

2.2 Cx Status Check Sheets

(Insert project specific check sheet(s) in this section.)

2.3 OPR/BOD Requirements

The commissioning effort shall verify that the following OPR/BOD goals have been achieved:

(CxA shall summarize the OPR/BOD requirements pertinent to the Cx process in this section.)

2.4 Order and Timing List

2.5 Water Treatment/Flushing and Cleaning Reports

(Insert water treatment and flushing and cleaning reports in this section)

2.6 AHJ Approval Documentation

(Insert AHJ approval documentation in this section.)

2.7 Commissioning Meeting Minutes

(Insert copies of Cx minutes in this section.)

2.8 Commissioning Reports

(Insert copies of Cx reports in this section.)

2.9 Transmittal Record

(Insert copies of Cx related transmittals in this section.)

2.10 Record of O&M Manual Submittals:

Manual Title	Date	Status

2.11 Record of Test and Balance Activities

Record of Test and Balance activities:

2.12 Mechanical Test Reports

(insert copies of all mechanically related test reports, e.g. duct leak test reports)

2.13 Electrical Reports

(insert copies of short circuit, coordination, and arc flash studies)

2.14 Owner Training Sessions Record

(insert copies of training attendance records)

Tab 3

Commissioning Documentation

Specific to Equipment and Systems