Generic Sample

Commissioning Manual

Building Name:_____

Project Name:_____

UM Project No._____

Commissioning (Cx) Manual Index

1.1 Introduction to Cx and Intent of this Manual

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 Owners Commissioning Authority, the University, the Architect/Engineer, and the Contractor (and his suppliers). The Commissioning Manual is the vehicle by which the Cx process is planned and documented. The draft version of the Cx Manual for this project was produced by the Commissioning Authority (CxA). The Owners Commissioning Authority and the Contractor are responsible for producing the final commissioning manual, with all necessary Cx sequences. 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 Manual
- Maintain up to date field copy of the project Cx Manual during construction.
- Assist in development of order and timing
- Integrate order and timing into the project schedule
- Obtain paperwork for inclusion in the Commissioning Manual
- Schedule start-ups and other events. Insure system is ready for start-up.
- Oversee the coordination drawing process
- O & Ms .

Contractors:

- Attend meetings
- Invite appropriate parties to meetings
- Provide paperwork for inclusion in the Commissioning Manual
- Assist in development of order and timing
- Assist in development of the Commissioning Manual
- Follow Cx Sequence, be ready at start-ups
- Conduct pre-start checks
- Organize vendor check/test/starts
- Attend/conduct start-ups
- Functionally test systems, with Commissioning Authority witnessing
- Attend/conduct training
- O & Ms

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 manual (lead)

- Schedule meetings
- Write Commissioning Reports
- Witness/Commission
- Coordinate UM personnel relative to commissioning
- Trouble shoot in cooperation with engineer of record
- Participate in punch-listing effort
- Enforce commissioning process
- Review and approve O&Ms

UM Commissioning Supervisor (CxS):

- Supervises the Commissioning Authority in all aspects of Cx.
- Attends Cx meetings, equipment start-ups, functional tests, etc. as he/she deems appropriate.
- As notified by the CxA, review and accept each systems as successfully commissioned.

1.3 Commissioning Team

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

University of Michigan/Architect-Engineers:

Affiliation/ Name	Phone	Fax
U of M - (User/ Owner)		
Architect/ Engineer	**Phone**	**Fax**
(U of M - Plant Extension)		

UM Construction Management **Office** **Mobile**

Fax unless otherwise noted: (734) 763-1249

Field Representative

Contractor:

Construction Manager -
Project Manager
On Site Foreman
Commissioning Lead
Coordination Drawing Lead

Mechanical & Piping -
Project Manager
On Site Foreman
Commissioning Lead
Coordination Drawing Lead

Fire Protection
Project Manager
On Site Foreman
Commissioning Lead
Coordination Drawing Lead

Sheetmetal
Project Manager
On Site foreman
Commissioning Lead
Coordination Drawing 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
Coordination Drawing 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 is intended to give the Commissioning Team the basic parameters for developing Project and System Specific Commissioning Procedures. Procedures and Check-sheets shall be developed by the Commissioning Authority with the assistance of the Commissioning Team.

The typically required documentation for commissioning is listed below. Copies of this documentation must be collected by the Contractor and inserted in the commissioning binder.

- Cx Progress Check Sheets a.k.a. Commissioning Sequence
- Cx Order and Timing, integrated into the Project Schedule
- Manufacturer's Factory Testing Certificates
- Various Project Specific Certifications
- Delivery, Installation and Pre-start checksheets
- Check, Test and Start checksheets
- Start-up/Functional Testing (and Procedure)
- Test and Balance Report
- Performance Test Data/ Report
- Duct Pressure Testing
- Pipe Flushing and Cleaning Plan
- Training Plan

These activities and the associated responsibilities are generally described below. Some sample Commissioning Progress Check Sheets are included on pages that follow.

Explanation of terms used in the Commissioning Process/Sequence

The below definitions describe the basic commissioning requirements for the project.

System Description and Design Intent

A basic description of the system design intent, including other useful information that facilitates the commissioning process. This description should include information regarding associated system interactions (i.e. new fire alarm system control of new smoke purge fans, new system interactions with existing systems, etc.), where the system originates, equipment designations, area served, etc. This shall be included in the appropriate system section of part 3 of the Commissioning Binder. These descriptions shall be written by the Commissioning Authority.

Commissioning (Cx) Manual

A hard cover 3 ring binder with a table of contents and tabbed sections that documents the commissioning process. 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 manual, which will be held by the Commissioning Authority. The GC (CM) shall maintain a parallel field copy of the Commissioning Manual. The Commissioning Authority shall forward the master Commissioning Manual to the UM Commissioning Supervisor at project completion.

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. 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

This section is reserved for insertion of 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.

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&Ms. 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 Progress Check Sheets shall be certified as examined via a standardized "Pre-Installation Check Sheet" form (see section 1.6). 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 for record. The Commissioning Authority will designate which materials or equipment require these check sheets.

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 an official start-up can be performed. 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 Manual. 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 1.6.

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 tech.s name, affiliation, date, equipment name and serial number, and actions taken, must be provided for inclusion in the Cx Binder. The Commissioning Authority must be invited to all CTS's.

Functional Testing (and Procedure)

"Official" start-up of the system, witnessed by the Commissioning Authority, occurs after all preliminary testing activity (including manufacturer's CTS's) have been successfully completed. Functional testing normally consists of two parts. The first is the actual start-up, where it is demonstrated that the equipment 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 Testing Procedures.

In the case of controls, in addition to a testing procedure for verification of each step of the controls sequence of operation, a detailed check list shall be provided listing every 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 in CTS. However, functional test procedures must be customized for each system, specific to the particular systems as installed and configured. Functional testing is the responsibility of the Contractor, with the cooperation and assistance of the CxA.

Functional test and CTS forms and procedures 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 in 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

Order and timing is a list of each commissioning activity with duration, in logical order, timed to meet the project's requirements. Once developed, it 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 objective is to logically schedule each commissioning activity, and to recognize (early) and make allowance for the commissioning of each system in the project construction schedule.

Commissioning Authority Punch-List Involvement

The Commissioning Authority shall be notified when project punch listing is to occur, and will normally participate with the engineer of record in the punch list effort.

Duct Leakage Testing

Duct leakage testing is typically conducted by the Sheetmetal sub-Contractor or a Test and Balance Contractor. A duct leak test plan must be submitted at least 1 week 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. This plan shall include sheetmetal 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 Binder. See sample form, Section 1.6.

Operating 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 as outlined in Section 2.4:"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&Ms that do not comply to the requirements of the O&M Manual checklist. Final O&Ms must be submitted at least two 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 spec.s, 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). See sample form, Section 1.6.

The final project O&M must be submitted at least two weeks prior to training. The training report form shall be included in the Cx. Binder 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.

1.5 Sample Commissioning Status Check Sheet

Project specific "Commissioning Status Check Sheets" shall be developed to track the progress toward final CxA sign-off for each system to be commissioned as well as for certain commissioning activities. These sheets are to be included under Tab 3. A sample page from a check sheet follows. Typically multiple pages are required for a project.

Tab: ____ Cx Status Check Sheet (SAMPLE):

Building: **Project:**

Cx Manual 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: X Deleted: /

1.6 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

Project Name: _____

Project Number: _____

Material/Equipment: _____

Equipment No.: _____

Check-off:

____ NO SHIPPING DAMAGE (list if any)

_____

_____

____ ALL NECESSARY COMPONENTS SHIPPED

____ THIS MATERIAL OR EQUIPMENT WAS REVIEWED AND COMPLIES WITH THE APPROVED SUBMITTAL.

____ EQUIPMENT IS RIGGABLE CONSIDERING SITE CONSTRAINTS

____ EQUIPMENT FITS SPATIAL CONSTRAINTS OF THE PROJECT

____ INSTALLATION INSTRUCTIONS INCLUDED

____ INSTALLATION INSTRUCTIONS HAVE BEEN RETAINED UNDER SAFE KEEPING

____ MATERIAL OR EQUIPMENT IS PROPERLY STORED AND PROTECTED

LIST AREAS OF NON-COMPLIANCE TO THE APPROVED SUBMITTAL AND/OR DESCRIBE PROBLEMS REVEALED AS A RESULT OF THIS INSPECTION:

_____

_____

_____

_____

_____

_____

_____

_____

Signed:

Name: _____ Title: _____

Date:_____ Company: _____

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 _____**

_____ **Sheetmetal_____**

_____ **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&Ms 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 Check List

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

Project Name:_____
Project Number: _____
Completed by/representing (print):_____

_____System

Provide identifying information for the following equipment, as applicable: [edit] heat exchangers, expansion tanks, air separators,

Tag No.	Model No.	Serial No.

At least two weeks prior to start-up

_____ Equipment installation manuals have been submitted to CxA
_____ The controls functional test procedure, generated by the controls Contractor, has been submitted to the CxA

At least one week prior to start-up

_____ Equipment/System Start-up Notification Form has been faxed to the CxA

System Piped Per Design Drawings and Code

_____ Make-up
_____ HWH Piping
_____ Steam Piping
_____ Equipment is installed in strict compliance with design documents/specification and per manufacturers installation instructions.

Flush, Clean, and Fill

_____System water piping has been flushed and cleaned
_____System steam and condensate piping has been flushed and cleaned
_____Strainers clean, steam side
_____Strainers clean, HWH Side
_____System piping has been filled and properly vented

Heat Exchanger:

_____No pipe weight, torque, or mis-alignment on flanges
_____Adequate support for HX
_____If bolted to floor, feet or bracket mounting bolts loose to allow expansion
_____Room for tube pull
_____Data plate legible, undamaged, and not concealed (by insulation, etc.)
_____Relief Valve(s) installed
_____Relief Valve capacities checked against HX nameplate and approved submittal

_____Relief Valve Discharge piped per design documents and Code

Vacuum Breakers

_____Installed on each HX
_____Bottom adjustment nut adjusted high on threads so vent operates under low vacuum condition? (if nut is low on threads vent will not open until high vacuum occurs, effecting HX modulation)
_____Top jam nut tight against bottom adjustment nut?

PRV/City Water Makeup

_____Bypass closed
_____PRV set?
Setting _____ PSIG
_____Gage Reading (downstream side of PRV)_____ PSIG
System is hot or cold? -_____

Steam Traps

_____Service accessibility- can trap covers be removed
_____Required vertical inlet leg provided ahead of trap
Inlet leg specified in CD's:_____ Inlet leg provided _____
_____Trap check valves installed where rising after trap (drips)
_____No rise in condensate line after trap
(MANDATORY for traps serving any equipment controlled by modulating control valves: PROVIDE CORRECT INLET LEG HEIGHT UPSTREAM OF TRAP(S), AND NO PIPE RISE DOWNSTREAM OF TRAP(S))
_____Drip before control valves
_____Trap iso. valves
_____Unions at traps
_____Dirt legs

Expansion Tank

Required Precharge (not "factory" charge):_____
_____Verify precharge pressure (tank must be isolated from system and drained to set or verify pre-charge pressure. Do not assume/use factory precharge)
_____Precharge pressure marked on tank?
_____Connected off side of main? (if off bottom, dirt leg and blowdown valve installed?)
_____Minimum 1" pipe size connection to main?
_____Auto air vent at top of 1" connection if connection rises above tank inlet
_____Tank connected as close as possible to pump suction
_____Anti siphon loop installed (12"-20" depth minimum)
_____Series B (Bladder Type) Tanks: 16" clear over bladder flange for bladder removal?
_____Data plate legible and undamaged

Air Separator

_____Valved blow-down/drain installed
_____Air vent in top installed
_____Supported at nozzles
(Units greater than 8" pipe size must be supported by body, not by piping or nozzles))
_____Data plate legible and undamaged

Air Vents *General* (all locations on system)

_____Installed at all system high points
_____Correct type (typically ball valves)
_____Correctly installed: (top of pipe)
_____Correct termination

Auto Air Vents (all locations on system)

_____Vent cap open only 1 full turn to prevent rapid air bleed?
_____Signs of excess water discharge?
_____Piped to drain?
_____Isolation valve for vent

Drains (all locations on system)

_____Drains: at all low points
_____Correct type (typically ball valves)
_____Correctly installed: (bottom of pipe)
_____Correct termination (hose connector) :

Insulation

_____Complete
_____Correct label nomenclature
_____Correct arrow directions
_____Vapor barrier integrity (no tears, punctures, gaps, lagging lapped onto insul shields, etc.)

Controls

_____Control air line for control valve(s) terminated at the valve and the DDC panel.
Contractor controls complete:

_____ DDC controls
_____ Pneumatic Controls

UM DDC Shop Complete:

_____ DDC Controls

General

_____Gages positioned to be readable
_____Gage scale ranges reasonable (spec./submittal)

_____Trace piping and verify correct installation (flow direction/crossed S&R)

_____Dirt/grime cleaned up

Pumps (use Pump Pre-start form)

Variable Frequency Drives (use VFD Pre-Start form)

List of other issues _____
_____
_____
_____
_____

_____

Certification: I certify the above checks have been made (signed/date)

1.7 Fundamental Cx Requirements for All Projects

1. Provide at least 1 weeks notice prior to manufacturers check-test-start. Commissioning Authority MAY attend.
2. Provide duct leak test plan at least 1 week prior to each test, Commissioning Authority to witness.
3. Provide 2 weeks notice prior to commissioning (functional testing), duct leak testing, and flushing.
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 & Ms for review.

2.1 Construction Schedules

[Sample]

2.2 List of Systems and Components 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 Exh., 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**

2.3 Shop Drawing Tracking

The following list of required shop drawings was submitted by the Contractor.

Status of selected shop drawings are indicated. Date released by engineer is listed.

2.4 O & M Manual Checklist

Do not submit O & Ms 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.

2.5 Record of O&M Submittals:

Manual Title	Date	Status

2.6 Punch Lists

Record of Punch Lists:

Include reference number, date inspected, inspectors, date corrections were completed and punch list was signed and returned, follow up.

Copies of punch lists follow:

2.7 Test and Balance Reports

Record of Test and Balance activities:

Copies of TAB Reports follow

2.8 As-Built Drawings

Record of As-Built Drawing activities: