



## The Whole is Greater than the Sum of its Parts: The Interdependence of MEP and Envelope Commissioning

Course Number: CXENERGY1901

EDUCATION CATION

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# The Whole is Greater than the Sum of the Parts: Integrated BECx and MEPCx



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### **AIA CES**

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

## **AIA CES - LEARNING OBJECTIVES**

Upon completing the course participants will be able to:

- 1. Define the BECx and MEPCx process and standards
- Identify BE/MEP Cx synergy opportunities to save time and money
- 3. Describe how the key **BECx and MEPCx tasks are** interdependent
- 4. Recognize **project types** where integration of MEP and BE systems are especially important





# COMMON MISCONCEPTIONS

Commissioning adversely affects budget.

Commissioning adversely affects schedule.

Only the mechanical systems need to be commissioned.

Commissioning starts in construction phase - it's just another name for testing the installed mechanical systems.

The Architect and General Contractor will handle all the design and construction issues.

Any post construction issues with the MEP or BE systems will be taken care of by GC during warranty stage.

It will cost us less to fix any MEP or BE defects after construction than during construction.

#### **OUR PREMISE:**



# THE BUILDING ENCLOSURE

#### **Today's Building Enclosure**

- Complex building materials
- Multi-layer construction / multiple trades
- Thinner construction
- Higher performance requirements
- Less skilled craftsman
- Limited training
- Higher expectations
- Compressed Schedules
- Reduced Budgets



# MECHANICAL ELECTRICAL PLUMBING

#### Today's MEP

- Technically complex
- Multiple Systems Working Together (or not)
- High Performance
- Integrated Controls
- Limited on-the-job training
- Higher expectations
- Schedule Critical
- Cost Sensitive



### **Traditional Approach:**

- Building Envelope and MEP are unrelated
- Different Process
- Different Timelines
- Different Subcontractors
- Different Objectives
- Keep Separate

# **Synergistic Approach:**

- Building Envelope and MEP are VERY related
- ✓ Same Process
- ✓ Overlapping Timelines
- ✓ One Team, One Owner
- Same Objectives
- Integrate!

### **COMPLEX BUILDINGS REQUIRE A <u>TEAM</u> APPROACH**



### WHO SETS THE STANDARDS



Commissioning is REQUIRED by CODE !!

#### **IECC 2015**

Mechanical Systems Commissioning (C408.2) Service Water Heating Systems, Pools, Spas (C408.2) Lighting Controls Functional Testing (C408.3)

# IECC C402.5.1: AIR BARRIERS AND CONSTRUCTION (MANDATORY)

CZ 2B Exempt

Placement allowed:

- Inside of building envelope
- Outside of building envelope
- Located within assemblies composing envelope OR
- Any combination thereof

Continuous for all assemblies part of the thermal envelope and across joints and assemblies

Three ways to comply with air barrier requirements	Requirement	Pressure Differential Testing Requirement	ASTM Standard
1. Materials	Permeance ≤ 0.004	0.3 in w.g	ASTM E 2178
2. Assemblies	Air Leakage ≤ 0.04 cfm/ft²	0.3 in w.g	ASTM E 2357, 1677 or 283
3. Building	Air Leakage ≤ 0.40 cfm/ft²	0.3 in w.g	ASTM E779 or equivalent method approved by AHJ
Joints and seams to be sealed	per C402.4.2		

# **IECC AIR BARRIER COMPLIANCE**





#### Materials

- ASTM E2178
- 0.004 cfm/ft<sup>2</sup> (75 Pa)

#### Assemblies

- ASTM E2357
- 0.04 cfm/ft<sup>2</sup> (75 Pa)

Whole Building

- ASTM E779
- 0.40 cfm/ft<sup>2</sup> (75 Pa)

### **IECC C402.5.3: AIR LEAKAGE OF FENESTRATION (MANDATORY)**



Fenestration Assembly	cfm/ft <sup>2</sup>	Test Procedure		
Windows, sliding glass doors, and swinging doors	0.20	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC		
Skylights - with condensation weepage openings	0.30	400		
Skylights – all other	0.20			
Curtain walls and storefront glazing	0.06	NFRC 400 or ASTM E283		
Commercial glazed swinging entrance doors	1.00	at 1.57 psi		
Revolving doors	1.00			
Garage doors	0.4	ANSI/DASMA 105, NFRC		
Rolling doors	1.00	400, 01 ASTM E203 at 1.57 psf		

Exceptions:

- Field-fabricated fenestration assemblies
- Fenestration in buildings that meet the building test for air barrier compliance option

# LEED COMMISSIONING: LEED V4

EA PREREQUISITE: FUNDAMENTAL COMMISSIONING AND VERIFICATION

> Follow ASHRAE Guideline 0 and ASHRAE Guideline 1.1

**Cx Systems**: energy, water, indoor environmental quality, and durability

Envelope: BOD/OPR and document review only

Must engage CxA during DD phase

Prepare Facilities Requirements and Operations and Maintenance plan

#### EA CREDIT: ENHANCED COMMISSIONING

**Option 1, Path 1** (3 pts): *Traditional ECx*, plus:

Verify seasonal testing and Develop an ongoing commissioning plan

**Option 1, Path 2** (4 pts): *Enhanced and Monitoring-Based Commissioning* 

Achieve Path 1 and Monitoring-based M&V procedures to assess performance of energy & water systems

**Option 2** (2 pts): *Envelope Cx* 

### DO I HAVE A ROLE IN COMMISSIONING?



# 02 COMMISSIONING PROCESS



#### THE COMMISSIONING PROCESS IS THE COMMISSIONING PROCESS









# WHAT DOES THE CXA ACTUALLY DO?

#### **Design Phase**

- Set up for Success
- OPR Workshop
- Commissioning Specifications
- Evaluate the Design against OPR & BOD
- Lend our Expertise & Experience
- Develop the Cx Plan
  - Pre-Functional Checklists
  - Functional Performance
    Tests
- Hygrothermal and thermal analysis









0	P1 : V : P2 :	PRES	SURE CITY I SSURE	IN P.S N M.P. IN H <sub>2</sub>	H. D INC	HES
2	P1	V	P2	P1	V	P2
1	.01	5	.01	31.0	110	5.96
5	0.3	10	.05	32.5	112	6.25
۲	0.6	15	.11	35.0	117	6.73
	1.0	20	.20	37.5	121	7.21
Ċ,	1.6	25	.31	40.0	125	7.69
	2.2	30	.44	42.5	129	8.17
	3.1	35	.60	45.0	132	8.65
1	4.0	40	.79	47.5	136	9.13
	4.5	42	.86	50.0	138	9.61
2	5.2	45	1.00	52.5	143	10.0
	6.24	49	1.20	55.0	146	10.5
	6.4	50	1.23	57.5	150	11.0
	7.7	55	1.49	60.0	153	11.5
	8.0	56	1.54	62.5	156	12.0
1	9.2	60	1.77	65.0	159	12.5
	10.0	63	1.92	67.5	162	13.0
5	10.8	65	2.08	70.0	165	13.5
	12.0	68	2.31	75.0	171	14.4
	12.5	70	2.41	80.0	176	15.3
1	14.4	75	2.76	85.0	182	16.3
1	15.0	76	2.88	90.0	187	17.3
1	16.4	80	3.15	95.0	192	18.2
	18.5	85	3.55	100.0	198	19.2
	20.0	88	3.84	105.0	202	20.1
	22.5	94	4.32	110.0	207	21.1
1	25.0	99	4.80	115.0	212	22.1
1	27.5	103	5.28	120.0	216	23.0
U	28.2	104	5.42	125.0	220	24.0
I	30.0	108	5.76	130.0	225	25.0

#### **BECx DESIGN PHASE**

#### Control Layers

- Water
- Air
- Vapor
- Thermal



### **MEPCx DESIGN PHASE**



### MEPCx DESIGN PHASE Sequences of Operation

#### HVAC



#### Plumbing



### MEPCx DESIGN PHASE Sequences of Operation

#### Lighting Controls



#### **Emergency Power System**



# **CONVENTIONAL SPECIFICATIONS**

#### **BECx Specification**

SECTION 01 91 15

BUILDING ENCLOSURE COMMISSIONING REQUIREMENTS

#### PART 1 - GENERAL

- 1.1 SECTION INCLUDES
  - A. The work under this Section is subject to requirements of the Contract Documents, including the Owner's General Conditions and articles of the Construction Manager's General Conditions.
  - B. This section includes the commissioning requirements for the Building Enclosure systems. Refer to Section 019117 for Building Enclosure Functional Performance Testing.
    - The commissioning requirements for the Building Enclosure systems given in this section are entirely separate from, and in addition to, the General Commissioning Requirements for this project. The General Contractor (GC), Subcontractors, and Suppliers are required to participate in both commissioning processes as required and any supplemental General Commissioning requirements.

#### 1.2 DESCRIPTION

- A. Building Enclosure Commissioning (BECx) is a systematic process of ensuring all building enclosure systems responsible for environmental separation perform interactively according to the Owner's Project Requirements and the Architect's Basis of Design. The BECx process is intended to achieve the following specific objectives according to the Contract Documents:
  - Verify and document proper installation and performance of building enclosure materials and systems.
  - Provide Owner with functional building enclosure systems with minimal performance problems at project completion.
- B. Commissioning does not take away from, or reduce responsibility of, system designers or installing contractors to provide a finished and fully functioning product.
- C. This section shall in no way diminish the responsibility of the Division 03, 05, 07 and 08 Contractors, Sub-contractors and Suppliers in performing all aspects of work and festing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in Division 03, 05, 07, and 08.

#### **MEPCx Specification**

SECTION 01 91 13 GENERAL COMMISSIONING REQUIREMENTS

A PART 1 - GENERAL

- 1.1 SUMMARY
  - A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
    - 1. Division 22 Plumbing
    - 2. Division 23 Mechanical
    - 3. Division 26 Electrical
  - B. It is of primary concern that all systems and assemblies in the project perform in accordance with the design intent and the Owner's operational needs. The process of assuring that such performance is achieved is referred to as "commissioning."
  - C. The Commissioning Team will include representatives of the Owner, Design A/E, General Contractor and Installing Subcontractors, Test and Balance Subcontractor, BAS Subcontractor and Commissioning Authority (CxA), (a.k.a., the commissioning professional (CxP))
  - D. Commissioning is a comprehensive and systematic process of verifying that the building systems perform interactively in accordance with the BOD, according to the construction documents (and the owner's project requirements documents and architectural program to the extent those were generated for this project).
    - The commissioning process shall encompass and coordinate the equipment and system documentation, equipment start up, field testing, control system calibration, testing and balancing, functional performance testing and training. Commissioning requires cooperation and direct involvement by all parties throughout the construction process.
    - In addition to fulfilling scheduling and planning requirements, the Contractor is further responsible for documenting the equipment and system installation and operational verification for all systems and assemblies.
  - E. Commissioning Process Overview: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

#### **SYNGERGIES - SPECIFICATIONS**

1.1

Α.

1.

2.

3.

4.

5.

#### **Combined Front End Specification**

SECTION 019113 GENERAL COMMISSIONING REQUIREMENTS PART 1 - GENERAL SUMMARY and DESCRIPTION OF WORK INCLUDED The University of Florida's use of commissioning recognizes the integrated nature of building systems and the importance of waterproof building envelope in loday's complex facilities. The performance of these systems impacts operating cost, efficiency, and sustainability, indoor air quality, comfort and productivity in the workplace or classroom/lab, and security. The goal of commissioning is to help deliver facilities that meet or exceed expectations for these factors. Strategies include periodic direct observation of envelope system construction and operation of dynamic building systems through their full range of intended and failure-mode operation. The specific new building systems and equipment to be commissioned on this project are as follows (note that existing equipment and existing building systems are not part of the commissioning scope unless otherwise indicated) : BUILDING ENVELOPE (including masonry, curtainwall/storefront and glazing, exterior walls & cladding, flashings & sealants, exterior drainage systems, and roofing) PLUMBING (including domestic water, hot water, and booster pumps) HVAC (including building entrance of distributed utilities, air handling units, terminal devices, general and hazardous exhaust systems, return air system, chillers, pumps, VFDs, cooling towers, boilers, heat exchangers, associated or supporting equipment, and TAB) ELECTRICAL (including motors, grounding, lightling and daylightling controls, switchboards, distribution panels >800 amps, emergency power supply system) Low Voltage (including DDC Building Automation System, security and access control, audio/visual)

RELATED SECTIONS and DOCUMENTS

Α. Documents affecting the work of this Section include other elements of the Contract for Construction. including the Owner/Builder Agreement or Owner/Design-Builder Agreement, the General Terms & Conditions, other sections of the Division 0 and Division 1 non-technical specifications, and the following technical plans and specifications:



## **SYNGERGIES – DESIGN REVIEW**

# Share our Expertise & Experience

- Common Timeframe
- Coordinated Comments
- Design Review Meetings
- Tracking on Common Platform

Number	Description	Status	Priority	Asset	Assign
	and copper is not intended to				
	maintain historic look.				
DR-6 198	Rod deck is unknown. Thickness of	CLOSED		Historic	
	insulation at stated R value is thick (5			Norman	
	inches). Use of fasteners as shown				
	way be challenging and expensive				
	Recommend adhering all layers if				
	conorde-dock and fasterring only the				
	first layer of insulation if metal deck.				
DR-6-199	Snow fence raits shown.	CLOSED		Historic	
	Confirm that intend is for failing definits			Norman	
	protection and that this protection				
	outweights the potential for water				
	intrusion due to fasteners.				
09.4.200	Fiber cant shown. UF Standards cell	010010		inatoric	
	for pressure treated.			Norman	
	Confirm if acceptable to UF.				
08.4-201	Detailing of membrane to post not	CLOSED		Haloric	
	dear			Norman	
	Consider adding additional detailing				
	showing flasing of post to membrane.				
	Also, recommend sealant at deck to				
	poet transition for air Sghtheas.				
DR-4-202	Neopnene misspelled	CLOSED		Historic	
				Norman	
	Correct spelling				
08.4.203	Exposed steel appears present at	CLOSED		Historie	
	roof edge.			Norman	
	Recommend revising detailing to				
	avoid exposed steel				
08.4.204	Cart shown at roofwall transition,	CLOSED		Haloni	
	even though liquid applied roofing			Norman	
	based				
	Recommend removing carit				
084205	Sealant bead location not shown on	0.000		Historic	
	detail			Norman	
Cenigr Ineu	en   Printed on ES1102015   Page 12 of 5				

lumber	Description	Status	Priority	Asset	Renigned.	Due Dete
	well, however there are CO2 and humidity sensors shown.					
DR-471	Recommend to provide isolation values at the wall near the riter take of to isolate branch supplies and returns especially where those branches are serving multiple units.	(1000) (1000)	ACCESSION TO	Hatoric Norman		
DR-4-73	There is a 5 th pipe on the headers supplying PCUs 2.3 to PCU 2.8 beginning at PCU 2.5. What is 8.7 it is not labeled or sized.	(LOSE)	MODEPLATE	Historic Norman		
084 N	There is a line partially drawn to the north of FOUE3 and a pipe rising from FOU 23 & FOU 2.4 not connected to anything	(1091)	MODERATE	Historii Norman		
08.4.75	Show service Access space requirements for ArtU 1	CLOSED	MODERATE	AHQ-1		
08.4.80	Show service Access space requirements for DOAS 1.6.2. Shade or helds the service access where not done.	(20060)	MOREMATE	Abi		
DR-4-81	Where tranches T provide toolation value one either side of the T split and at the riser takeoffs.	ELOSED	100	Atte		
DR-4-82	Pipes for DOAS are dropping too close to the ANU to be piped and thed drop will interfere with the VFD bennoe access when piped as shown, especially when those pipes are between the closest wall and the unit as for DOAS 2	(CECONER)		Atte		
DR-443	This diagram is good but would be befor with an flows indicated its evaluate building pressurization	(ci osito)		Historic Norman		4272018
DR-4-84	Iso valves for CHMS/R (M802) and MMS/R (M802) vale as needed on the plans for branch line isolations off the risers are shown on these sheets.	(CIONIC)	LOCETUTE	Historic Norman		
DR-4-85	No HW or Steam metering indicated as was provided on the CHW and required to UFL PDC standards	CLOSED	MOCHENNES!	Historic Norman		

### SYNERGIES – CX PLAN

#### **One Plan vs Two Plans**



UF-22TA NORMAN HALL REHABILITATION	JF FLORI
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# 04

# **CONSTRUCTION PHASE**




# WHAT DOES THE CXA ACTUALLY <u>DO</u>?

- Construction Phase
  - Kickoff Meeting
  - Submittal Review
  - Update Cx Plan
  - Site Observation
  - Issue Tracking
  - Start-Up Testing
  - Envelope Testing

# SYNERGIES – CX KICK OFF AND OTHER MEETINGS

#### **Construction Phase**

#### **Kickoff Meeting**

- Prepare an Agenda
- Entire Team Attends
- Review Goals
- Site Review Process
- Set Roles &
   Responsibilities
- Discuss Schedule
- Discuss Start-Up & Functional Testing



#### **Cx Meetings**

- Prepare an Agenda
- Review Issues / Resolution Log
- Discuss Progress & Updates
- Document Revisions
- Review Schedule & Key Dates

## **SYNERGIES - CONSTRUCTION OBSERVATION**



### **SYNERGIES – ISSUE TRACKING**

#### Issue Communication, Tracking, and Resolution



Performance Mockups



## **Building Enclosure**

enterpointe 0	1/14/2015	Log 337
Extenior Doors Flieshing		
<ol> <li>Self-adhered membrane installed at door jumbs.</li> </ol>	Checked	
<ol> <li>Door Pau flochings folyicated with a 1/2" restined data.</li> </ol>	Checked	
<ol> <li>Door pen flackings installed tightly interest specing.</li> </ol>	<sup>(5)</sup> N3.	
<ol> <li>Door threshold substrate slope instead pri- to pan installation.</li> </ol>	* Nik	
3. All threesers think	Checked	
6 Door beck dame are protected.	Checkel	
Windows Flashing		
1. Rough opening clean and framing ready for fexable finding application.	2638	
2. All thereases use fluids.	Classified	
). Self adhered membrane primer installed.	NR	
4. Self-adhered membrane thingled where required.	Checked	
<ol> <li>Self-adhered membrane themistic flashing in processed.</li> </ol>	<sup>pt</sup> Checked	
6. Self-adlered membrane paper backing senared where required.	Checked	
Exterior Door Installation		
2. Review Gendlie Gailing at 2-Hour ferwoll conditions.	NOL	
<ol> <li>If derivall is required for fire, Gendule Sada is to be installed over the drywall.</li> </ol>	M NOL	
<ol> <li>If the issuit is metal, 3-model is required along the issuits and a min, of 1147 between the door trim and 3-model is required to allow for becket and</li> </ol>	NA	
4. Head finding installed over the door jush flexible finding wapping into opening.	NOL	
5. Door jambs notched around the back jamb.	N(8,	
Window Installation		
I. Renew sealant type used at familie families	p. Claskel	
2 Window installed with scalast soring itom.	for Checked	



#### **Protect the Design**





MEP























## 05 ACCEPTANCE / FUNCTIONAL PERFORMANCE VERIFICATION



# WHAT DOES THE CXA ACTUALLY DO?

#### Acceptance Testing

aka Functional Performance Testing:

making sure the systems can do what the Construction Documents say they're supposed to do.

#### **OVERSEE PERFORMANCE TESTING – ASTM E779**



## ASTM E1186 (4.2.6) "SMOKE TRACER"







### **ASTM D4541 ADHESION TESTING**



#### **OVERSEE PERFORMANCE TESTING – AAMA 501.2**





### **OVERSEE PERFORMANCE TESTING – ASTM E1105**



#### **OVERSEE PERFORMANCE TESTING – AAMA 501.1**





#### **OVERSEE PERFORMANCE TESTING – ASTM D7877**



## **OVERSEE ROOF TESTING**





### **OVERSEE ROOF TESTING**



#### **OVERSEE ROOF TESTING**



## **DUCT / PIPE PRESSURE TESTING**







# WHAT DOES THE CXA ACTUALLY DO?

#### • Post Occupancy

- Deferred Testing
- Scheduled site visits
- Warranty & Close-Out Items
- Owner conference
- Develop Ongoing Cx Plans
- Final Cx Report

#### SYNERGIES – CX REPORT One Reports vs Two Reports





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UF400 Cypress Hall Residence Hall	
TLC Project #813081	



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Appendix B	Owner Project Requirements & Basis of Design
Appendix C	Commissioning Plan (CxP)
Appendix D	Design plans (A reduced copy of the MEP plans) & Design Review Comments
Appendix E	ALC Building Automation System (BAS) submittal.
Appendix F	Equipment start up verification checks/ pre-functional testing
Appendix G	Functional Performance Tests
Appendix H	Test and Balance Report & Building Envelope Tests
Appendix I	Other project miscellaneous documents (Meeting Agenda & Minutes, Reports)
Appendix J	BE Cx Issues Log and Systems Cx Issue Log
Appendix K	Training Documentation



Final Commissioning Report - March 5, 2018

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# LEAKY BUILDINGS SUCK



#### **KITCHEN HOODS**



#### **NEGATIVE PRESSURE**



# **VAPOR DRIVE**



### WATER DAMAGE



# IN SUMMARY....

- Integrated MEPCx + BECx:
  - High Performance Buildings must address BE and MEP
  - Better Execution of Project Goals
  - Cx Process & Timelines
  - Streamlined Documentation & Meetings
  - Save Owner & Team Time and Money



# **Thank You!**

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