Commissioning & Retro-Commissioning Meet Energy Code

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Agenda

- Introductions
- What is Commissioning
- Value of Commissioning
- Code Required Cx Process
- Customize your Cx Process
- What documentation should be expected
- Lessons Learned
- What’s Next?

Tyson Glimme

Senior Vice President & Madison Office Director

P.E., LEED® AP, QCxP
Commissioning Engineer
Mechanical Engineer

- Tyson is a registered Professional Engineer and a Qualified Commissioning Provider with over 10 years of professional experience.
- He specializes in energy services related to high performance systems and facilities.
- He has provided commissioning and energy performance services for various facility types from stem cell research facilities to LEED Platinum Pilot restaurants.

Scott Kading

Director of Commissioning & Commissioning Provider

QCxP
Commissioning Engineer
Mechanical Engineer

- Scott is a commissioning provider and mechanical engineer with extensive experience with commissioning services including documentation review, field visits and operational verification of major electrical, HVAC and plumbing systems.
- He has managed MEP system and building envelope commissioning services and LEED reporting and submittal reviews for new construction and retro-commissioning.
- He has also participated in commissioning standards workgroups that develop national standards for project documentation.

What is Commissioning?

is a quality oriented process for

achieving, verifying and documenting

that the performance of

facilities, systems and assemblies

meets defined objectives and criteria

Why Apply the Commissioning Process?

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5-10%

Of the total life cycle cost of owning & operating a building is design and construction

Building systems consume more than

39%

of the energy today

Commissioning and Retro-Commissioning can reduce a facilities energy costs by more than

15%

Top performing buildings use

3-4x

less energy per square foot than the worst performers

Why Apply the Commissioning Process in the Healthcare Facilities?

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Hospitals are

3x

more energy intensive than other commercial buildings

Courtesy of: http://www.energy.gov

Roughly

8%

of greenhouse gas emissions are directly related to fossil fuels consumed by health systems facilities

Information provided by U.S. Department of Energy

$8+ Billion

Spent annually on energy costs

Information provided by U.S. Department of Energy

Most facilities can save more than

20%

of utility costs by conservation measures & improving processes

Information provided by U.S. Department of Energy

Value of Commissioning

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Project Cost of Medical Office Building	Total Life Cycle *high construction cost	~35% to 40% of cost of ownership is energy costs
$20M	$200M	$70M

This equates to $1.4M per year (over 50 years)

The Value of Commissioning

- Standard energy savings associated with commissioning services is ~ 20%
- Normally a minimum of 13% energy savings per year
- A 13% savings per year is roughly $182,000 of energy savings every year
- $182,000 savings per year equates to $4.5M of gross profit (assuming 4% profit margin) necessary to offset this cost

Retro-Commissioning Case Study

Sample Project	Energy Star Rating	Electrical kBTU	Natural Gas kBTU	Total kBTU
Prior to Retro-Cx	49	81,987,454	186,550,300	268,537,754

- Phase I energy savings have resulted in $296,757 in energy cost savings in the first year
- Facility continues to implement energy saving measures and has reduced complaints
- Results equal 5% electrical savings and 14% gas savings

Retro-Commissioning Case Study

Sample Project	Energy Star Rating	Electrical kBTU	Natural Gas kBTU	Total kBTU
Prior to Retro-Cx	49	81,987,454	186,550,300	268,537,754
After Phase I	60	76,911,719	172,396,700	249,308,419

- Phase I energy savings have resulted in $296,757 in energy cost savings in the first year
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Retro-Commissioning Case Study

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Prior to Retro-Cx	49	81,987,454	186,550,300	268,537,754
After Phase I	60	76,911,719	172,396,700	249,308,419
After Phase 2	62	78,644,494	160,512,000	239,156,494

- Phase I energy savings have resulted in $296,757 in energy cost savings in the first year
- Facility continues to implement energy saving measures and has reduced complaints
- Results equal 5% electrical savings and 14% gas savings

Commissioning Designations

School	Degree	Designation
UW-Madison	Qualified Commissioning Process Provider	QCxP
	Accredited Commissioning Process Authority Professional	CxAP
	Accredited Commissioning Process Manager	CxM
Building Commissioning Association (BCxA)	Associated Commissioning Professional	ACP
	Certified Commissioning Firm	CCF
ASHRAE	Building Commissioning Professional Certification	BCxP
National Environmental Balance Bureau (NEBB)	Commissioning Process Professional	CxPP
AABC Commissioning Group (acg)	Certified Commissioning Authority	CxA
Association of Energy Engineers (AEE)	Certified Building Commissioning Professional	CBCP

Commissioned Systems Required by Code

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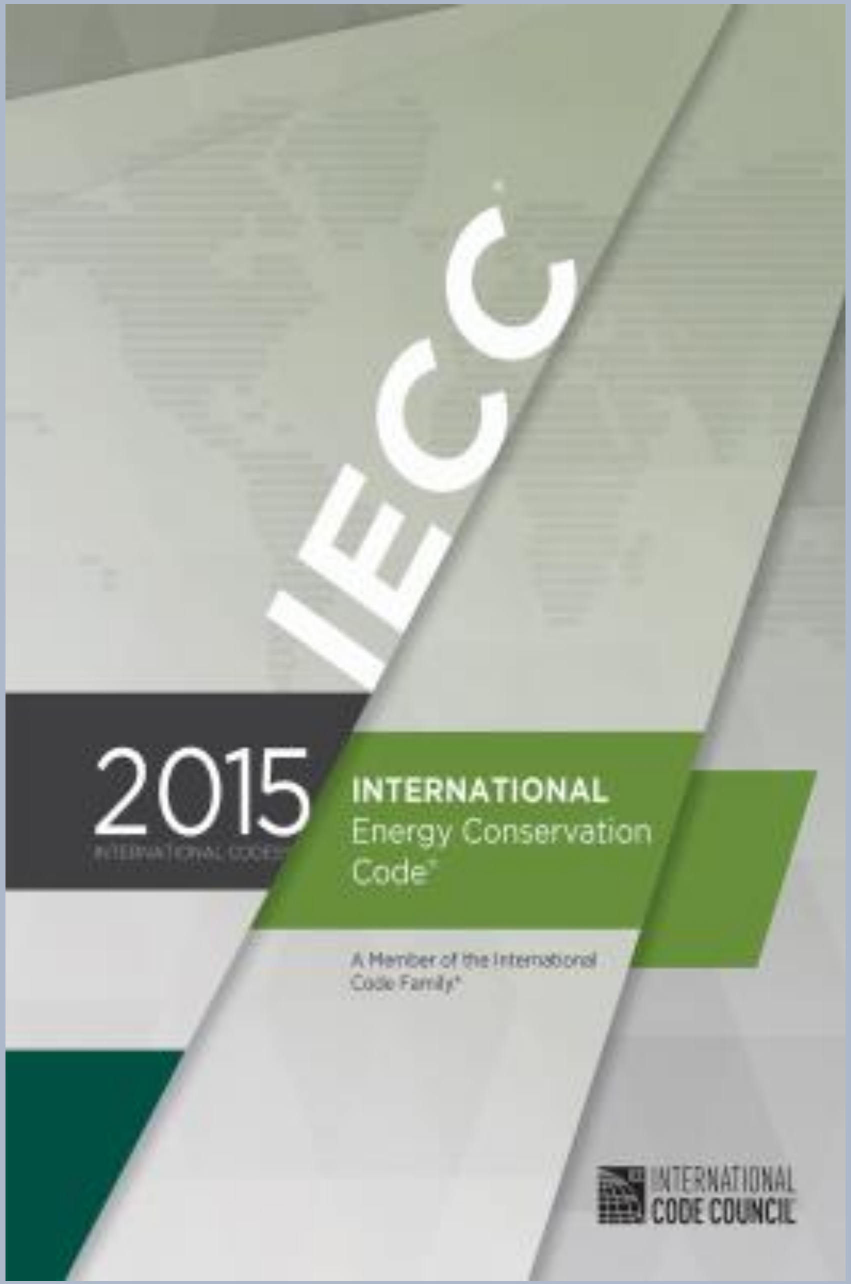
IECC
2015
INTERNATIONAL CODES
INTERNATIONAL
Energy Conservation
Code
A Member of the International
Code Family
INTERNATIONAL
CODE COUNCIL

Mechanical Systems – Section C403

- Heating and Cooling 5˚F Deadband
- Off-Hour Controls controlled by time clock or programmable Controller
- Unoccupied spaces must be capable of resetting from 55˚F to 85˚F
- Systems serving < 25,000 SF or serve more than 1 floor must be divided into isolation areas
- Heat trace shall have temperature setbacks
- Hot water boiler setback temperatures
- Required Energy Recovery
- Demand Control Ventilation for spaces > 500 SF and average occupant load 25 people/1000 SF
- Kitchen Exhaust Systems shall not provide < 10% make-up air directly into hood
- Supply air temperature reset controls
- Heat recovery for service water heating
  - Facility is in operation 24 hours/day
  - Heat capacity < 6,000,000 Btu/Hr
  - Hating load exceeds 1,000,000 BTU/Hr

Electrical Systems – Section C405

- Mandatory Occupancy Sensor Controls
  - Eliminate Nuisance Trips
  - Maximize Performance
- OR Time Switch Controls
  - Exception: Patient Care spaces or endanger occupant safety
- AND Manual Light Reduction Controls
- Day-Light Responsive Controls (spaces with >150 watts of general lighting).
  - Exception: Patient Care Spaces
- Specific Application Controls
  - Display and Accent Lighting
  - Task lighting to be wired directly to readily accessible control device
- Exterior Lighting Controls
  - Dawn to Dusk Control
  - Daylight Controls
  - Lighting to be reduce by >30% between midnight and 6 am if activity is not sensed within 15 minutes

Commissioning Process per ASHRAE Guidelines 0-2005

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Planning Phase

		◆	Assist the Owner in creating the OPR
○		◆	Develop a preliminary copy of the Commissioning Plan
			Develop Submittal Checklists
			Develop Design Phase Checklist

- ○ International Energy Conservation Code
- ◆ LEED Fundamental Commissioning Prerequisite

Design Phase

- Document the Basis of Design
- ■ Review design for compliance to the OPR
- ◆ Integrate Commissioning Process requirements during construction and occupancy phases into the specifications

■ LEED Enhanced Commissioning

◆ LEED Fundamental Commissioning Prerequisite

Construction Phase

	■		Review submittals for compliance
			On-going Cx Meetings
		◆	Develop and track construction checklists
	■		Obtain and verify O&M Manuals for inclusion into the Systems Manual
⭘			Testing and Balancing is verified (water and air)
	■		Accomplish initial training and O&M walk-throughs

- ⭘ International Energy Conservation Code
- ■ LEED Enhanced Commissioning
- ◆ LEED Fundamental Commissioning Prerequisite

Turnover

⭘		◆	Accomplish and verify Functional Performance Testing (FPT's)
			Verify on-going system training
			Verify the Commissioning Issues Record
			Review and verify final O&M documentation
			Substantial Completion

⭘ International Energy Conservation Code

◆ LEED Fundamental Commissioning Prerequisite

Operation Phase

⭘			Provide Preliminary Commissioning Report
	■		Perform seasonal testing and re-training
	■		Review equipment performance prior to warranty expiration and provide recommendations to improve performance
			Lessons learned meeting
⭘		◆	Complete and submit Final Commissioning Report
	■		Complete and submit Final Commissioning Report including Systems Manual

⭘ International Energy Conservation Code

■ LEED Enhanced Commissioning

◆ LEED Fundamental Commissioning Prerequisite

Commissioning Services

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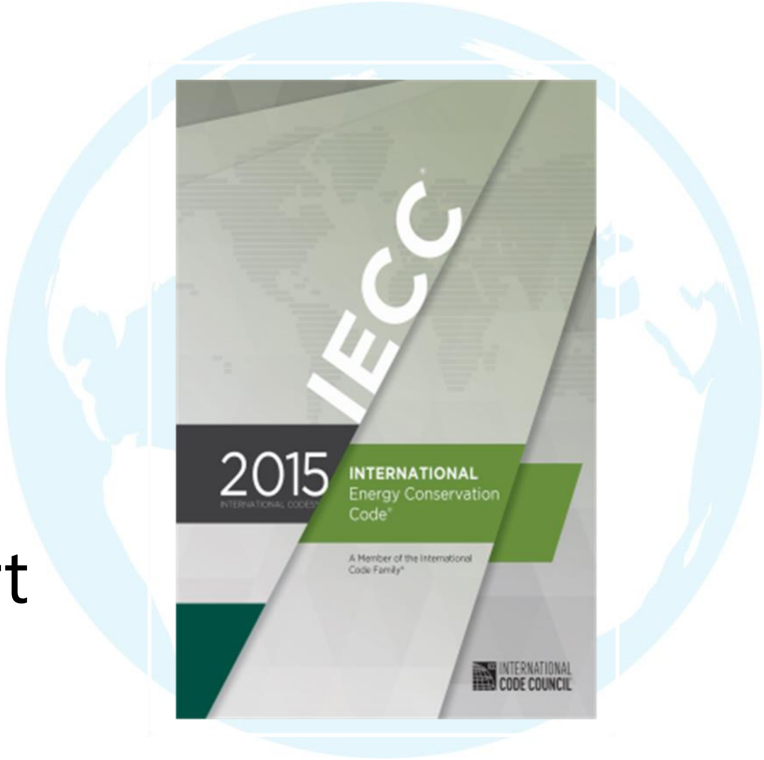
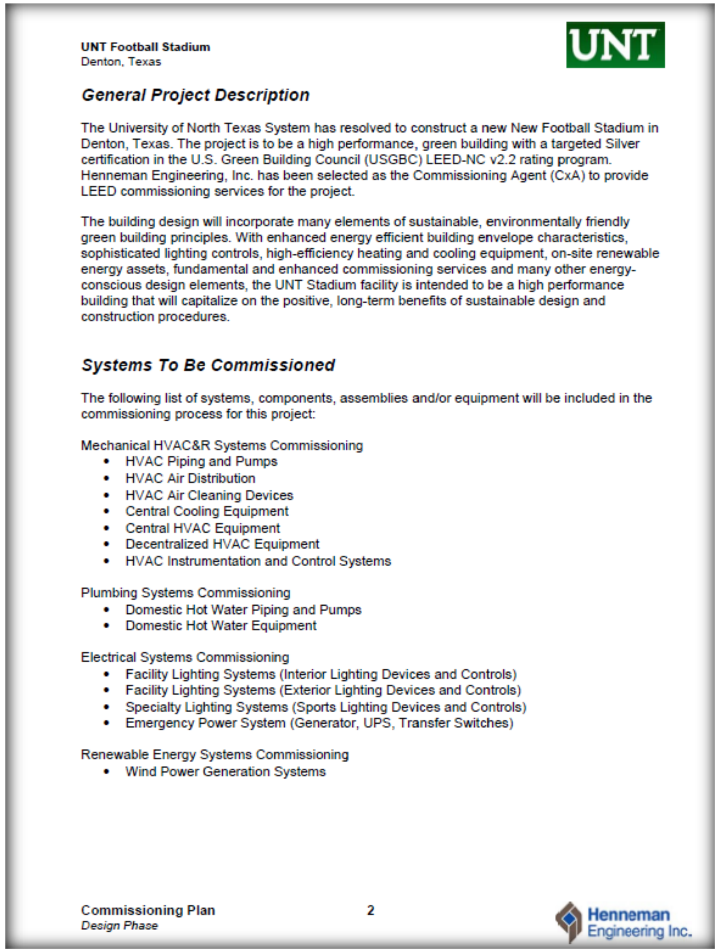
System Commissioning – Section C408

- Develop Commissioning Plan
- Verify Air System Balancing
- Verify Water System Balancing
- Verify Functional Testing
- Provide Preliminary Commissioning Report
- Written Balance Report
- Final Commissioning Report



The Commissioning Plan

- Description of the goals for the project and the commissioning scope
- Listing of equipment and systems to be tested including expectations.
- Functions to be tested
- Optimal conditions that will be tested



UNT Football Stadium
Denton, Texas

UNT

General Project Description

The University of North Texas System has resolved to construct a new New Football Stadium in Denton, Texas. The project is to be a high performance, green building with a targeted Silver certification in the U.S. Green Building Council (USGBC) LEED-NC v2.2 rating program. Henneman Engineering, Inc. has been selected as the Commissioning Agent (CxA) to provide LEED commissioning services for the project.

The building design will incorporate many elements of sustainable, environmentally friendly green building principles. With enhanced energy efficient building envelope characteristics, sophisticated lighting controls, high-efficiency heating and cooling equipment, on-site renewable energy assets, fundamental and enhanced commissioning services and many other energy-conscious design elements, the UNT Stadium facility is intended to be a high performance building that will capitalize on the positive, long-term benefits of sustainable design and construction procedures.

Systems To Be Commissioned

The following list of systems, components, assemblies and/or equipment will be included in the commissioning process for this project:

Mechanical HVAC&R Systems Commissioning
- HVAC Piping and Pumps
- HVAC Air Distribution
- HVAC Air Cleaning Devices
- Central Cooling Equipment
- Central HVAC Equipment
- Decentralized HVAC Equipment
- HVAC Instrumentation and Control Systems

Plumbing Systems Commissioning
- Domestic Hot Water Piping and Pumps
- Domestic Hot Water Equipment

Electrical Systems Commissioning
- Facility Lighting Systems (Interior Lighting Devices and Controls)
- Facility Lighting Systems (Exterior Lighting Devices and Controls)
- Specialty Lighting Systems (Sports Lighting Devices and Controls)
- Emergency Power System (Generator, UPS, Transfer Switches)

Renewable Energy Systems Commissioning
- Wind Power Generation Systems

Commissioning Plan 2
Design Phase

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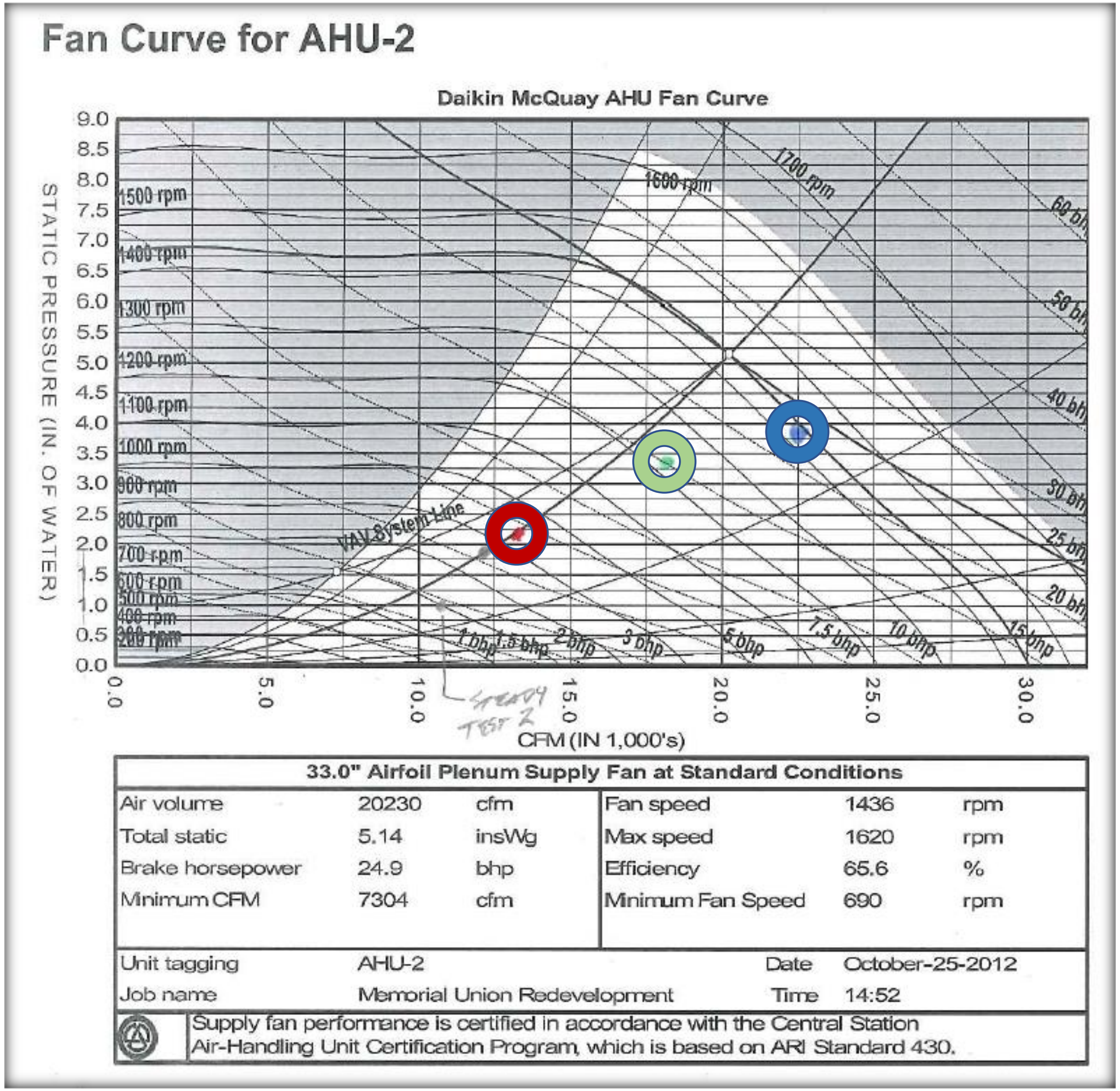
Verification of Air System Balancing

- Each zone shall be equipped with air balancing device
- Constant volume systems shall not have discharge dampers installed
- Demand Control Ventilation has limits
- Un-explained “Winds”



Air volume	20230	cfm	Fan speed	1436	rpm
Total static	5.14	insWg	Max speed	1620	rpm
Brake horsepower	24.9	bhp	Efficiency	65.6	%
Minimum CFM	7304	cfm	Minimum Fan Speed	690	rpm

Unit tagging	AHU-2	Date	October-25-2012
Job name	Memorial Union Redevelopment	Time	14:52

Supply fan performance is certified in accordance with the Central Station Air-Handling Unit Certification Program, which is based on ARI Standard 430.

Verification of Air System Balancing

- Each zone shall be equipped with air balancing device
- Constant volume systems shall not have discharge dampers installed
- Demand Control Ventilation has limits
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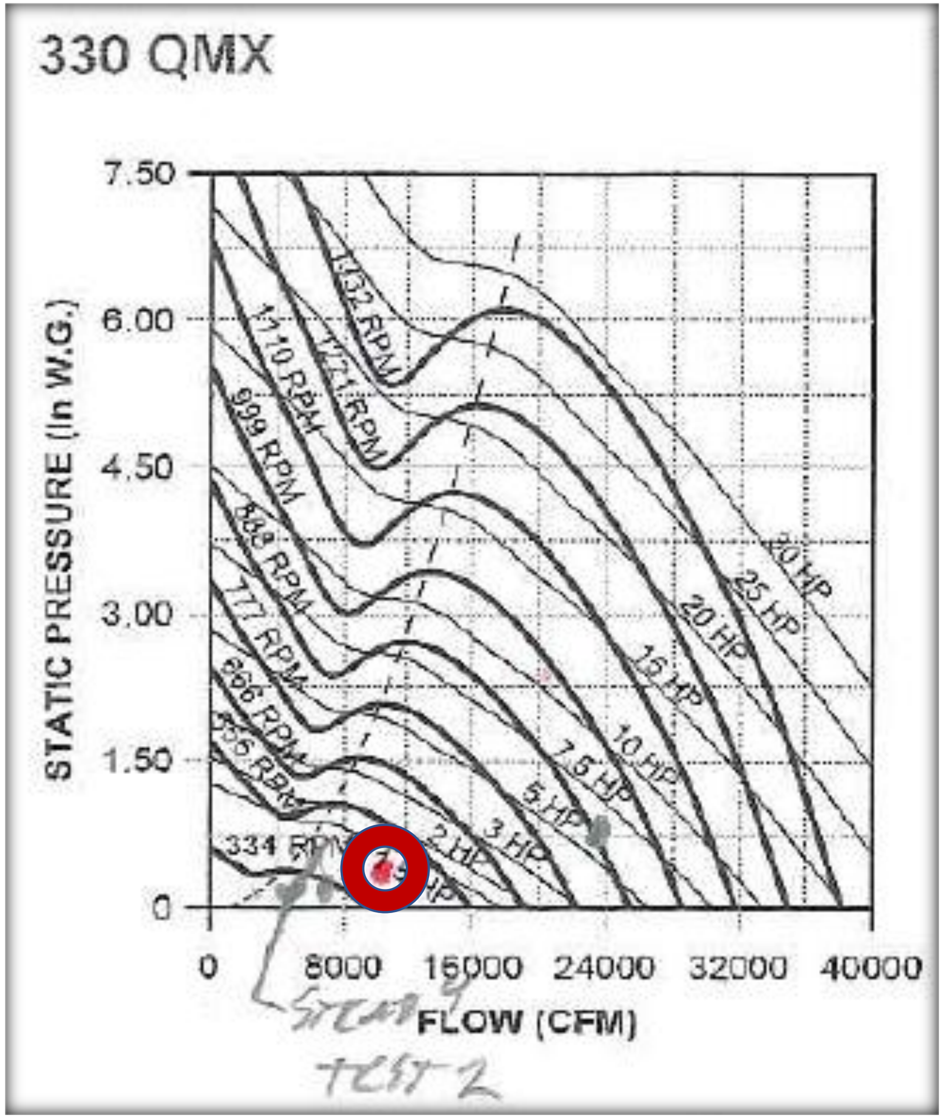


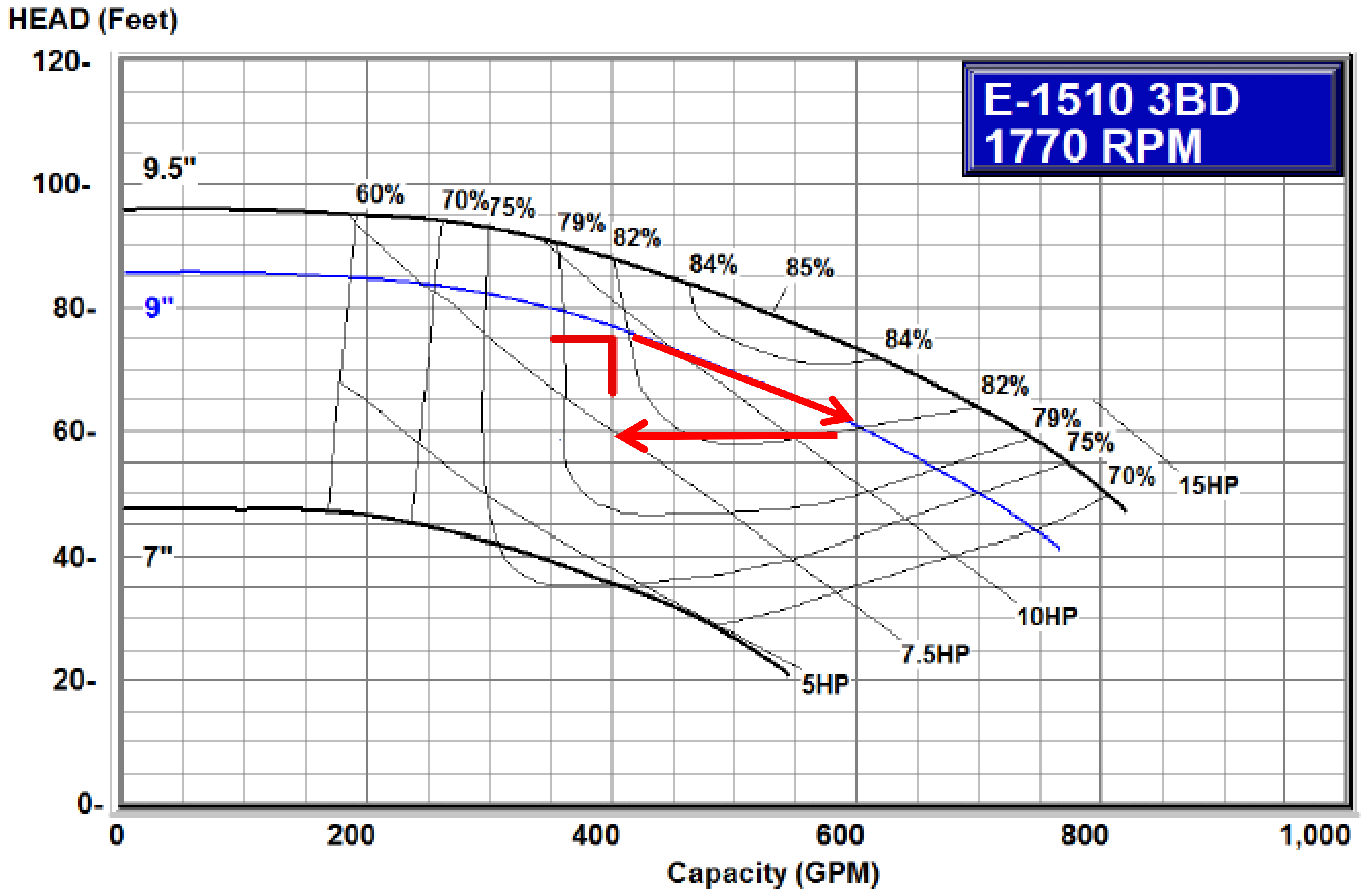
Verification of Hydronic System Balancing

- Each heating and cooling coil to be provided with means for balancing and measuring flow.
- Pump impeller to be trimmed or pump speed adjusted to meet design flow.
- When should the pump impeller be trimmed vs. speed adjusted?
    - "Permanent Conditions"

SERVICE OR DESIGNATION	SIZE	MODEL	DESIGN GPM	VALVE SETPOINT DEGREE	VALVE P.D.	GPM	NOTES
Room							
47	1"	B&G	14	0	12.2	13.5	
70N	1.25"	B&G	13.2	40	43	12.4	
73	2"	TA	24.5	1.4	24	25.1	
143	1.5"	B&G	56.1	24	52	52	
145	1.5"	B&G	46.4	0	12.1	46	
145	1.5"	B&G	9	50	16.1	9.8	
277	1.5"	B&G	26.6	34	3.5	24.9	
278	1"	B&G	8.8	30	5.8	9.1	
343	2"	B&G	35.9	33	3.2	36	
377A	1.5"	B&G	59.2	0	17.6	55	
445	1"	B&G	2.5	25	3.5	2.7	
445	1"	B&G	4.2	38	31	4.1	
473K	1.25"	B&G	11	33	17	11.1	
473M	1.25"	B&G	6.2	41	14	6.8	

REMARKS:
There are 3 balance valves reflected for corridor 445. VAV 4-4, 4-5, 4-11, 4-12, and 4-13 have been struggling with heating. The additional balance valve should have roughly 12.5 gpm through it.

When to trim the impeller?



Design Capacity =400.0 GPM
Design Head =75.0 Feet

Suction Size = 4 "
Suct. Velocity = 10.1 fps
Discharge Size = 3 "
Disc. Velocity = 17.4 fps

Min. Imp. Dia. = 7 "
Max. Imp. Dia. = 9.5 "
Cut Dia. = 9 "

Max. Flow = 767 GPM
B.E.P. Flow = 505 GPM

Eff. @ Duty-Point = 81.22 %
Motor Size =15 HP

B.H.P. @
Duty-Point = 9.51 BHP
Max. B.H.P. for
Imp. Cut = 11.78 BHP

Functional Testing & Associated Reports

- Includes all modes described in Sequence of Operations
- All redundant or back-up modes
- Performance of alarms
- Modes of operation related to loss of power or restoration of power

Functional Test Procedure

Factory Fabricated Custom Air Handling Unit

FT ID:	FT- 23 73 13
Tag ID:	AHU-25
Location:	MECHANICAL ROOMS, FLOORS 8

1. General Information:

Date:

8/27/2013

Participants:

Name	Organization
Tyson Glimme	Henneman Engineering
Edward Walters	UW FP&M

Recorded by:

Tyson Glimme	Henneman Engineering, Inc.

2. Objective:

This test is performed to investigate the ability of the AHU to maintain discharge temperatures to supply air distribution systems for the facility, as well as evaluate the functionality of the integral sequences related to this primary service.

3. Sequence of Operation:

LABORATORY AIR HANDLING UNITS CONTROL

GENERAL:

Air handling units and are factory-fabricated, custom air handling units, located on each floor. These units supply air to the laboratory, laboratory support spaces, and office spaces in the building. Each unit has (2) supply fans that are each sized to provide 50% of the peak supply air requirement of the building service area. Each air handling unit has a single return fan with relief / return dampers.

Each air handling unit operates as a separate system.

System is designed as heating-cooling, single duct, variable volume reheat system with heat recovery.

UNIT OPERATING MODE:

System shall operate continuously with single operating mode.

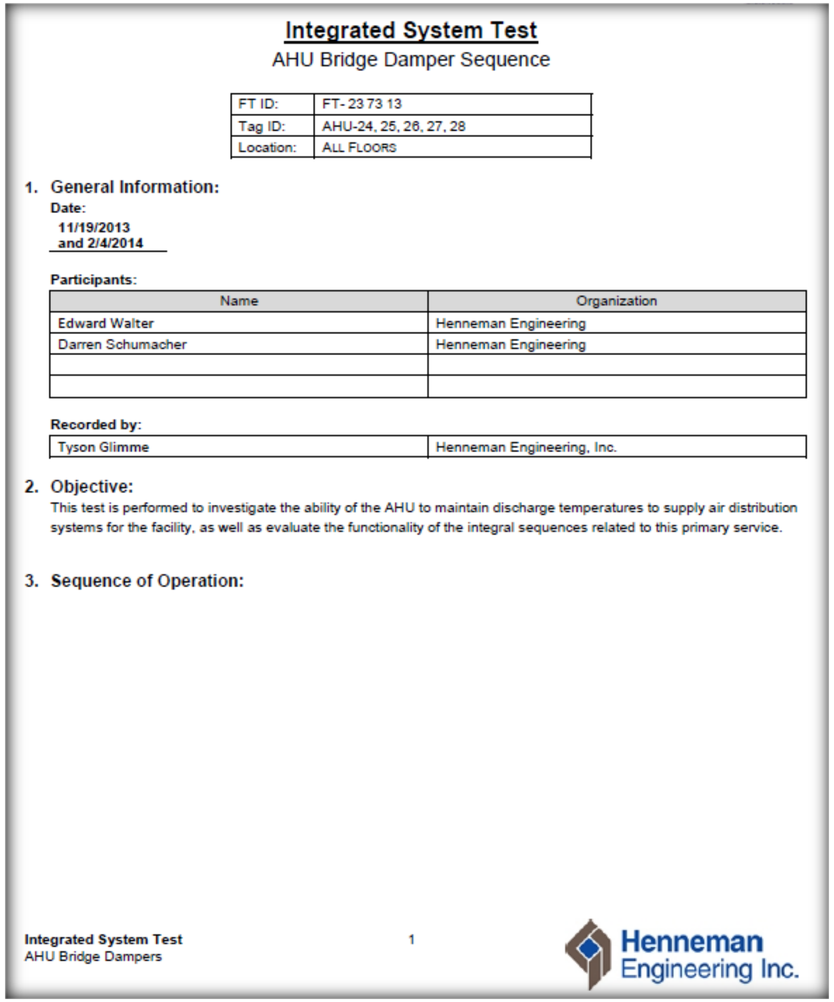
UNIT OPERATION:

Unit operation shall be automatic and activated through building automation system.

Control contractor to provide all necessary devices such as relays required for interface.

Integrated Systems Tests for Healthcare & Reports

- Energy Recovery Wheels
- Redundant AHU's
- Exhaust Fans tied to facility systems
- Modes of operation related to loss of power or restoration of power



Integrated System Test

AHU Bridge Damper Sequence

FT ID:	FT- 23 73 13
Tag ID:	AHU-24, 25, 26, 27, 28
Location:	ALL FLOORS

1. **General Information:**

Date:
11/19/2013
and 2/4/2014

Participants:

Name	Organization
Edward Walter	Henneman Engineering
Darren Schumacher	Henneman Engineering

Recorded by:

Tyson Glimme	Henneman Engineering, Inc.

2. **Objective:**
This test is performed to investigate the ability of the AHU to maintain discharge temperatures to supply air distribution systems for the facility, as well as evaluate the functionality of the integral sequences related to this primary service.

3. **Sequence of Operation:**

Integrated System Test
AHU Bridge Dampers 1

Henneman Engineering Inc.

Integrated Systems Tests for Healthcare & Reports

- Energy Recovery Wheels
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SMOKE CONTROL:
Smoke detectors are located in each air handling unit discharge duct and the return fan discharge duct. The detectors will be furnished, installed and wired to the Fire Alarm System by the Electrical Contractor. Fire Alarm Control Module shall be located at the temperature control panel by the electrical contractor, and shall be programmed by the fire alarm contractor to shutdown the AHU and close smoke / isolation dampers on smoke detection of any of the associated duct smoke detectors for the AHU. Associated wiring between the fire alarm control module and the AHU to shutdown the AHU shall be provided by the DDC contractor.

Return fan's smoke detector, upon detection of smoke, shall stop respective return fan, return air damper shall close and respective office supply air terminals shall be modulated to minimum position.

4. Test Equipment Used:

Instrument	Accuracy	Calibration Certificate Available?
Alnor Velometer	0.5°F	Yes
Dwyer Manometer	0.01"	No

5. Initial Conditions (Pre-Test):

ID	Test Procedure *(complete if checked)*		Expected Result *(pass if checked)*		Value	Units
Mode 0: Bridge Damper Pre-Test Conditions (11-19-2013/2-04-2013)						
0.1	Prior to overriding the AHU, document the existing conditions.	☒	Current OAT	☒	8.3/15.6	
			Current MAT	☒	52.4/49.9	
			Current DAT	☒	66.9/67	
			Current Operating Mode of the AHU (Eco, Heating)	☒	Heat	
			Current HV Position	☒	39.7/45	
			Current CV Position	☒	0/0	
			Current OA Damper position (BAS/Actual)	☒	Open	
			Current Return Air Damper Position (BAS/Actual)	☒	49.8/20.9	1
			Current Relief Damper Position (BAS/Actual)	☒	0/0	
			Supply Fan VFD (Hz/RPM/%)	☒	55.9/55.8	

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Integrated Systems Tests for Healthcare & Reports

- Energy Recovery Wheels
- Redundant AHU's
- Exhaust Fans tied to facility systems
- Modes of operation related to loss of power or restoration of power

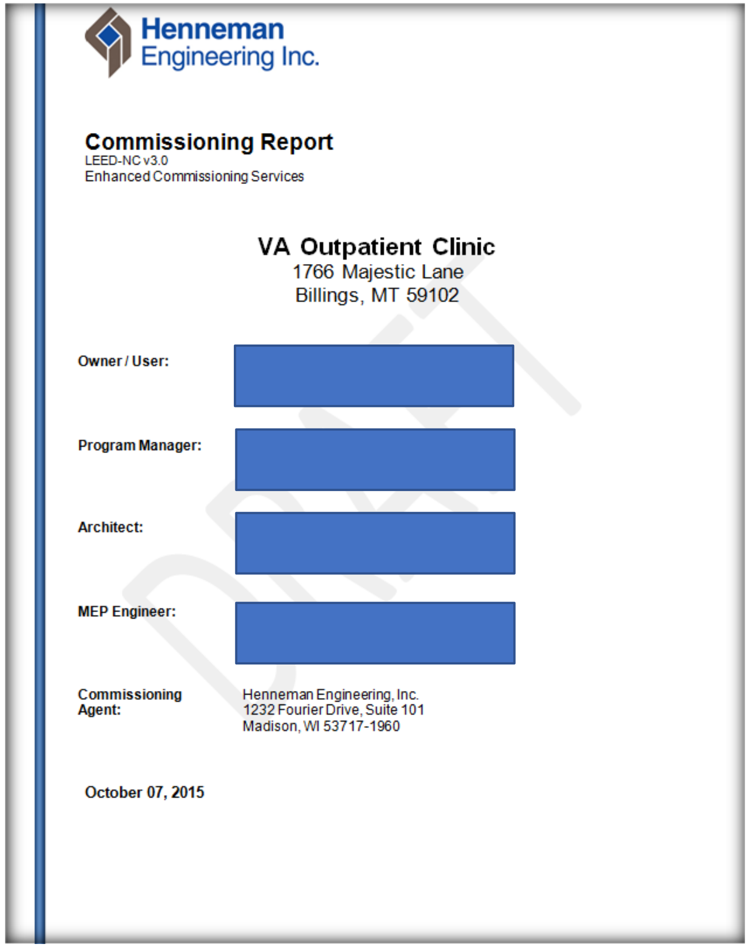
ID	Test Procedure *(complete if checked)*		Expected Result *(pass if checked)*		Value	Units
			Supply Fan TSP	☒		
			Current Floor SP	☒		
			Return Fan VFD (Hz/RPM/%)	☒		
			Return Fan TSP	☒		
			Return Flow	☒		
0.2	Document AHU conditions of AHU providing bridge air	☒	Current Floor SP	☒	1.003	
			Current Supply Fan (Hz, A,%) 5th	☒	55.5%	
			6th	☒	50.9%	
			7th	☒	56.8	
			8th	☒	51.8	
			9th	☒	48.8	
			Current supply fan RPM	☒	0	
			Current Return Fan Flow	☒	1253	
ID	Test Procedure *(complete if checked)*		Expected Result *(pass if checked)*		Value	Units

6. Functional Test Script:

ID	Test Procedure *(complete if checked)*		Expected Result *(pass if checked)*		Value	Units
Mode 1: Remote Start/Stop (Failing two lowest AHU's)						
1.1	Over-ride unit into occupied mode.	☒	Unit is in occupied mode.	☒		
			Fire/smoke/isolation damper in bridge ductwork closed.	☒		
			Supply fire/smoke/isolation damper opened.	☒		
1.2	Over-ride one unit to OFF.	☒	Unit de-energized.	☒		
			Outside air and exhaust dampers close fully and return air damper opens fully.	☒		
			Fire/smoke/isolation damper in bridge ductwork opened within 120 seconds.	☒		
			Supply smoke/isolation damper closed within 120 seconds.	☒		
			Alarm generated at BAS within 60 seconds.	☒		
			Chilled water valve closed.	☒		2
			Steam valve opens and face & bypass modulates to full face.	☒		
			Return fan dis-engages.	☒		
			Humidifier valve closed.	☒		
			Record static pressure of failed unit and recovery unit once stabilized	☒		
1.3	Document VFD conditions	☒	5th Hz/A/%	☒	0	
			Floor Static pressure	☒	1.133	

Preliminary Commissioning Report

- Separate sections:
  - Mechanical Testing
  - Service Water Testing
  - Electrical Systems Testing
- Itemized deficiencies found during testing
- Necessary deferred tests that could not be accomplished
- Climate conditions needed for deferred tests



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Commissioning Report
LEED-NC v3.0
Enhanced Commissioning Services

VA Outpatient Clinic
1766 Majestic Lane
Billings, MT 59102

Owner / User:

Program Manager:

Architect:

MEP Engineer:

Commissioning Agent: Henneman Engineering, Inc.
1232 Fourier Drive, Suite 101
Madison, WI 53717-1960

October 07, 2015

Preliminary Commissioning Report

- Separate sections:
  - Mechanical Testing
  - Service Water Testing
  - Electrical Systems Testing
- Itemized deficiencies found during testing
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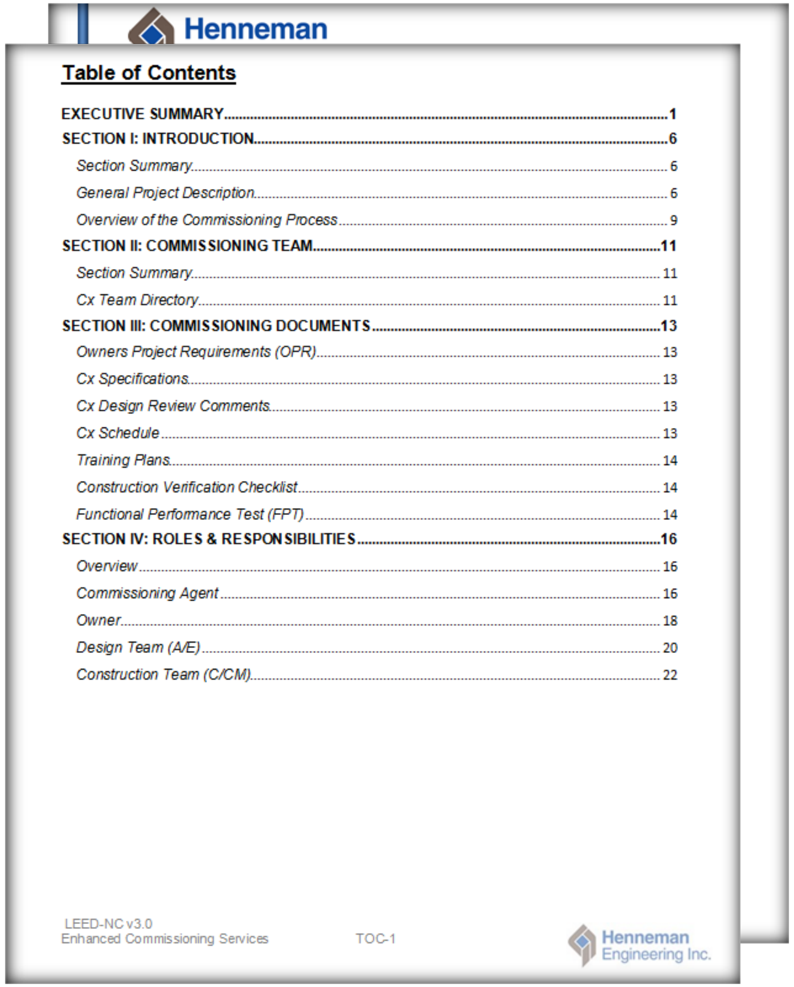

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Itemized Deficiencies

Cx STATUS REPORT (CSR) LOG

Project Name:	VA Billings
Project Location:	Billings, Montana
Project Owner:	Summit Smith
HEI Client:	Summit Smith
CSR Revision:	Revision #06
Revision Date:	Date 8/14/2015

Trade or Discipline Type			
HVAC	HVAC Systems	FSS	Fuel Supply Systems
CTRL	Controls Systems	EPWR	Electrical Power Systems
MECH	Mechanical Systems	LTG	Lighting Systems
FP	Fire Protection Systems	FA	Fire Alarm Systems
DWS	Domestic Water Systems	COM	Communication Systems
PDS	Plumbing Drain Systems	ARCH	Architectural Systems
MGAS	Medical / Lab Gas Systems	MISC	Miscellaneous

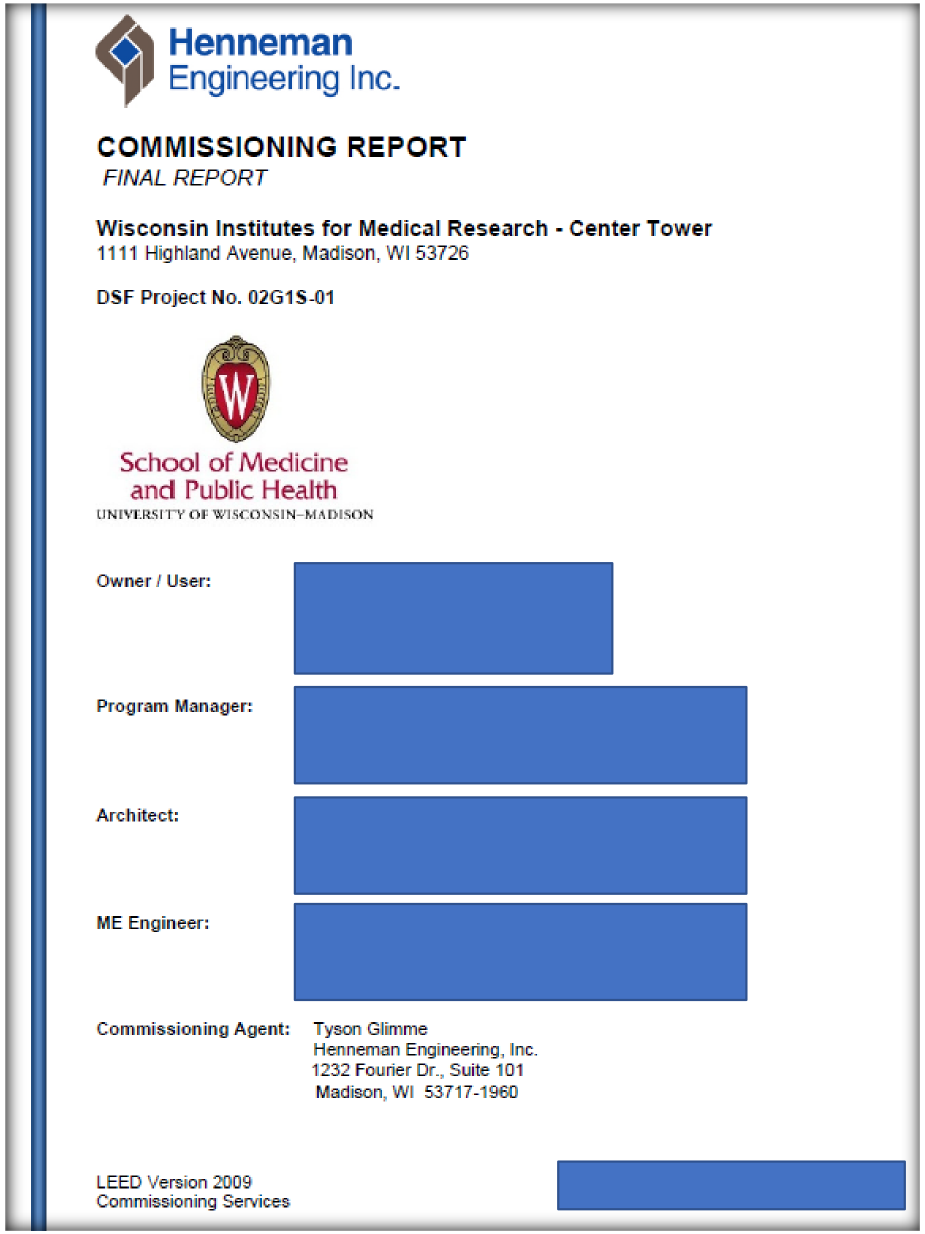
Activity Type			
FT	Functional Testing	SU	Start-up
IST	Integrated System Testing	SR	Submittal Review
OMT	O&M Training	SRC	System Readiness Checklist
SO	Site Observation	TAB	Testing, Adjusting, & Balancing

Comment Type			
CL	Clarification	LEED	LEED Related Issue
CO	Coordination Issue	O	Observation
CR	Critical Issue	R	Recommendation
DEF	Deficiency	S	Suggestion

ID	ID Cross Reference	Action Party	Comment Type	Activity Type	CxA Comment	Date Entered	Status	Response / Resolution	Date Resolved
001	Functional Test	R&D	DEF	FT	UH-1 is specified to have a aqua stat to control the fan, the aqua stat is not visible on the unit.	1/26/2015	Resolved	Heating valve and fan operate in parallel. There is no aqua stat. Is this acceptable. 2/23/2015 - R&D Response: System can function without aqua stat.	2/23/2015
002	Functional Test	Summit Smith	DEF	FT	CRAC 5 is set to 62 degrees and cooling the space. The ceiling is open to the surrounding spaces which basically means a CRAC should not be needed. A more reasonable space temperature needs to be set. Should this be disabled when the OA temps are below 60 degrees.	1/26/2015	Resolved	4/30/2015 - The thermostat needs to be set by the owner. This is not a contractor issue and is considered resolved.	4/30/2015
003	Functional Test	Summit Smith	DEF	FT	CRAC 5 does not report to the BAS system along with the associated condensate pump. This is a MR Slim which does not have reporting ability.	1/26/2015	Resolved	2/23/2015 - Trane Response - OK	2/23/2015
004	Functional Test	R&D	DEF	FT	UH-1 is specified and submitted to have a line voltage thermostat. The unit appears to control to a temperature sensor in the mechanical room.	1/26/2015	Resolved		2/23/2015
005	Functional Test	Trane	DEF	FT	CUH-1 has two thermostats in the space (one on the wall and one mounted on the unit) the wall appears to control the heating valve of the unit and the speed of the supply fan. What does the other thermostat do?	1/26/2015	Resolved	The thermostat on the wall is controlling and the thermostat on the unit can control the fan but is not used for control .	1/30/2015
006	Functional Test	R&D	DEF	FT	CUH's are specified to control the fan via a aqua stat mounted on the heating piping. Aqua stat not visible. The fan is always on at the lowest speed and CUH modulates heating coil an increases fan speed if needed.	1/26/2015	Resolved	Per the spec the fan is only to run when hot water is routed to the unit. Is the operation of the fan in parallel with the heating valve acceptable? 2/23/2015 - R&D Response: Parallel operation will be acceptable.	2/23/2015
007	Functional Test	Trane	DEF	FT	CUH-2 only has the thermostat mounted on the unit.	1/26/2015	Resolved	CUH-2 is controlled via its thermostat integral to the unit. Can be seen at the device level of the BAS.	1/30/2015
008	Functional Test	Trane	DEF	FT	CUH-3 serves the front vestibule along with VAV S1-6 and is not affected by changes in thermostat in the vestibule. What is the control of the CUH in relation to the VAV?	1/26/2015	Resolved	CUH-3 controls in parallel with the VAV box. The same thermostat controls both. Fan is to be updated to only control upon a call for heating. 2/23/2015 Resolved per R&D response.	2/23/2015
009	Functional Test	Summit Smith	DEF	FT	Insulation has been removed from the ductwork above the front vestibule. Was this intentional, and acceptable.	1/26/2015	Unresolved	This is the result of the heating issues in the vestibule. Should the insulation be re-applied? 8/10/2015 - The insulation has not been replaced.	
010	Functional Test	Norpac	DEF	FT	VAV Box 1-15 is 100% open while all other VAV boxes in 37% open. This box is not reflected on the drawings, where is it located?	1/26/2015	Resolved	V AV S1-15 is actually installed as S3-53. During testing the VAV was re-assigned to RTAC #3. The actual air flow in the cart washing areas needs to reevaluated.	1/29/2015
011	Functional Test	Trane	DEF	FT	VAV 3-18 design is 840 cfm and controlling to 1000 cfm. Where did additional air come from. This is ambulatory surgery family waiting and is noisy and over pressurized.	1/26/2015	Resolved	VAV box was reset to 840 cfm. The e noise is the result of the high pressure needed for the OR branch.	1/30/2014
012	Functional Test	R&D	DEF	FT	Convector C-1 (126) is wired to VAV 1-26 controller. It will then go into heating when this VAV box goes into heating and when its space falls below setpoint. C-1 space is not relative to VAV 1-26, this should be 1-46.	1/26/2015	Resolved	C-1 is controlled based on factory setting with factory deadband of estimated 0.5 degrees. VAV 1-26 is the nearest geographic VAV. The unit controls to its own setpoint. They were set to 68 degrees. 2/23/2015 - R&D Response: Control of VAV 1-26 and Convector C-1 should be independent from one another.	1/30/2014

Final Commissioning Report

- Separate sections (Similar to Preliminary Report):
  - Mechanical Testing
  - Service Water Testing
  - Electrical Systems Testing
- Results of all tests
- Disposition of deficiencies, including corrective measures
- Functional performance test procedures used during the commissioning process



Henneman Engineering Inc.

COMMISSIONING REPORT
FINAL REPORT

Wisconsin Institutes for Medical Research - Center Tower
1111 Highland Avenue, Madison, WI 53726

DSF Project No. 02G1S-01

School of Medicine and Public Health
UNIVERSITY OF WISCONSIN–MADISON

Owner / User: [redacted]

Program Manager: [redacted]

Architect: [redacted]

ME Engineer: [redacted]

Commissioning Agent: Tyson Glimme
Henneman Engineering, Inc.
1232 Fourier Dr., Suite 101
Madison, WI 53717-1960

LEED Version 2009
Commissioning Services

[redacted]

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consists of occupancy sensors wired directly to the fixtures and mechanical system. The occupancy sensors are adaptive which means they learn the habits of the occupants to calculate the amount of time the person stays out of the office and adjusts. This feature is problematic to functional test but will result in a tuned system as the occupants use the building.

Commissioning Provider Observation Overview

Henneman Engineering was contracted directly through the State of Wisconsin Division of Facilities Development (DFD) to provide the Commissioning Authority (CxA) services for the Wisconsin Institutes for Medical Research Center Tower during programming and extending into the warranty phase. Our services include commissioning services for the mechanical, electrical and plumbing systems installed for the Center Tower project.

Overall the Wisconsin Institutes for Medical Research Center Tower project operates extraordinarily well. The entire Commissioning Team (see Section III) has worked very effectively through the course of this project to proactively resolve issues. The below summary identified the main struggles the commissioning team addressed during the commissioning process.

Fan Coil Units
A main challenge for the project from design review through the warranty phase was the location, accessibility and maintainability of the fan coil units located in the LER. During the design review we recognized the access to the fan coils would be problematic. Comments and discussions were documented to ensure the units had the appropriate access, the system access verified during submittal review, and access documented during field observations. At each stage the condition was reviewed with the client. Once the systems were installed maintenance staff expressed a few final concerns echoing the concerns of the commissioning team during the project. Final pipe routing adjustments were completed and the access has been approved at the time of this report.

Energy Recovery Wheels
The Energy Wheels are extremely effective for this project. During extreme cold weather the energy wheels have been able to maintain the space temperatures without the help of steam heat. This greatly reduces the need for steam and resulted in the PRV's being oversized.

During the first winter of operation, the general exhaust energy recovery wheels failed due to the wheel and motor not being aligned during -30°F outdoor air temperatures. AEI modified the original control strategy, the actuators were rewired, DDC Group reprogrammed the controls and Henneman Engineering functional tested the final operation. This operation was installed and functional tested in November of 2014 and will provide protection during wheel failure scenarios.

This project also implemented an energy saving measure to utilize OA downstream of the ERU's to widen the window the ERU can be utilized. This allows the system an infinite discharge setpoint range from the outside air temperature to the discharge air temperature set point while utilizing the energy wheels.

Heating Capacity
As the result of the energy recovery efficiency there is minimal heating load on the converters. During testing we were also able to maintain the water flow to the most remote VAV box (9th

The Commissioning Process

is a quality oriented **process** for

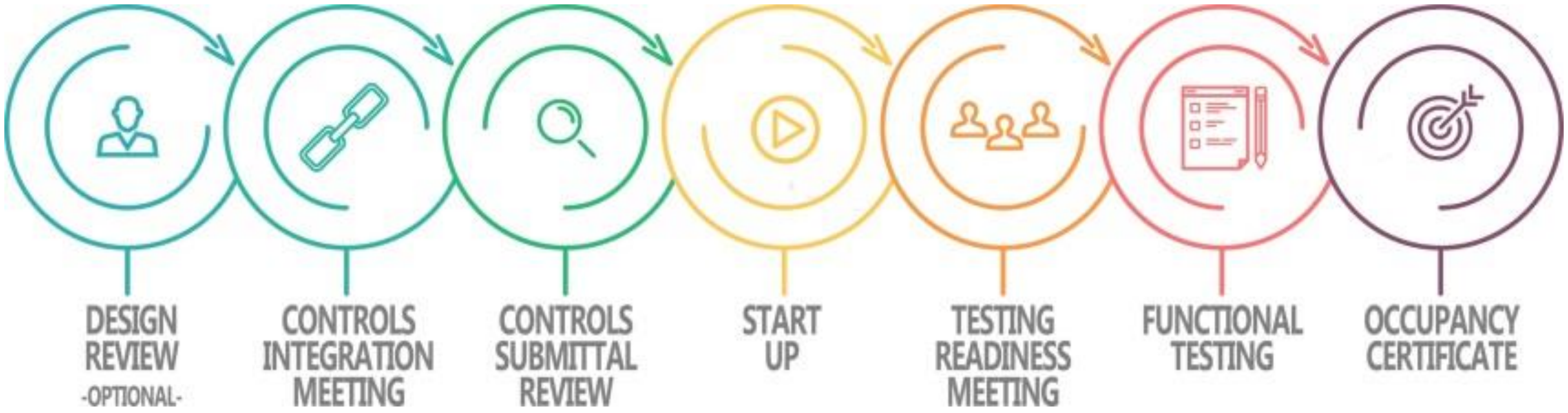
achieving, verifying and documenting

that the performance of

facilities, systems and assemblies

meets defined objectives and criteria

Valuable Elements of the Commissioning Process



- No required design reviews
- No submittal reviews required
- No meetings required
- No interaction between the team to optimize performance.

Make YOUR Commissioning Process

- What are your goals for this project?
- Are they documented and reflected in the Cx Plan?
- How do you get there?
- Review the drawings to ensure goals are met
- Conduct meetings to stay on track
- Functional Testing preparedness meeting
- Systems do not get corrected by documentation
- Focus on Resolution

Lessons Learned

- Keep deficiency list from design review through construction.
  - Many troubling issues are identified during the design review process and resolved.
  - Some are re-introduced due to installation variances.

Demand Control Ventilation is extremely limited by hardware selections

  - Fans have an optimum performance. Varying fan CFM significantly greatly effects performance and operation.
  - Consider return fans.

- The relief plenum in an AHU is usually a second OA intake that costs $XXX,XXX per year.
- Energy Recovery Units should have a bypass installed.
- Maintain the Construction Schedule through the end of the project.
- Hot water temperature reset must be considered during VAV selection.

Not Only Energy Savings

- Reduced maintenance time
- Increased equipment life
- Increased productivity due to less “Brush fires”
- Proactive maintenance plans
- Reduced change orders due to system corrections
- Improved indoor air quality
- Eliminate “inheriting” a project

International Energy Code General Commentary

2009

Section 501:

The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings.

2015

Section C401:

The provisions in this chapter are applicable to commercial buildings and their building sites.

Questions

Henneman Engineering Inc.
energy. focused.