Steven Winter Associates, Inc.
Improving the Built Environment Since 1972

Multifamily Construction Verification – Planning for Success

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2018 PHIUS North American Passive House Conference

Overview of Presentation

- PH Basics
- Construction Phase QA/QC
- Case Study - Beach Green North
- Planning Final Blower Door Testing
- Recommendations for Success

PH BASICS

Multifamily

ELEMENTS OF A LARGE MULTIFAMILY PASSIVE HOUSE BUILDING

MULTIFAMILY CONSIDERATIONS

Energy Recovery Ventilation
Determining the right system for any project can be challenging. There are pros and cons to both central and decentralized systems. A certified Passive House consultant can help the project team decide which system is best for your building.

Domestic Hot Water
In large scale multifamily buildings in the US the majority of DHW systems are central systems with recirculation loops and high efficiency, natural gas water heaters. Minimizing pipe lengths and optimizing pump sizes and insulation are essential to meet the rigid Passive House primary energy and cooling thresholds.

Efficient LIghts & Appliances
Multifamily projects face special challenges here because they must run corridor and egress lighting 24/7. They are also faced with a greater number of appliances per square foot compared with single family homes. Both of these factors result in increased cooling and primary energy demands. The use of controls and daylighting should be incorporated wherever possible to reduce energy use.

PHI vs PHIUS: Differences

Requirement	PHI	PHIUS	Notes
Comfort criteria	Mandatory	Recommended	Leads to triple pane windows in NYC for PHI
Whole building energy demand	/ft^2 of conditioned envelope	/person	
Heating demand	Same for all climates	Changes based on climate	
Cooling demand	Changes based on latent load from climate and occupant density & internal loads	Changes based on climate, sensible only	Temporary adjustment being allowed for cooling demand by PHIUS
Air Tightness	**0.6 ACH50 required / 0.033 cfm/ft2 of façade recommended for large buildings**	**0.08 cfm/ft2 of façade for 5+ stories & non-combustible, 0.05 cfm/ft2 for all others**	
Ventilation	Not a lot of approved ERVs in US	Approve a lot more ERVs	
Cooling & Heating Loads	Can certify based on demand or load	Must meet both demand and load thresholds	Can be difficult to meet both

Blower Door Testing

- Basic Components
  - Gauge (manometer)
  - Shroud
  - Frame
  - Fan

Blower Door Testing – Whole Building

CONSTRUCTION PHASE QA/QC

PH Contractor Buy-In

- General contractor and subcontractor buy-in is critical to project success
- All trades have an impact on project results and may require a mind shift on performance testing
- Passive House Tradesperson training mandatory for key personnel
- GC needs at least two people who will be dedicated to PH scope and coordination

PH Contractor Buy-In

- Ensure GC & trades fully understand what's included in respective work scopes
- Ask questions, dispel myths
- Discuss expectations with whole project team during bidding phase

Verification for Large Projects

- Foundations
  - Abutting neighbor(s)
  - Staging of foundation
  - Under slab / stem walls
- Above Grade Walls
  - Wall construction type: CMU, wood framed, etc.
  - Sequencing for hoistways, upper vs. lower floors
- Roof
  - Thermal breaks and roof membrane penetrations
  - Bulkheads, louvers & dampers

Verification for Large Projects

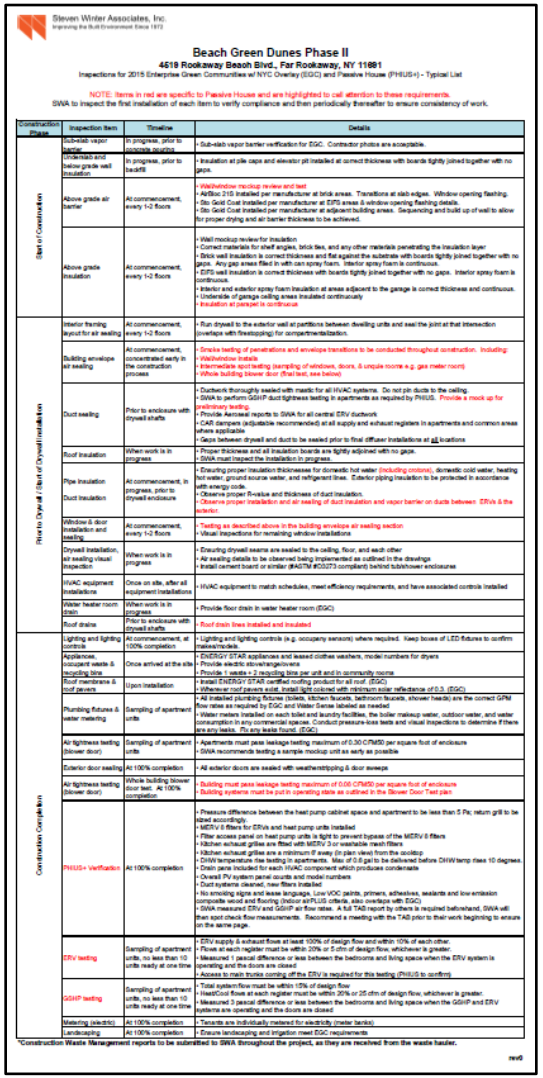
- MEP
  - In unit heat/cool duct testing
  - Ventilation
  - TAB process
  - Pipe insulation
  - Lighting wattages & controls

Typical & Unique Checklists

Start of Construction

Prior to Drywall / Start of Drywall Installation

Construction Completion



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Beach Green Dunes Phase II
4619 Rockaway Beach Blvd., Far Rockaway, NY 11691
Inspections for 2015 Enterprise Green Communities w/ NYC Overlay (EGC) and Passive House (PHIUS+) - Typical List

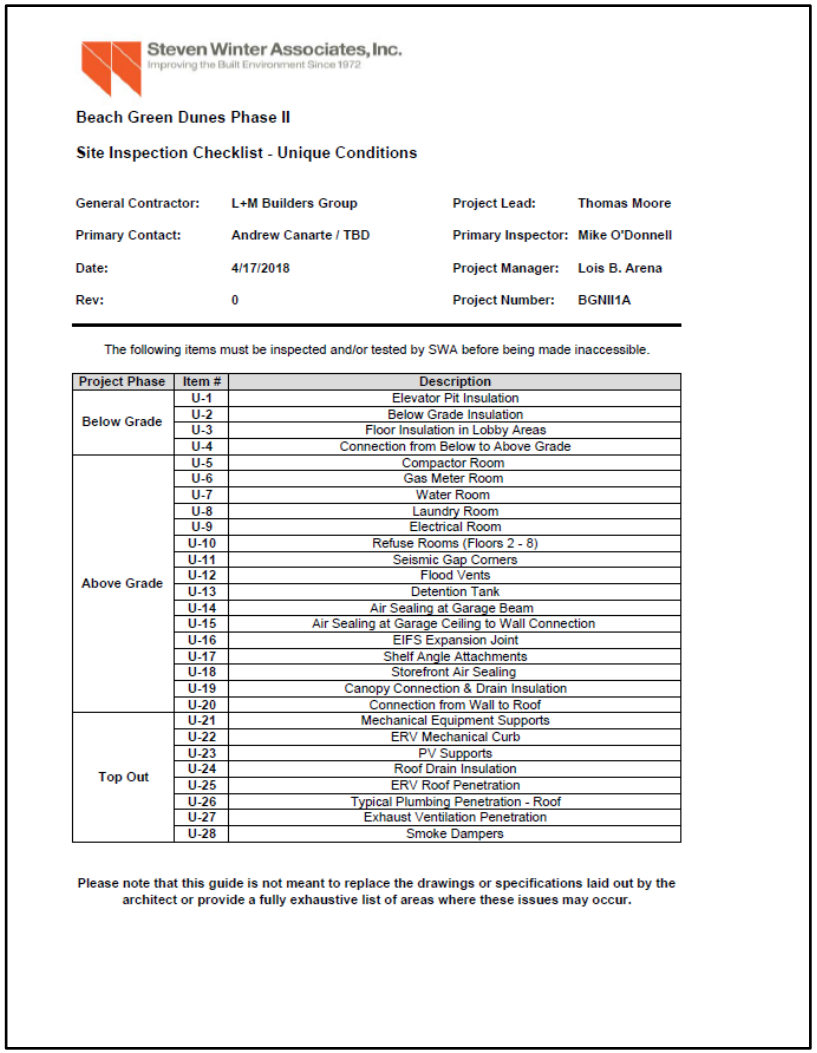
NOTE: Items in red are specific to Passive House and are highlighted to call attention to these requirements.
SWA to inspect the first installation of each item to verify compliance and then periodically thereafter to ensure consistency of work.

Construction Phase	Inspection Item	Timeline	Details
Start of Construction	Sub-slab vapor barrier	In progress, prior to concrete pouring	- Sub-slab vapor barrier verification for EGC. Contractor photos are acceptable.
	Underslab and below grade wall insulation	In progress, prior to backfill	- Insulation at pile caps and elevator pit installed at correct thickness with boards tightly joined together with no gaps.
	Above grade air barrier	At commencement, every 1-2 floors	- Wall/window mockup review and test - AirBloc 31S installed per manufacturer at brick areas. Transitions at slab edges. Window opening flashing. - Sto Gold Coat installed per manufacturer at EIFS areas & window opening flashing details. - Sto Gold Coat installed per manufacturer at adjacent building areas. Sequencing and build up of wall to allow for proper drying and air barrier thickness to be achieved.
	Above grade insulation	At commencement, every 1-2 floors	- Wall mockup review for insulation - Correct materials for shelf angles, brick ties, and any other materials penetrating the insulation layer - Brick wall insulation is correct thickness and flat against the substrate with boards tightly joined together with no gaps. Any gap areas filled in with can spray foam. Interior spray foam is continuous. - EIFS wall insulation is correct thickness with boards tightly joined together with no gaps. Interior spray foam is continuous. - Interior and exterior spray foam insulation at areas adjacent to the garage is correct thickness and continuous. - Underside of garage ceiling areas insulated continuously - Insulation at parapet is continuous
Prior to Drywall / Start of Drywall Installation	Interior framing layout for air sealing	At commencement, every 1-2 floors	- Run drywall to the exterior wall at partitions between dwelling units and seal the joint at that intersection (overlaps with firestopping) for compartmentalization.
	Building envelope air sealing	At commencement, concentrated early in the construction process	- Smoke testing of penetrations and envelope transitions to be conducted throughout construction. Including: - Wall/window installs - Intermediate spot testing (sampling of windows, doors, & unpule rooms e.g. gas meter room) - Whole building blower door (final test, see below)
	Duct sealing	Prior to enclosure with drywall shafts	- Ductwork thoroughly sealed with mastic for all HVAC systems. Do not pin ducts to the ceiling. - SWA to perform GSHP duct tightness testing in apartments as required by PHIUS. Provide a mock up for preliminary testing. - Provide Aeroseal reports to SWA for all central ERV ductwork - CAR dampers (adjustable recommended) at all supply and exhaust registers in apartments and common areas where applicable - Gaps between drywall and duct to be sealed prior to final diffuser installations at all locations
	Roof insulation	When work is in progress	- Proper thickness and all insulation boards are tightly adjoined with no gaps.
	Pipe insulation Duct insulation	At commencement, in progress, prior to drywall enclosure	- SWA must inspect the installation in progress. - Ensuring proper insulation thicknesses for domestic hot water (including crosnes), domestic cold water, heating hot water, ground source water, and refrigerant lines. Exterior piping insulation to be protected in accordance with energy code. - Observe proper R-value and thickness of duct insulation. - Observe proper installation and air sealing of duct insulation and vapor barrier on ducts between ERVs & the exterior.
	Window & door installation and sealing	At commencement, every 1-2 floors	- Testing as described above in the building envelope air sealing section - Visual inspections for remaining window installations
	Drywall installation, air sealing visual inspection	When work is in progress	- Ensuring drywall seams are sealed to the ceiling, floor, and each other - Air sealing details to be observed being implemented as outlined in the drawings - Install cement board or similar (#ASTM #D3273 compliant) behind tub/shower enclosures
	HVAC equipment installations	Once on site, after all equipment installations	- HVAC equipment to match schedules, meet efficiency requirements, and have associated controls installed
	Water heater room drain	When work is in progress	- Provide floor drain in water heater room (EGC)
	Roof drains	Prior to enclosure with drywall shafts	- Roof drain lines installed and insulated
Construction Completion	Lighting and lighting controls	At commencement, at 100% completion	- Lighting and lighting controls (e.g. occupancy sensors) where required. Keep boxes of LED fixtures to confirm makes/models
	Appliances, occupant waste & recycling bins	Once arrived at the site	- ENERGY STAR appliances and leased clothes washers, model numbers for dryers - Provide electric stove/range/ovens - Provide 1 waste + 2 recycling bins per unit and in community rooms
	Roof membrane & roof pavers	Upon installation	- Rated ENERGY STAR certified roofing product for all roof. (EGC) - Whenever roof pavers exist, install light colored with minimum solar reflectance of 0.3. (EGC)
	Plumbing fixtures & water metering	Sampling of apartment units	- All installed plumbing fixtures (toilets, kitchen faucets, bathroom faucets, shower heads) are the correct GPM flow rates as required by EGC and Water Sense labeled as needed - Water meters installed on each toilet and laundry facilities, the boiler makeup water, outdoor water, and water consumption in any commercial spaces. Conduct pressure-loss tests and visual inspections to determine if there are any leaks. Fix any leaks found. (EGC)
	Air tightness testing (blower door)	Sampling of apartment units	- Apartments must pass leakage testing maximum of 0.30 CFM50 per square foot of enclosure - SWA recommends testing a sample mockup unit as early as possible
	Exterior door sealing	At 100% completion	- All exterior doors are sealed with weatherstripping & door sweeps
	Air tightness testing (blower door)	Whole building blower door test. At 100% completion	- Building must pass leakage testing maximum of 0.06 CFM50 per square foot of enclosure - Building systems must be put in operating state as outlined in the Blower Door Test plan
	PHIUS+ Verification	At 100% completion	- Pressure difference between the heat pump cabinet space and apartment to be less than 5 Pa; return grill to be sized accordingly - MERV 8 filters for ERVs and heat pump units installed - Filter access panel on heat pump units is tight to prevent bypass of the MERV 8 filters - Kitchen exhaust grilles are fitted with MERV 3 or washable mesh filters - Kitchen exhaust grilles are a minimum 8" away (in plan view) from the cooktop - DHW temperature rise testing in apartments. Max of 0.6 gal to be delivered before DHW temp rises 10 degrees. - Drain pans included for each HVAC component which produces condensate - Shared PV system panel counts and model numbers - Duct systems cleaned, new filters installed - No smoking signs and lease language. Low VOC paints, primers, adhesives, sealants and low-emission composite wood and flooring (indoor airPLUS criteria, also overlaps with EGC) - SWA to inspect measured ERV and GSHP air flow rates. A full TAB report by others is required beforehand, SWA will then spot check flow measurements. Recommend a meeting with the TAB prior to their work beginning to ensure on the same page.
	ERV testing	Sampling of apartment units, no less than 10 units ready at one time	- ERV supply & exhaust flows at least 100% of design flow and within 10% of each other. - Flows at each register must be within 20% or 5 cfm of design flow, whichever is greater. - Measured 1 pascal difference or less between the bedrooms and living space when the ERV system is operating and the doors are closed - Access to main trunks coming off the ERV is required for this testing (PHIUS to confirm)
	GSHP testing	Sampling of apartment units, no less than 10 units ready at one time	- Total system flow must be within 15% of design flow - Heat/Cool flows at each register must be within 20% or 20 cfm of design flow, whichever is greater. - Measured 3 pascal difference or less between the bedrooms and living space when the GSHP and ERV systems are operating and the doors are closed
	Metering (electric)	At 100% completion	- Tenants are individually metered for electricity (meter banks)
	Landscaping	At 100% completion	- Ensure landscaping and irrigation meet EGC requirements

*Construction Waste Management reports to be submitted to SWA throughout the project, as they are received from the waste hauler.

rev0

PH specific criteria in red



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Beach Green Dunes Phase II

Site Inspection Checklist - Unique Conditions

General Contractor:	L+M Builders Group	Project Lead:	Thomas Moore
Primary Contact:	Andrew Canarte / TBD	Primary Inspector:	Mike O'Donnell
Date:	4/17/2018	Project Manager:	Lois B. Arena
Rev:	0	Project Number:	BGNII1A

The following items must be inspected and/or tested by SWA before being made inaccessible.

Project Phase	Item #	Description
Below Grade	U-1	Elevator Pit Insulation
	U-2	Below Grade Insulation
	U-3	Floor Insulation in Lobby Areas
	U-4	Connection from Below to Above Grade
Above Grade	U-5	Compactor Room
	U-6	Gas Meter Room
	U-7	Water Room
	U-8	Laundry Room
	U-9	Electrical Room
	U-10	Refuse Rooms (Floors 2 - 8)
	U-11	Seismic Gap Corners
	U-12	Flood Vents
	U-13	Detention Tank
	U-14	Air Sealing at Garage Beam
	U-15	Air Sealing at Garage Ceiling to Wall Connection
	U-16	EIFS Expansion Joint
	U-17	Shelf Angle Attachments
	U-18	Storefront Air Sealing
	U-19	Canopy Connection & Drain Insulation
	U-20	Connection from Wall to Roof
Top Out	U-21	Mechanical Equipment Supports
	U-22	ERV Mechanical Curb
	U-23	PV Supports
	U-24	Roof Drain Insulation
	U-25	ERV Roof Penetration
	U-26	Typical Plumbing Penetration - Roof
	U-27	Exhaust Ventilation Penetration
	U-28	Smoke Dampers

Please note that this guide is not meant to replace the drawings or specifications laid out by the architect or provide a fully exhaustive list of areas where these issues may occur.

Testing Tools and Protocols

- Window mockup testing
- Interim guarded blower door testing
- Interim whole building test if schedule and sequencing allows
- Envelope compartmentalization and window testing
- Unique component testing
- Whole building blower door test

Mock up

CASE STUDY

BEACH GREEN NORTH

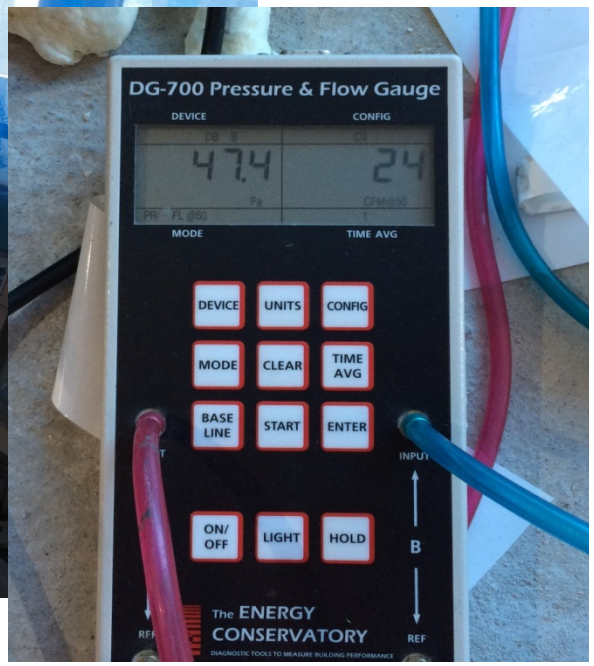
Affordable Housing – 101 units

QUEENS, NY

Wall Inspections

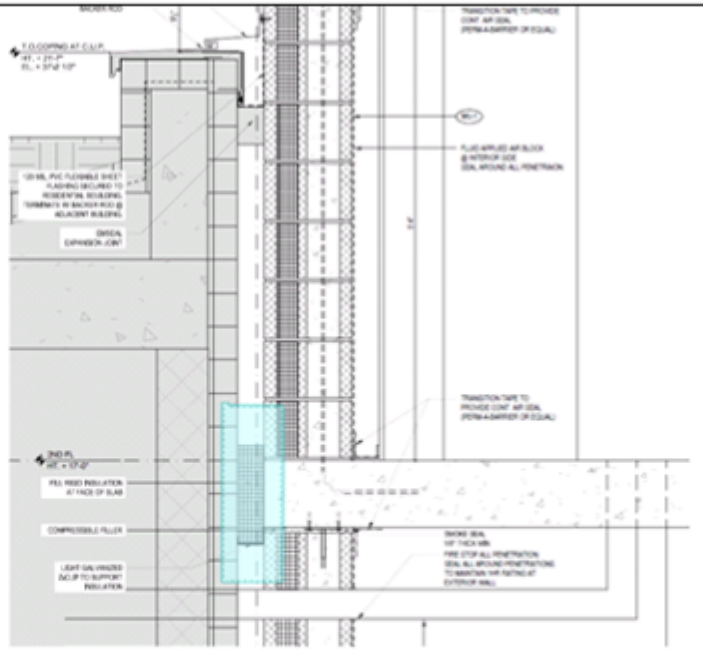
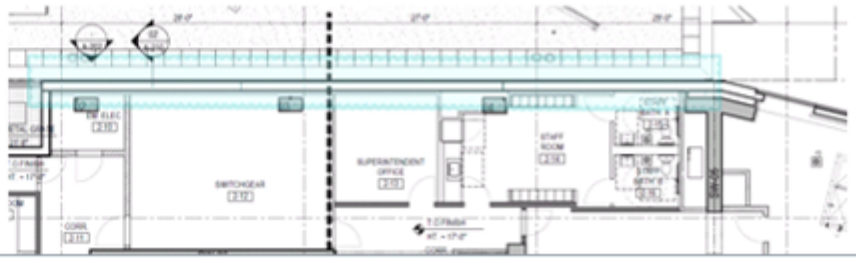
- ICF doesn't require as many inspections for insulation and air barrier

1st Window Mockup



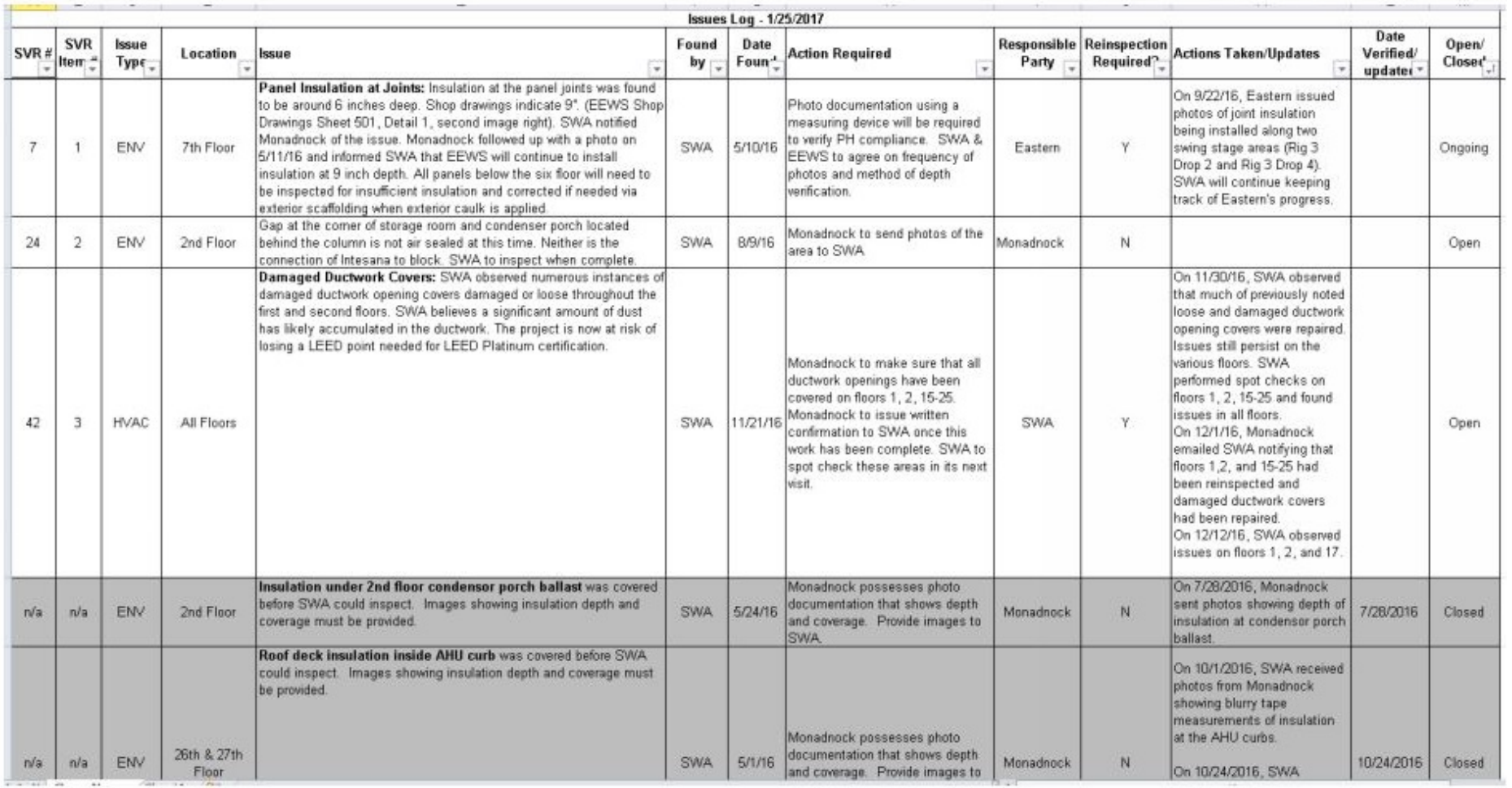
2nd Window Mockup

Site Visit Reports

Item #	Description	Image
	2nd Floor Slab Edge Insulation: Refer to architectural details 20 A-356. Detail 20 shows 4" thick insulation at the slab edge between the CUP and the Residential Tower extending 2" above and below the slab (highlighted area in detail at right). This conditions exits at the area highlighted on the plan to the right.	 

Sample from Cornell Tech

Issues Log



Issues Log - 1/25/2017

SVR #	SVR Item #	Issue Type	Location	Issue	Found by	Date Found	Action Required	Responsible Party	Reinspection Required?	Actions Taken/Updates	Date Verified/ updated	Open/ Closed
7	1	ENV	7th Floor	**Panel Insulation at Joints:** Insulation at the panel joints was found to be around 6 inches deep. Shop drawings indicate 9". (EEWS Shop Drawings Sheet 501, Detail 1, second image right). SWA notified Monadnock of the issue. Monadnock followed up with a photo on 5/11/16 and informed SWA that EEWS will continue to install insulation at 9 inch depth. All panels below the six floor will need to be inspected for insufficient insulation and corrected if needed via exterior scaffolding when exterior caulk is applied.	SWA	5/10/16	Photo documentation using a measuring device will be required to verify PH compliance. SWA & EEWS to agree on frequency of photos and method of depth verification.	Eastern	Y	On 9/22/16, Eastern issued photos of joint insulation being installed along two swing stage areas (Rig 3 Drop 2 and Rig 3 Drop 4). SWA will continue keeping track of Eastern's progress.		Ongoing
24	2	ENV	2nd Floor	Gap at the corner of storage room and condenser porch located behind the column is not air sealed at this time. Neither is the connection of Intesana to block. SWA to inspect when complete.	SWA	8/9/16	Monadnock to send photos of the area to SWA	Monadnock	N			Open
42	3	HVAC	All Floors	**Damaged Ductwork Covers:** SWA observed numerous instances of damaged ductwork opening covers damaged or loose throughout the first and second floors. SWA believes a significant amount of dust has likely accumulated in the ductwork. The project is now at risk of losing a LEED point needed for LEED Platinum certification.	SWA	11/21/16	Monadnock to make sure that all ductwork openings have been covered on floors 1, 2, 15-25. Monadnock to issue written confirmation to SWA once this work has been complete. SWA to spot check these areas in its next visit.	SWA	Y	On 11/30/16, SWA observed that much of previously noted loose and damaged ductwork opening covers were repaired. Issues still persist on the various floors. SWA performed spot checks on floors 1, 2, 15-25 and found issues in all floors. On 12/1/16, Monadnock emailed SWA notifying that floors 1,2, and 15-25 had been reinspected and damaged ductwork covers had been repaired. On 12/12/16, SWA observed issues on floors 1, 2, and 17.		Open
n/a	n/a	ENV	2nd Floor	**Insulation under 2nd floor condensor porch ballast** was covered before SWA could inspect. Images showing insulation depth and coverage must be provided.	SWA	5/24/16	Monadnock possesses photo documentation that shows depth and coverage. Provide images to SWA.	Monadnock	N	On 7/28/2016, Monadnock sent photos showing depth of insulation at condensor porch ballast.	7/28/2016	Closed
n/a	n/a	ENV	26th & 27th Floor	**Roof deck insulation inside AHU curb** was covered before SWA could inspect. Images showing insulation depth and coverage must be provided.	SWA	5/1/16	Monadnock possesses photo documentation that shows depth and coverage. Provide images to	Monadnock	N	On 10/1/2016, SWA received photos from Monadnock showing blurry tape measurements of insulation at the AHU curbs. On 10/24/2016, SWA	10/24/2016	Closed

Sample from Cornell Tech

Progress

- AeroBarrier by Aeroseal was utilized
- 6/24/2017 - envelope leakage test performed but couldn't finish, Building Department shut down site for working on Saturday
- 7/6/2017 - infiltration test for energy model passed!!
- ERV testing & commissioning completed
- *4/4/2018 - PHIUS Certification received!!!*

PLANNING FINAL BLOWER DOOR TESTING

Blower Door Test Conditions

Key: HVAC Contractor; Plumber; GC / Builder

Intentional Opening	Test Setting	Notes
Windows, doors, skylights in the building enclosure	Closed and latched	
Doors and operable windows inside the test enclosure	Open	Use stairways to connect all zones of the building
Fire dampers	Remain as found	
Dryer doors	Closed and latched	
Gas meter room	Door to gas meter room closed and weather stripped	
Waste handling system	Trash chute termination at roof taped off. Door to trash rooms closed.	
ERVs (apartments)	Fan off, any dampers closed. Ducts to the outside sealed inside the ERV cabinet in each apartment.	Ventilation is continuous, so can remain taped off
Motorized dampers: ERV-4 (cellar)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed off
Motorized dampers: ERV-5 (1st floor)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed off
Motorized dampers: ERV-2A (1st floor)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed off
Motorized damper: Laundry Room (2nd floor)	Fan off, dampers closed. Taped off from the exterior	Untaped for Method A test
Motorized damper: ERV-2 (2nd floor)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed
Motorized dampers: EMR (1st floor), Stair A, Star B, Elevator, Boiler Room (roof)	Taped off from the exterior	Untaped for Method A test
ERV-3 (roof)	Fan off, dampers closed	Ventilation is continuous, so

Whole Building Test Logistics

- Enough fans, cruise manometers, frames, shrouds, tubing, CAT5 cabling, people?
- Is building access limited to avoid people opening and closing doors, windows, etc.?
- Thorough walkthrough the day prior to test date to confirm prep has taken place?
- GC and appropriate subs on site to help with building prep and issues that come up on the test day?
- Saturday work permits pulled?

Central ERVs & Blower Door

- Need to seal off ERVs for the final test
- Wrap rooftop ERVs or seal exterior intake and exhaust louver ports

Individual ERVs & Blower Door

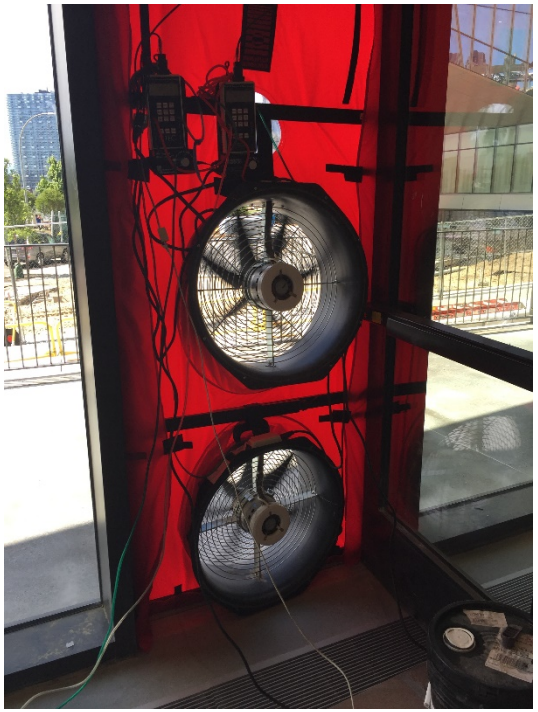
- Typically can't reach all vents to seal from outside

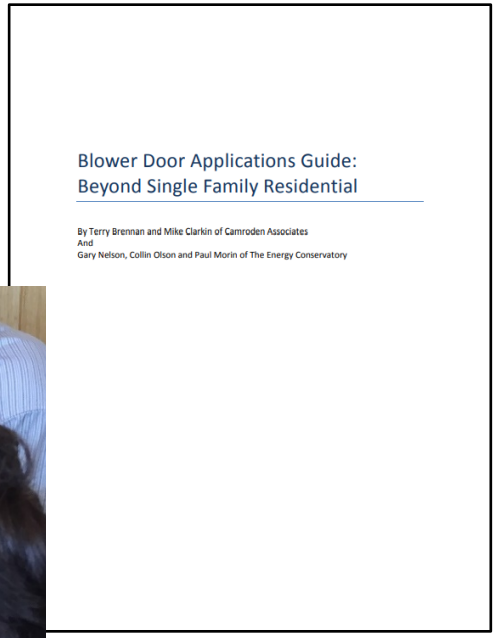
- Tape off both outdoor connection ports inside every ERV

- Some ERV's can't be sealed inside the cabinets

Whole Building Test Logistics

- A great resource is **Blower Door Applications Guide: Beyond Single Family Residential** PDF (Brennan, Clarkin, Nelson, Olson, Morin)





RECOMMENDATIONS FOR SUCCESS

Do This ✓

- Insist on
  - Training for construction staff
  - Mockups
  - Interim blower door testing
- Advanced Planning
  - Typical and unique checklists
  - Blower door testing plan
- Quality Control
  - Typical details readily available on site for all subs
  - Communication between GC and PH verifier
  - Panelized construction, if applicable

Do NOT Do This ✘

- Be wary
  - Assume if the GC has done a PH project that the second will automatically pass
  - Keep going without passing the window mockup
  - Depend on subs understanding contract docs without communication
  - Allow the GC to exclude meeting PH requirements from the contract
- Ignore your PH Consultant!!!!!

Questions?

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THANK YOU!