BUILDINGENERGY BOSTON

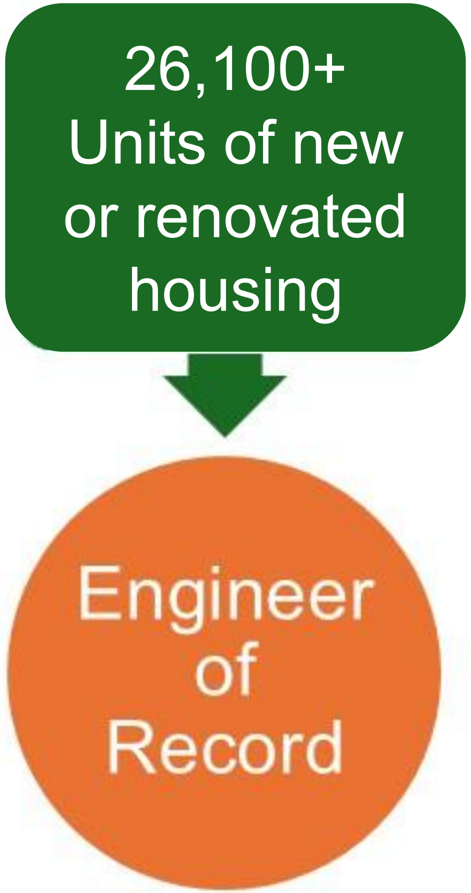
Multifamily Ventilation Systems: Do We Really Need CAR Dampers?

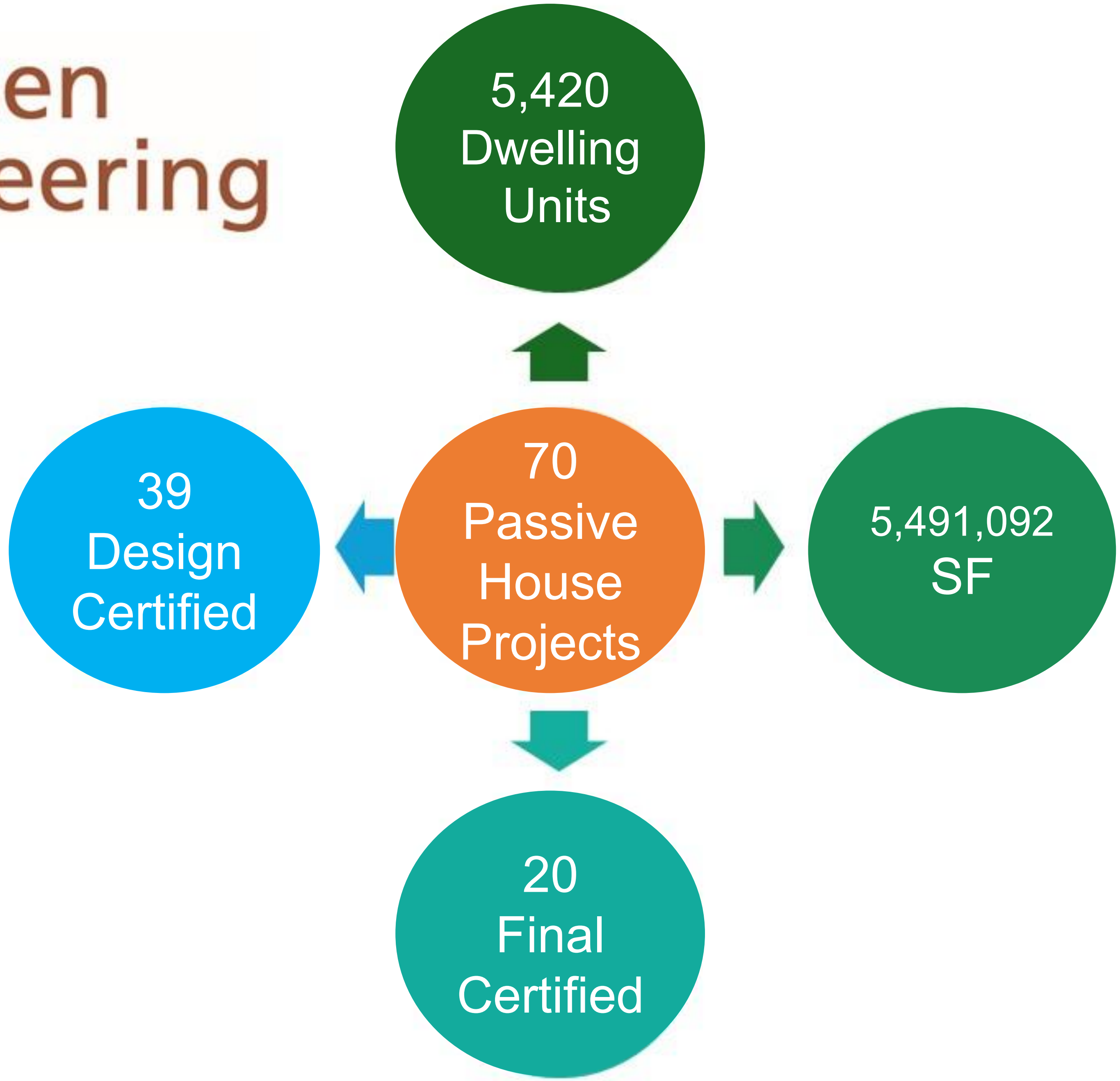
Sarah Carter P.E. and James Petersen P.E.
Petersen Engineering, Inc

Curated by Nicole Schuster

Northeast Sustainable Energy Association (NESEA) | March 24, 2026

PE | Petersen Engineering



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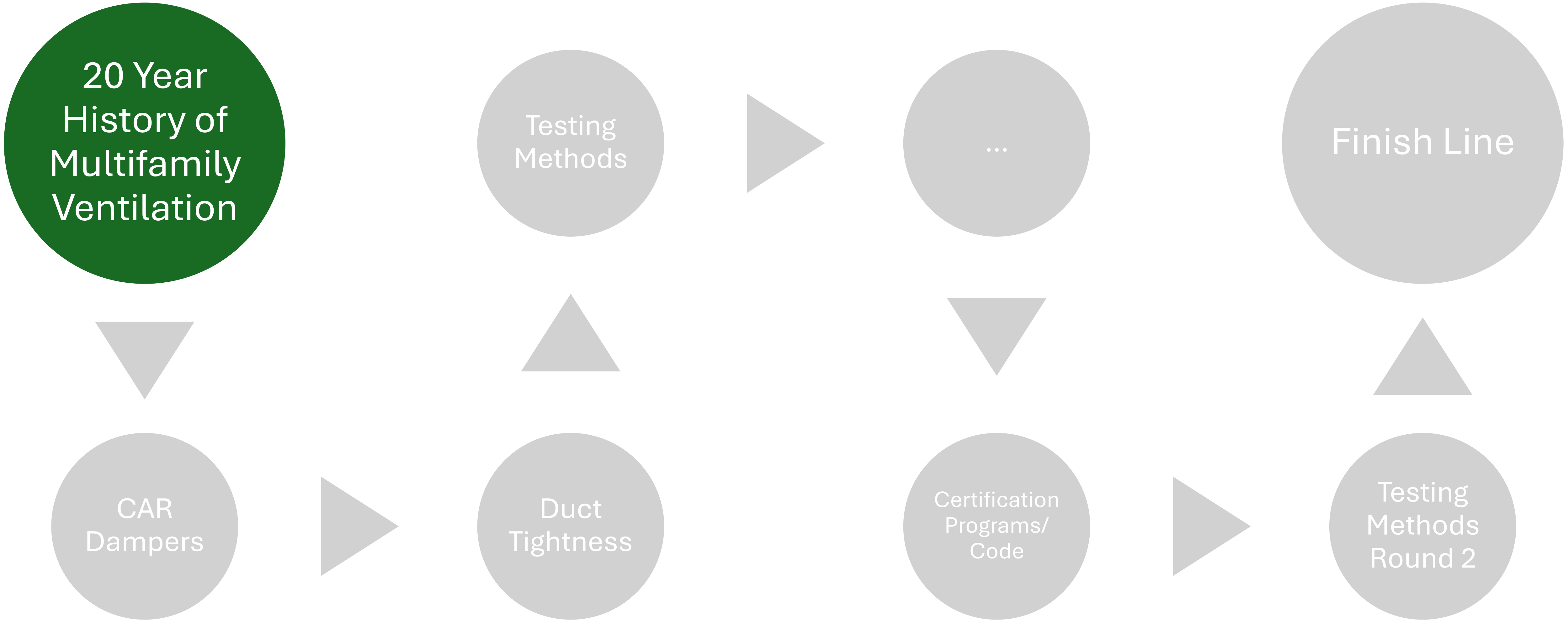

20 Year History of Multifamily Ventilation
CAR Dampers
Duct Tightness
Testing Methods
...
Certification Programs/ Code
Testing Methods Round 2
Finish Line

Some History….

Ventilation Rates Were Based on Odor Control

Health Science Basis for Ventilation Rates is Extremely Limited

Almost Nothing Cited Applies to Housing

The Applicable Studies Focus on Dampness

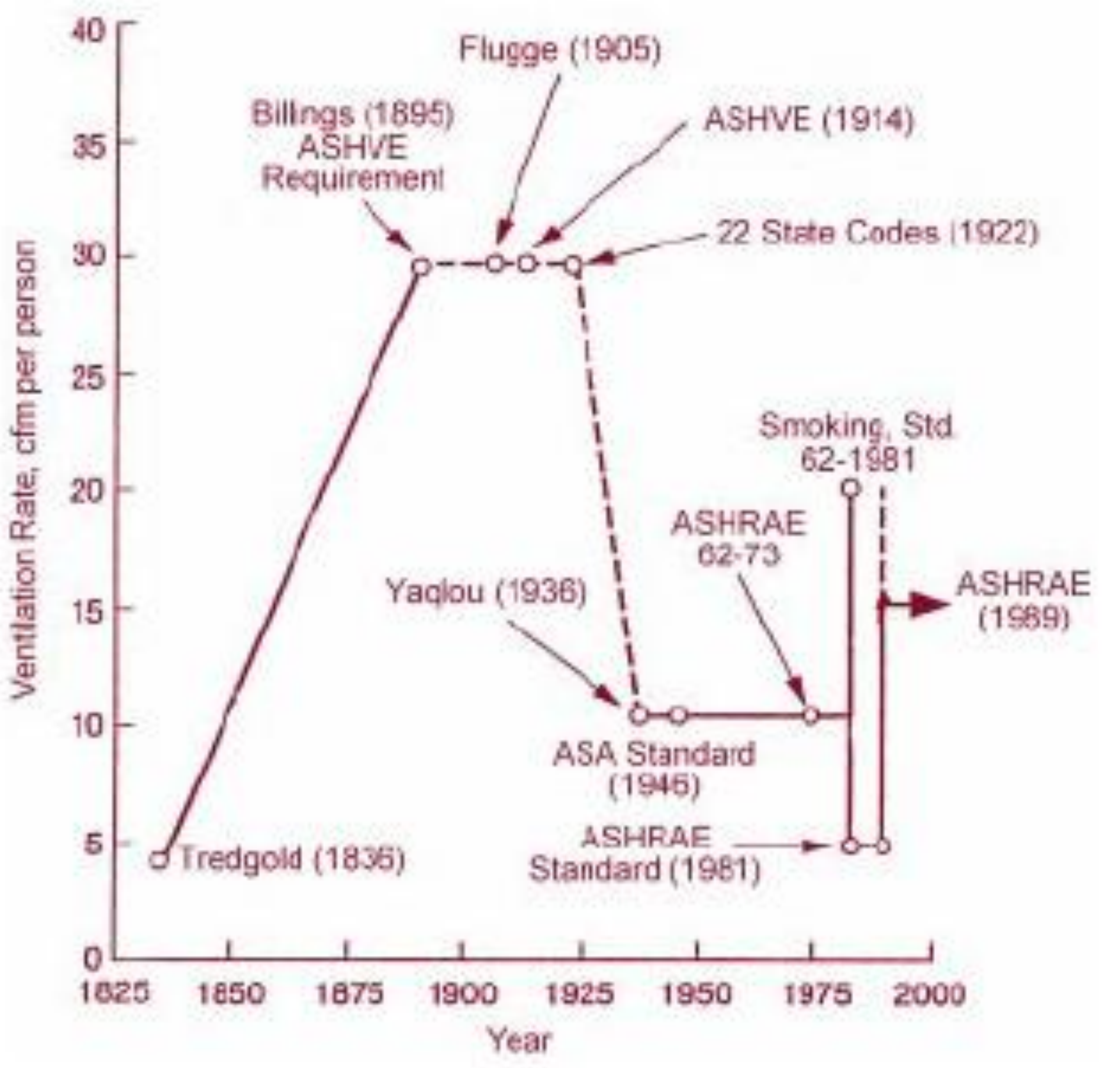
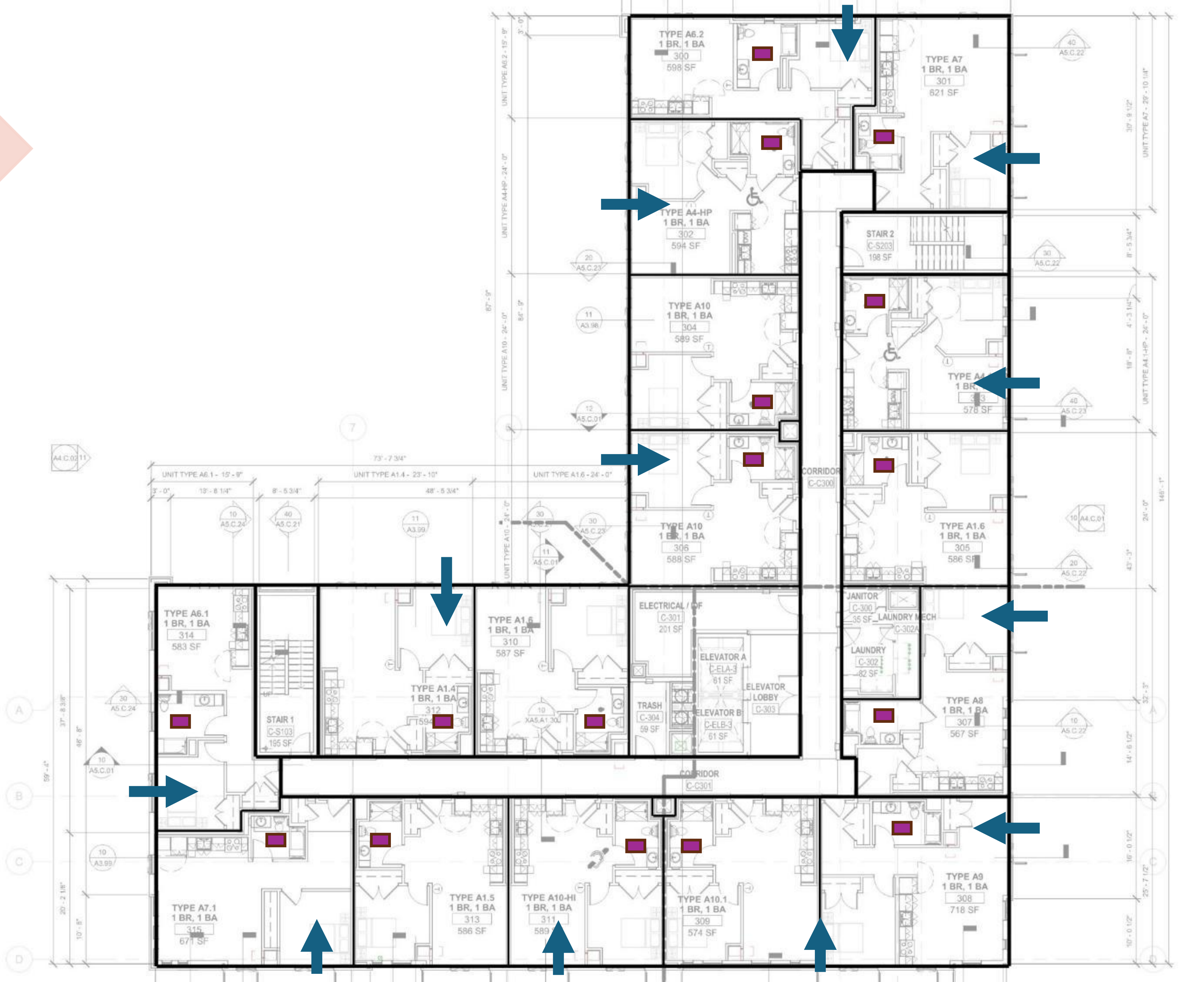


Figure 1: Minimum ventilating rate history.

Ventilation History

Exhaust only



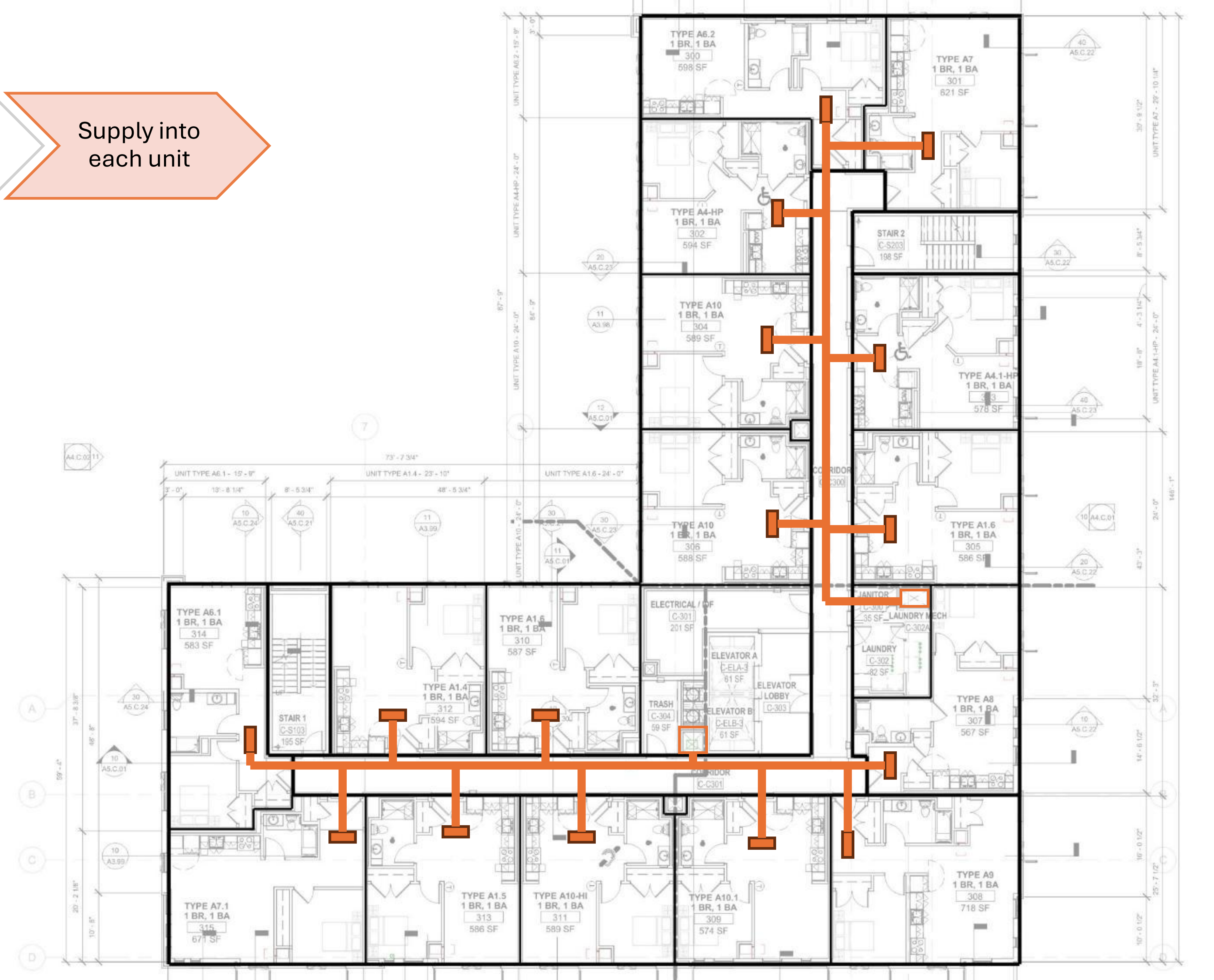
Ventilation History

MAU with supply into corridor

Ventilation History

MAU with supply into corridor

Supply into each unit

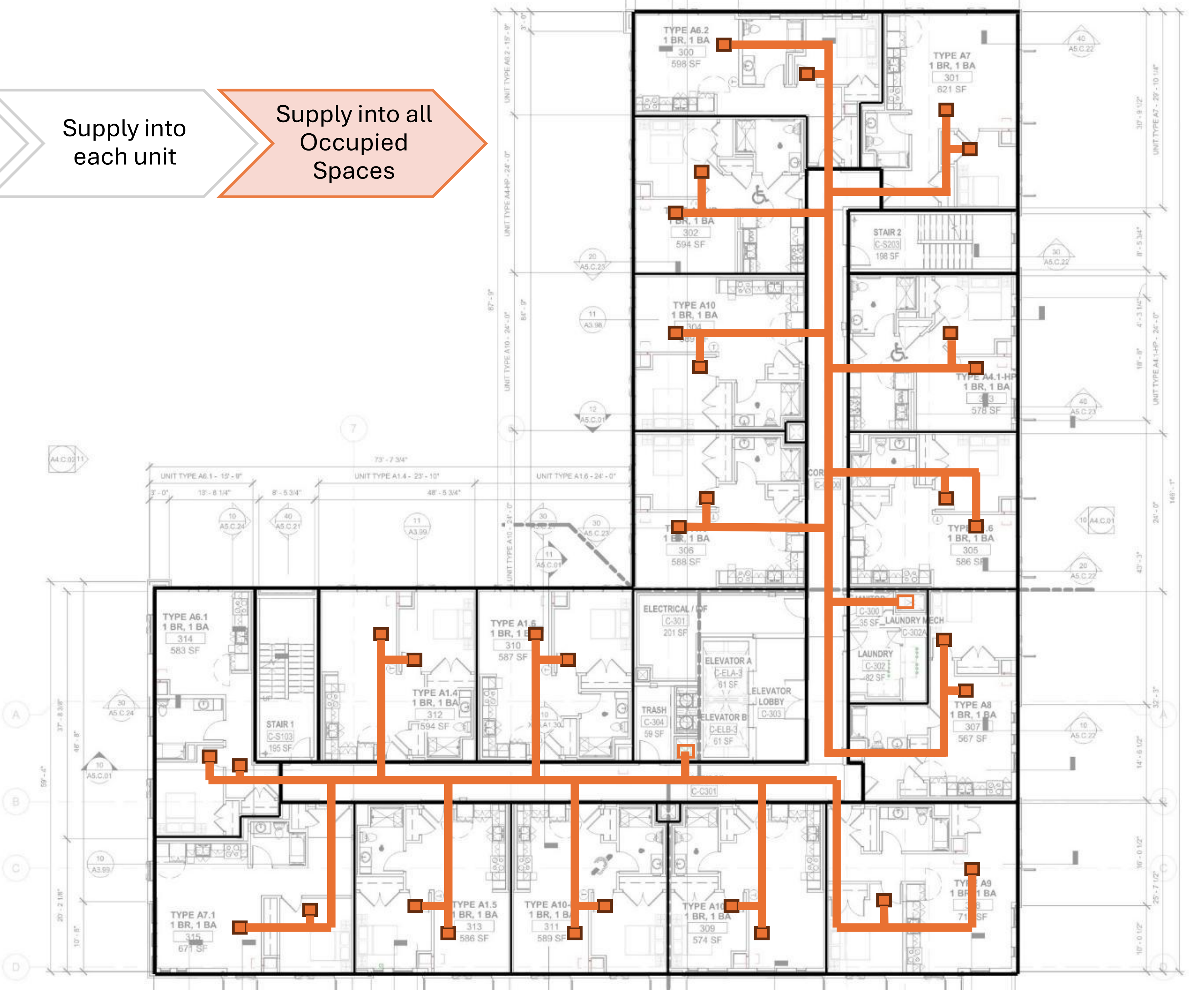


Ventilation History

MAU with supply into corridor

Supply into each unit

Supply into all Occupied Spaces

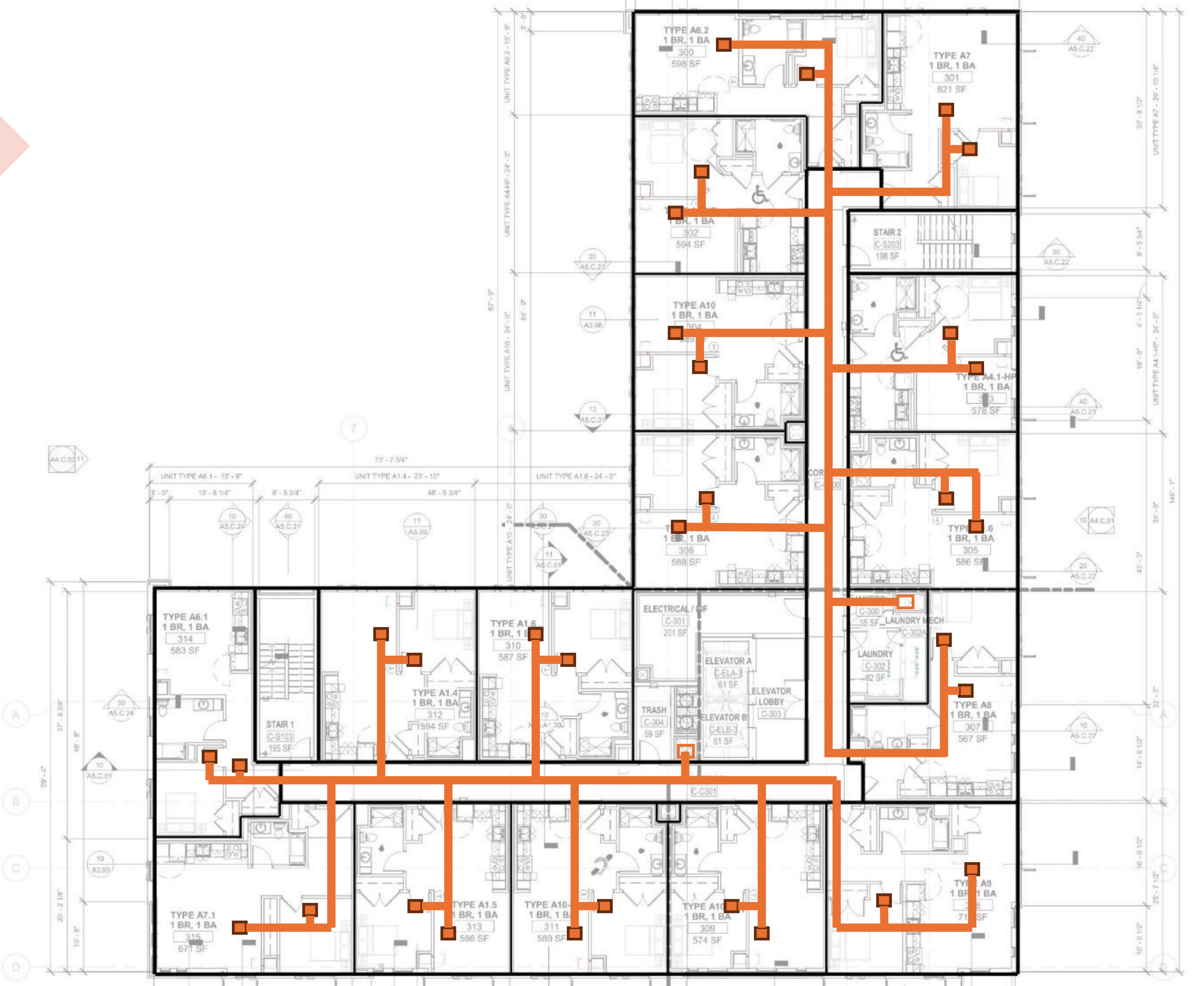


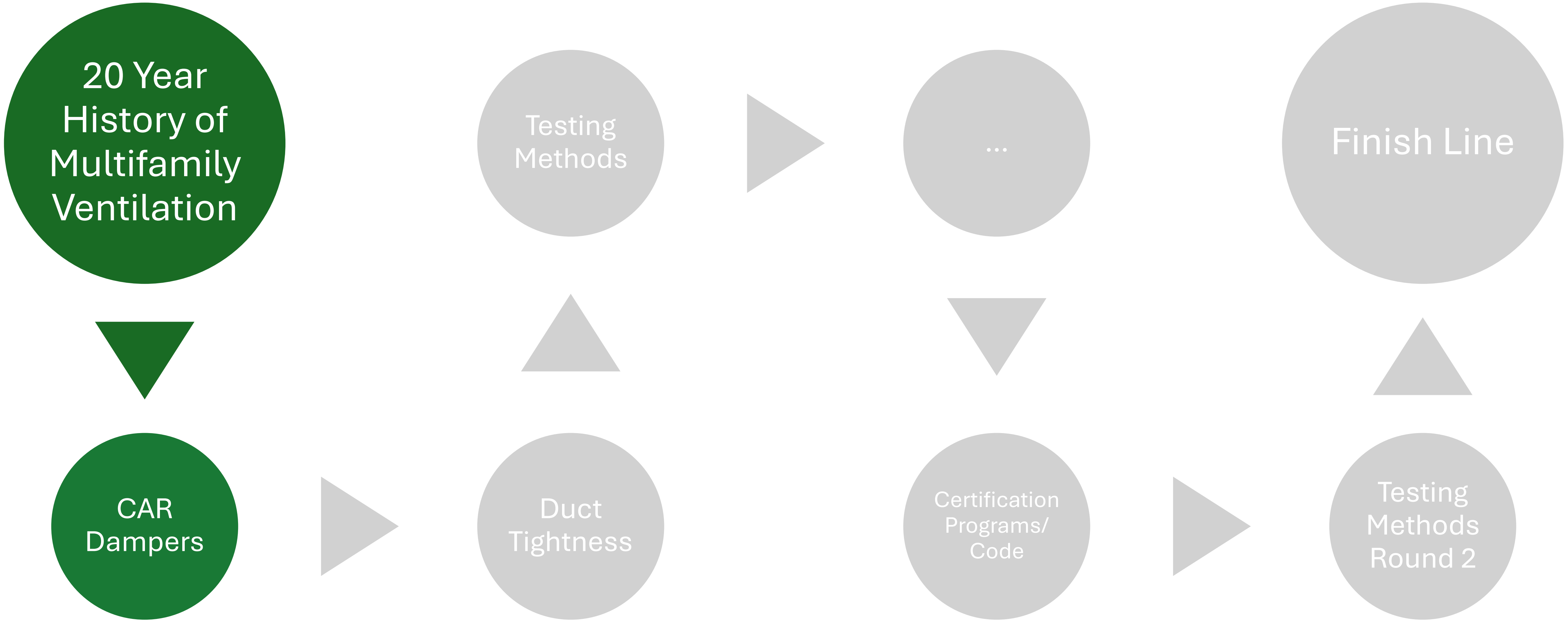
Ventilation History

In-Unit Ventilation

Ventilation History

Central DOAS




20 Year History of Multifamily Ventilation
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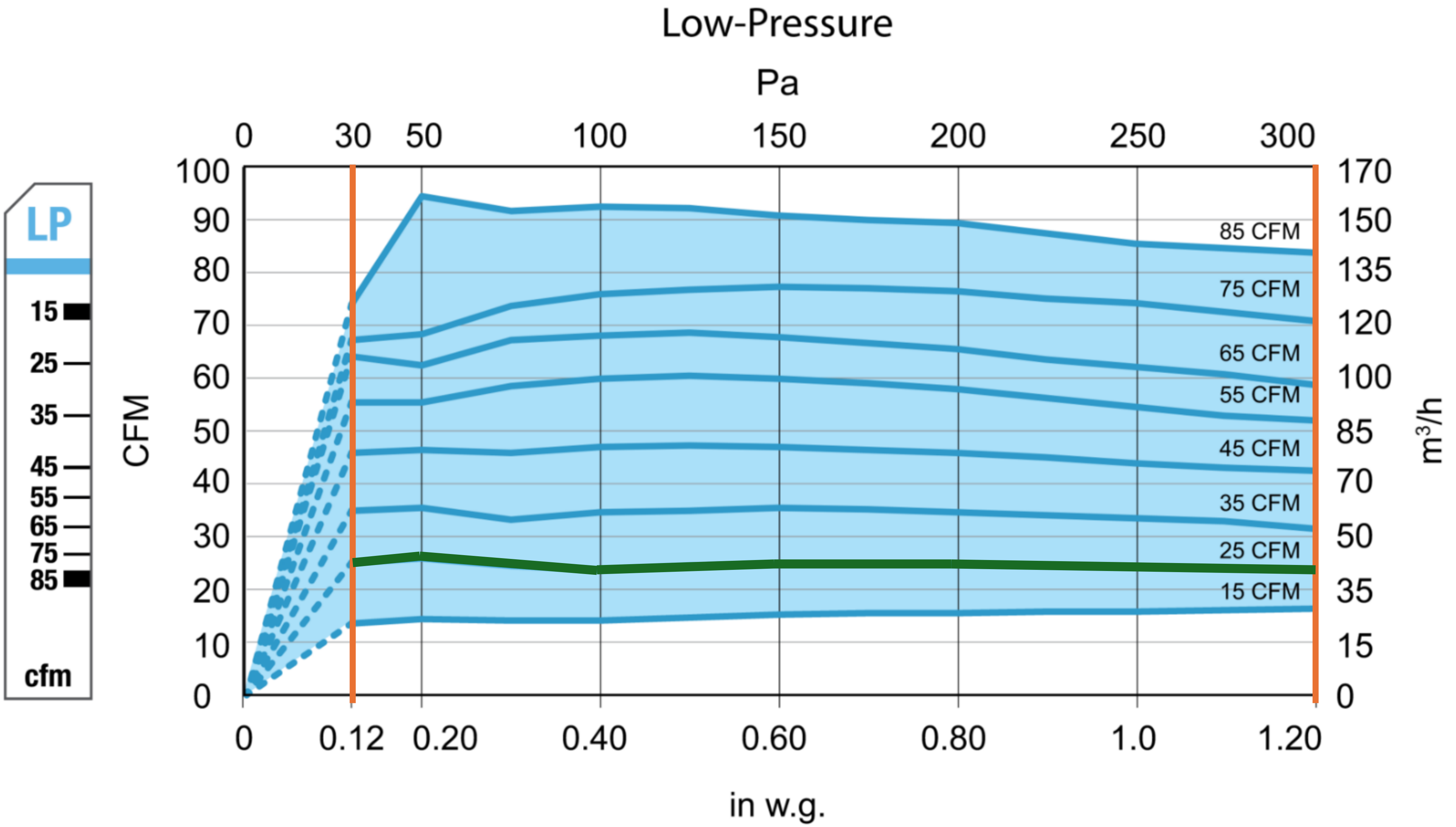
Duct Tightness
Testing Methods
...
Certification Programs/ Code
Testing Methods Round 2
Finish Line

CAR Dampers

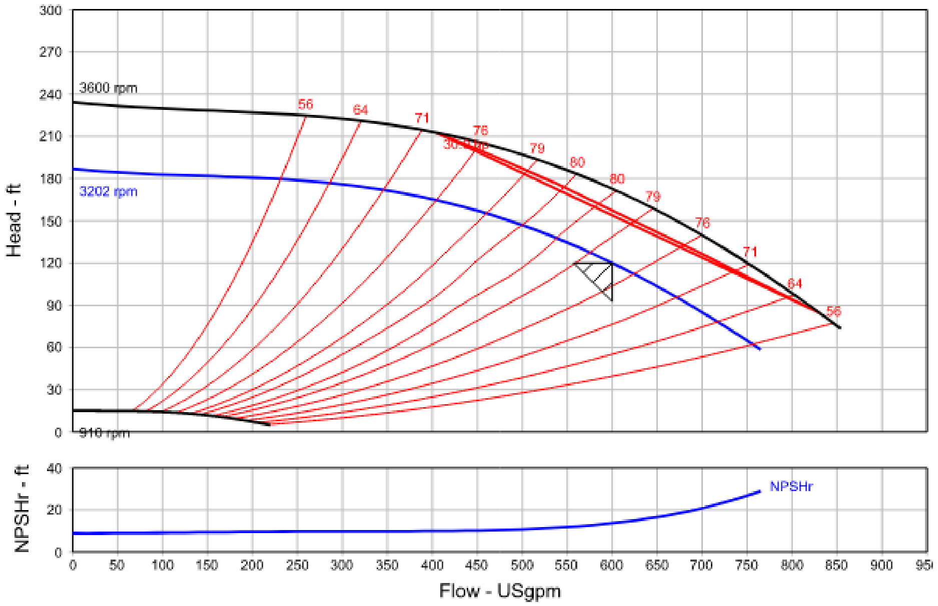

LP
SAMPLE
aldes
800.255.7749
aldes-na.com


LP
15
25
35
45
55
65
75
85
cfm
Made in USA

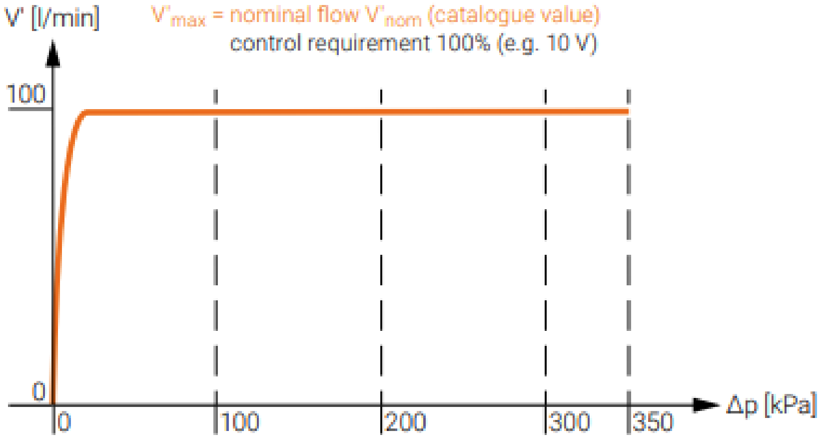


How do they work?

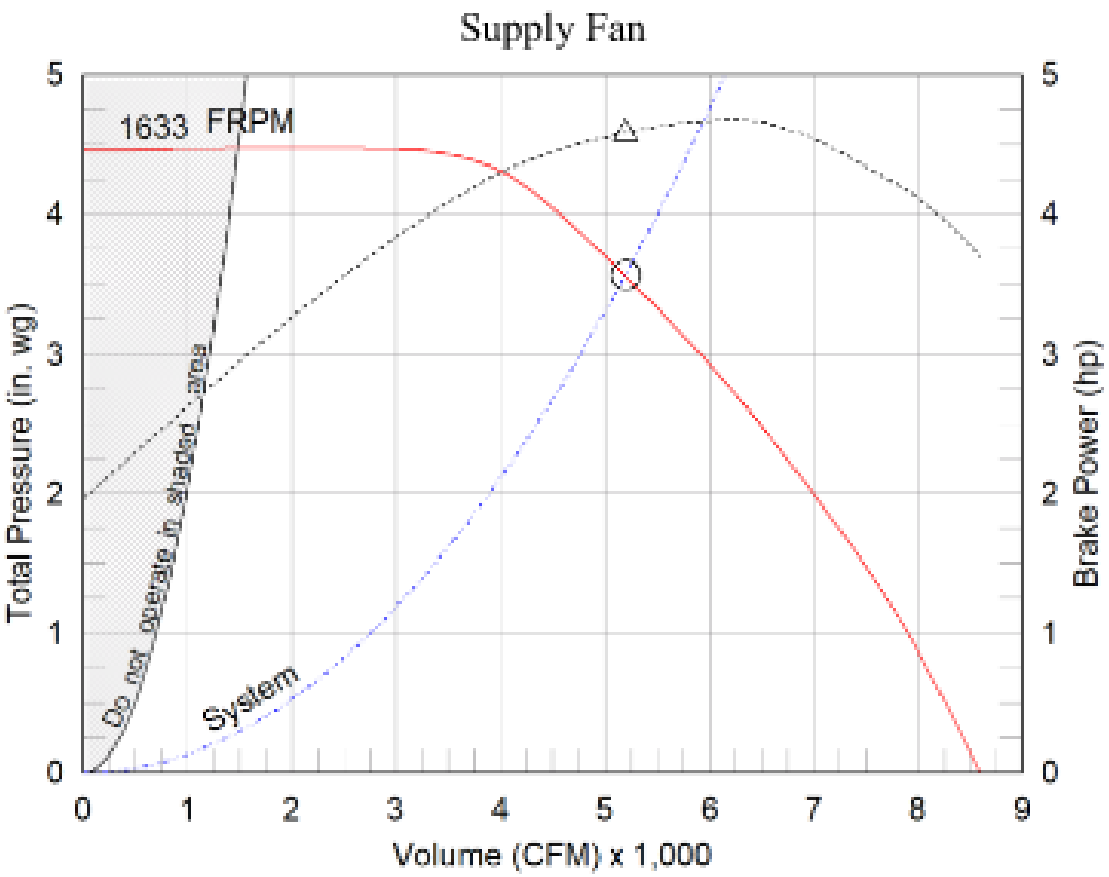
(PRESSURE)



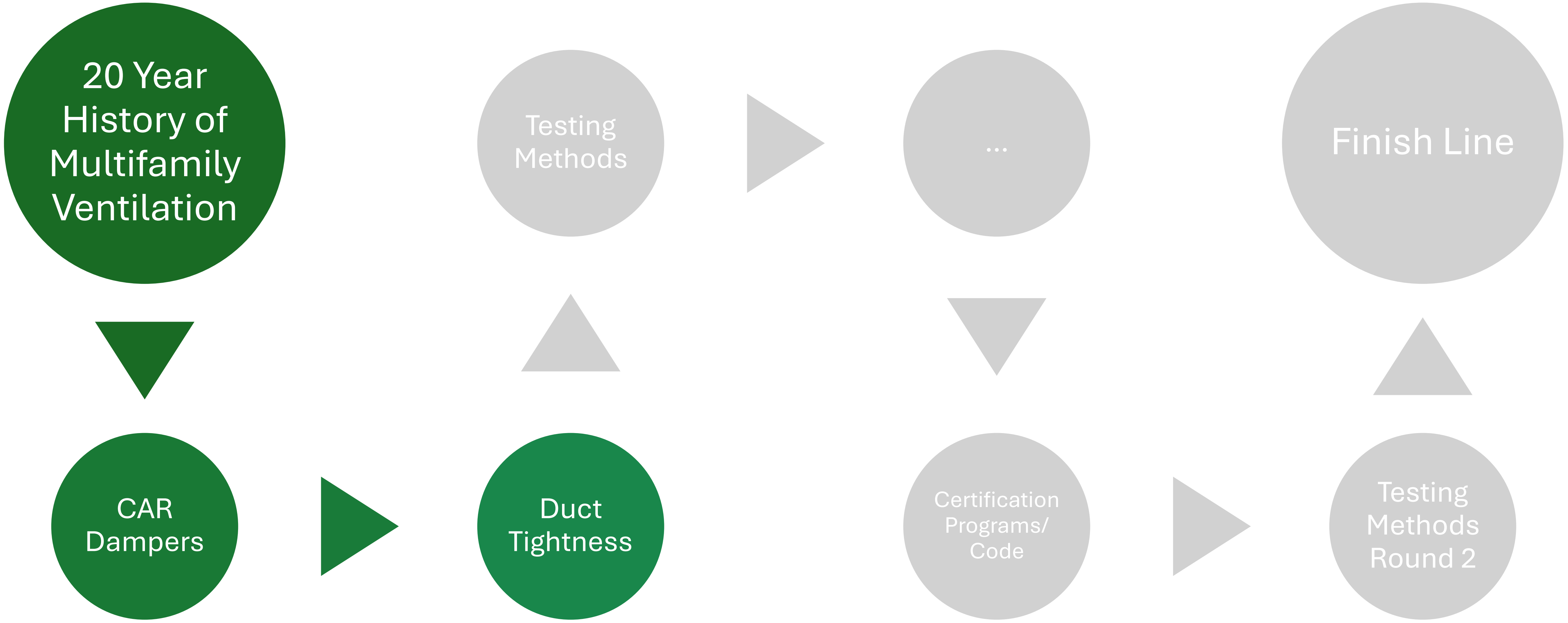
(FLOW)



(PRESSURE)



(FLOW)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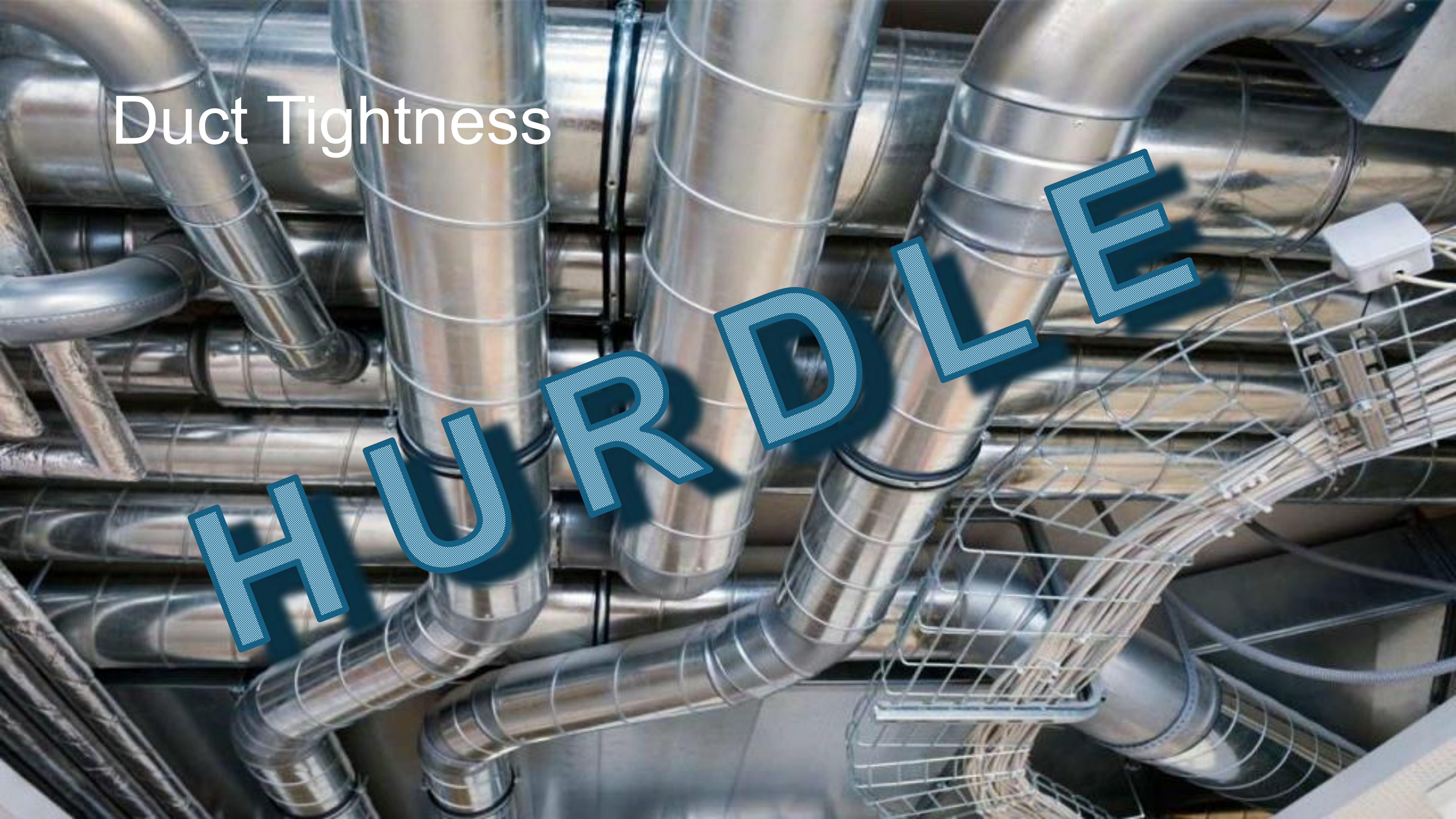
Testing Methods
...
Certification Programs/ Code
Testing Methods Round 2
Finish Line

Duct Tightness

Duct Tightness



aeroseal DUCT

COMMERCIAL LEAKAGE REPORT

Building Type: Commercial Building
Seal Date: 5/28/2025
Barometric Pressure (Inches in HG): 29.90

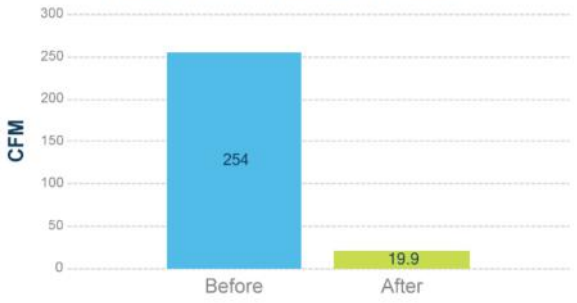
Aeroseal Gen2 Case ID: 7020
Manometer Model: -
Manometer Serial Number: -

Seal Specifics
System Description: ERV-3
Operating Pressure (wg): 1 Inches
Fan Capacity: 2730 CFM
Seal Description: 5th Floor Exhaust Air
Seal Type: Exhaust
Seal CFM: 480 CFM

Duct Class (wg): 1 Inches
Seal Class: A

	Rectangle	Round
Test Duct Surface Area (ft²)	368.3	432.0
SMACNA Leakage Class	6	3
Leakage Allowed at 1" WG	22.1	13.0

Leakage at 1" WG (operating pressure)



Allowable Leakage at 1" WG
(duct class test pressure)
35.1 CFM

Leakage Before Sealing
254.5 CFM

Leakage After Sealing
19.9 CFM

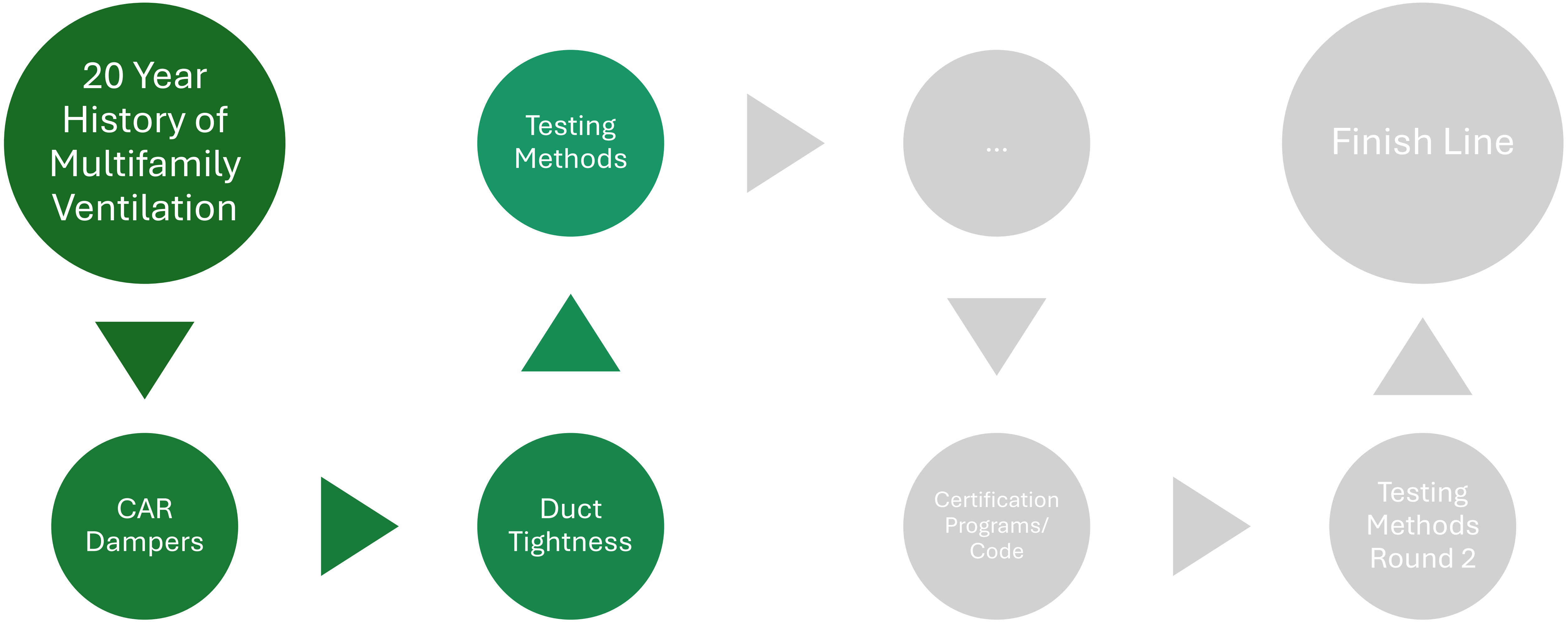
Leakage Test
PASS

Duct sealing performed by:

Aeroseal Technician
Aspen Air Duct
270 Lawrence St.
Methuen, MA 01844
Phone: 9786815023

ASPEN
AIR DUCT CLEANING LLC

Note: Duct leakage results reported by Aeroseal conform to the calculations laid out in method D of ASTM E 1554: Standard Test Methods for determining air leakage of air distribution systems by fan pressurization.


20 Year History of Multifamily Ventilation
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Duct Tightness
Testing Methods
...
Certification Programs/ Code
Testing Methods Round 2
Finish Line

Testing Methods

Bag and Stopwatch

Flow Hood

Static Pressure

Testing Methods

Bag and Stopwatch

Flow Hood

Static Pressure

LBNL-49697

Accuracy of Flow Hoods in Residential Applications

Craig Wray
Iain Walker
Max Sherman

Environmental Energy Technology Division
Indoor Environment Department
Lawrence Berkeley National Laboratory
Berkeley, CA 94720
May 2002

Experimental Assessment of Accuracy

Measuring residential airflows with a flow hood developed for commercial systems is a challenge for the following four key reasons:

1. Residential supply grille airflows are typically much lower than non-residential ones. Usually, residential flows range from 25 to 120 L/s (53 to 250 cfm), with many in the lower half of this range and some substantially lower: some small interior bathrooms have design flows in the 5 L/s (10 cfm) range. For comparison, commercial system flows typically exceed 120 L/s (250 cfm). Manufacturers of commercially available hoods indicate their equipment is capable of measuring the lower flows; however, they provide no data to support using their measurement techniques for these flows.
2. Residential grilles do not have diffusers that make the flow spatially homogeneous. For supply grilles in particular, the vanes that direct the flow in a particular direction to control the throw of air from the grille into the room lead to highly non-uniform flows entering the flow hood.
3. Residential supply grilles are often physically smaller than those used in commercial systems. A typical residential supply grille is 150 mm × 300 mm (6 × 12 inches) rather than the 560 mm (22 inches) square grille used in commercial systems. This size difference introduces measurement errors, because the flow is non-uniform over the inlet of the flow hood.

AREA	OUTLET				DESIGN		PRELIMINARY		FINAL	
SERVED	NO.	TYPE	SIZE	AK	VEL	AIRFLOW	VEL	AIRFLOW	VEL	AIRFLOW
HRV-1 SUPPLY	**(SPEED RANGE 4)**									
LIVING AREA	1	SG	6 X 6	.16	219	35	262	43	262	43
BEDROOM 1	2	SG	6 X 6	.16	94	15	210	34	210	34
BEDROOM 2	3	SG	6 X 6	.16	94	15	275	44	275	44
TOTAL						65		121		121
HRV-1 EXHAUST	**(SPEED RANGE 4)**									
KITCHEN	1	ER	6 X 6	.19	132	25	172	33	172	33
BATHROOM	2	ER	6 X 6	.19	105	20	127	24	127	24
MASTER BATH	3	ER	6 X 6	.19	105	20	121	23	121	23
TOTAL						65		80		80

AREA	OUTLET				DESIGN		PRELIMINARY		FINAL	
SERVED	NO.	TYPE	SIZE	AK	VEL	AIRFLOW	VEL	AIRFLOW	VEL	AIRFLOW
HRV-2 / SUPPLY	**(SPEED RANGE 3)**									
LIVING AREA	1	SG	6 X 6	.19	219	35	238	38	238	38
BEDROOM 1	2	SG	6 X 6	.19	94	15	269	43	269	43
BEDROOM 2	3	SG	6 X 6	.19	94	15	200	32	200	32
BEDROOM 3	4	SG	6 X 6	FH	FH	15	FH	107	FH	107
TOTAL						80		220		220
HRV-2 / EXHAUST	**(SPEED RANGE 3)**									
KITCHEN / DINING	1	ER	6 X 6	.19	132	25	175	33	175	33
BATHROOM	2	ER	6 X 6	.19	105	20	110	21	110	21
MASTER BATH	3	ER	6 X 6	.19	184	35	264	50	264	50
TOTAL						80		104		104

“Homemade Air Flow Diagnostic Tools Get Professionally Tested”

Iain Walker

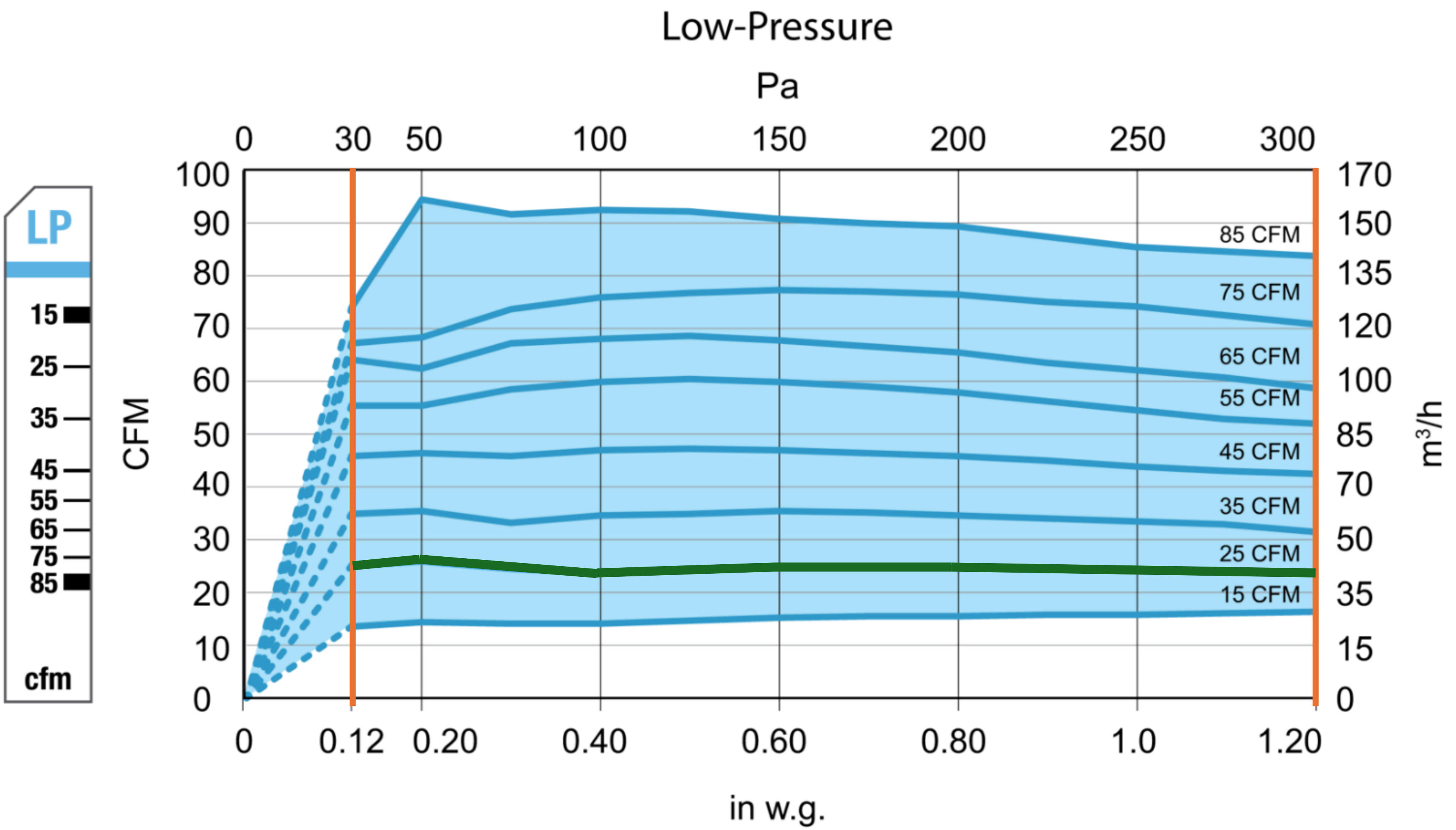
November 2003

Home Energy Magazine

JOE LSTIBUREK

Joe Lstiburek and Gary Nelson work with an early air flow measuring device.

Garbage bags can be pretty handy components of an HVAC contractor's tool kit, recent research at Lawrence Berkeley National Laboratory (LBNL) has confirmed (see "Air Flow Measurements in the Bag,"HE Sept/Oct '02 p. 8).Toting around a laundry basket is also a good idea. Indeed, contractors can often diagnose HVAC system pressures more accurately by using these common household objects than they can using commercially available flow hoods.



How do they work?

Tolerances

- Calculated error (Uc) on flow measurement:

$$Uc = \sqrt{(u1^2 + u2^2 + u3^2 + u4^2 + u5^2 + ux^2)}$$

u1 = tolerance of the product
u2 = tolerance of the measurement tool
u3 = error due to method repeatability
u4 = error due to leakage
u5 = installation uncertainties
ux = … any other elements which could impact the reading

Then the measured value (Mv) based on the reading (Re) is expressed as below:

$$Mv = Re \pm Uc$$

Tolerances

- Calculated error (Uc) on flow measurement:

$$Uc = \sqrt{(u1^2 + u2^2 + u3^2 + u4^2 + u5^2 + ux^2)}$$

u1 = tolerance of the product = **0.1**

u2 = tolerance of the measurement tool = **0.09**

u3 = error due to method repeatability = **0.09**

u4 = error due to leakage = **0**

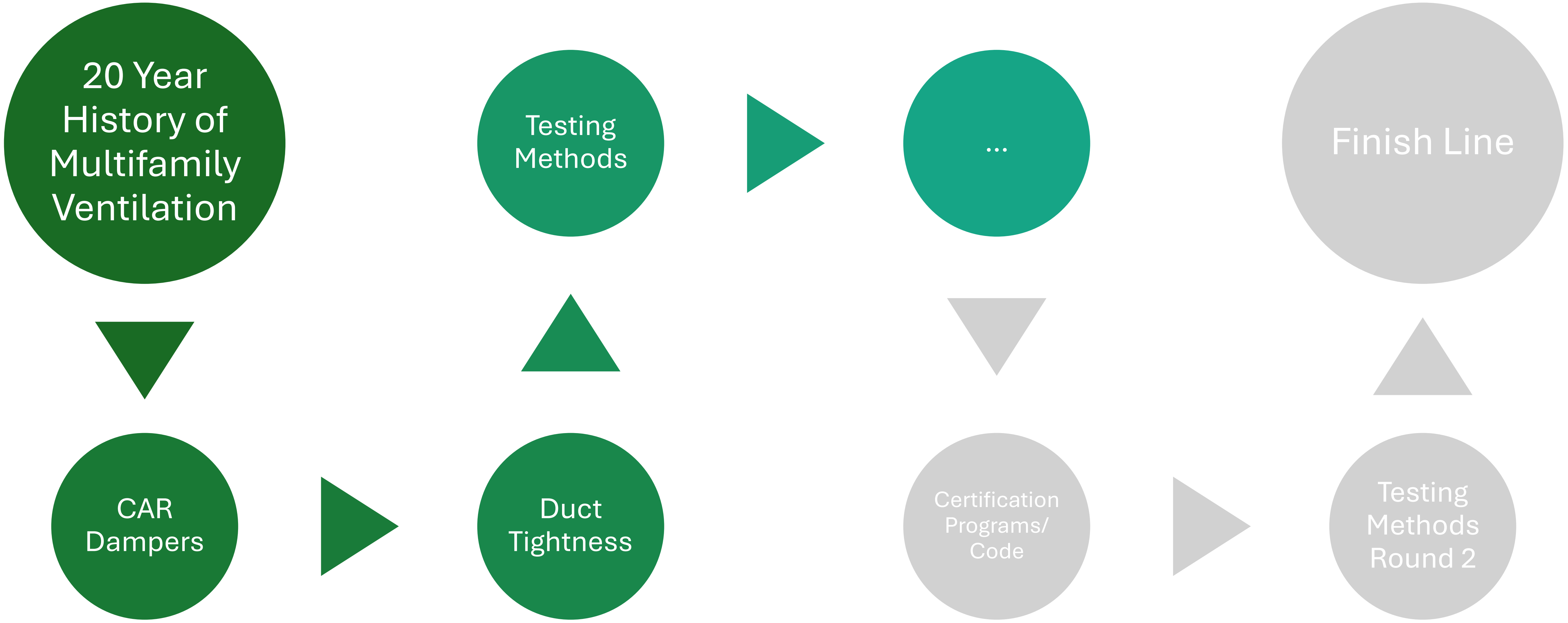
u5 = installation uncertainties = **0**

ux = … any other elements which could impact the reading = **0**

Uc = 0.162 (16.2%)

Then the measured value (Mv) based on the reading (Re) is expressed as below:

$$Mv = Re \pm Uc$$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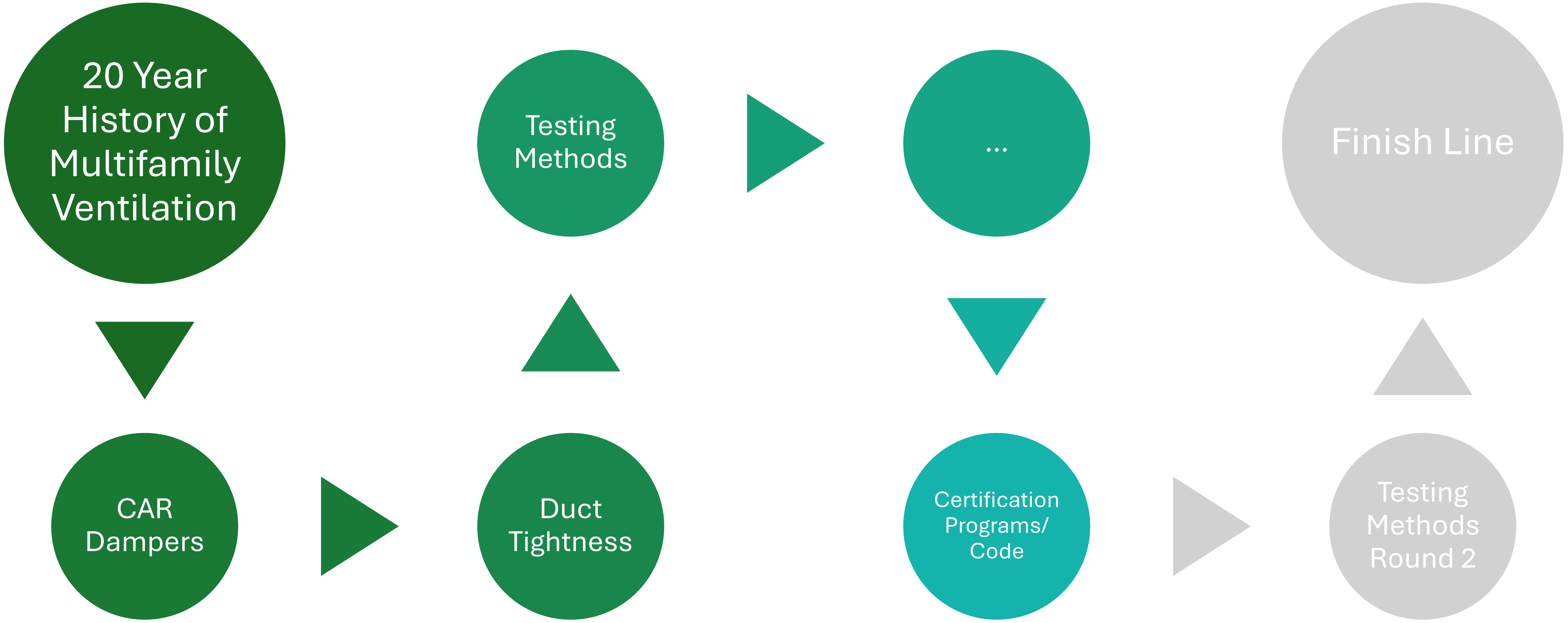
CAR Dampers
Duct Tightness
Testing Methods
...
Certification Programs/ Code
Testing Methods Round 2
Finish Line


20 Year History of Multifamily Ventilation
CAR Dampers
Duct Tightness
Testing Methods
...
Certification Programs/ Code
Testing Methods Round 2
Finish Line

Certification Programs

Certification Programs

Phius – Measured Rates to be:

- Unit Supply and Exhaust within +/-10% balanced
- Within +/-20% or +/-5cfm of design per register
- EXCEPT
  - Kitchen 25cfm MIN
  - Bath 20cfm MIN

Energy Star – Measured Rates to be:

- Total Unit Supply and Exhaust within +/-15% or +/-15cfm of total design values per unit
- AND meet ASHRAE 62.1 and 62.2 requirements

phius

September 2, 2025

Exhaust Air Flows

- Airflow measurements must be taken per ANSI/RESNET/ICC Standard 380-2022.
- Measured exhaust air flow rates must meet the design intent within allowable tolerances.
  - Exhaust airflows per register must be **+/-**5 cfm or **+/-**20% of the design rate (whichever is greater) as per Phius' revised tolerances.
  - **Exception 1:** Bathrooms with continuous exhaust systems (and no intermittent direct exhaust fan) are required to provide >= 20 cfm of exhaust regardless of the tolerances noted above.
  - **Exception 2:** Kitchens with continuous exhaust systems (and no intermittent direct exhaust range hood) are required to provide >= 25 cfm of exhaust regardless of the tolerances noted above.
- If measured exhaust air flows are found to be out of the tolerances described above, but meet all applicable requirements for ASHRAE 62.1, 62.2, and/or mechanical code and co-requisite programs, the Mechanical Design Engineer of Record may sign off using either option **a.** or **b.** below:
  - **a.** Direct sign-off approving the measured airflows.
  - **b.** Where Constant Airflow Volume Devices (also known as CAR Dampers) are installed, verification of the following items per **Addendum A: 6.6.1** below is required:
    - Static pressure limits are within manufacturer tolerances for damper operation.
    - Direction of the damper is correct.
    - Ducts are sealed.

Exhaust airflows per register must be **+/-**5 cfm or **+/-**20% of the design rate (whichever is greater) as per Phius' revised tolerances.
Exception 1: Bathrooms with continuous exhaust systems (and no intermittent direct exhaust fan) are required to provide >= 20 cfm of exhaust regardless of the tolerances noted above.
Exception 2: Kitchens with continuous exhaust systems (and no intermittent direct exhaust range hood) are required to provide >= 25 cfm of exhaust regardless of the tolerances noted above.

ENERGY STAR Multifamily New Construction National Rater Field Checklist [1], Version 1.1 / 1.2 / 1.3 (Rev. 05)

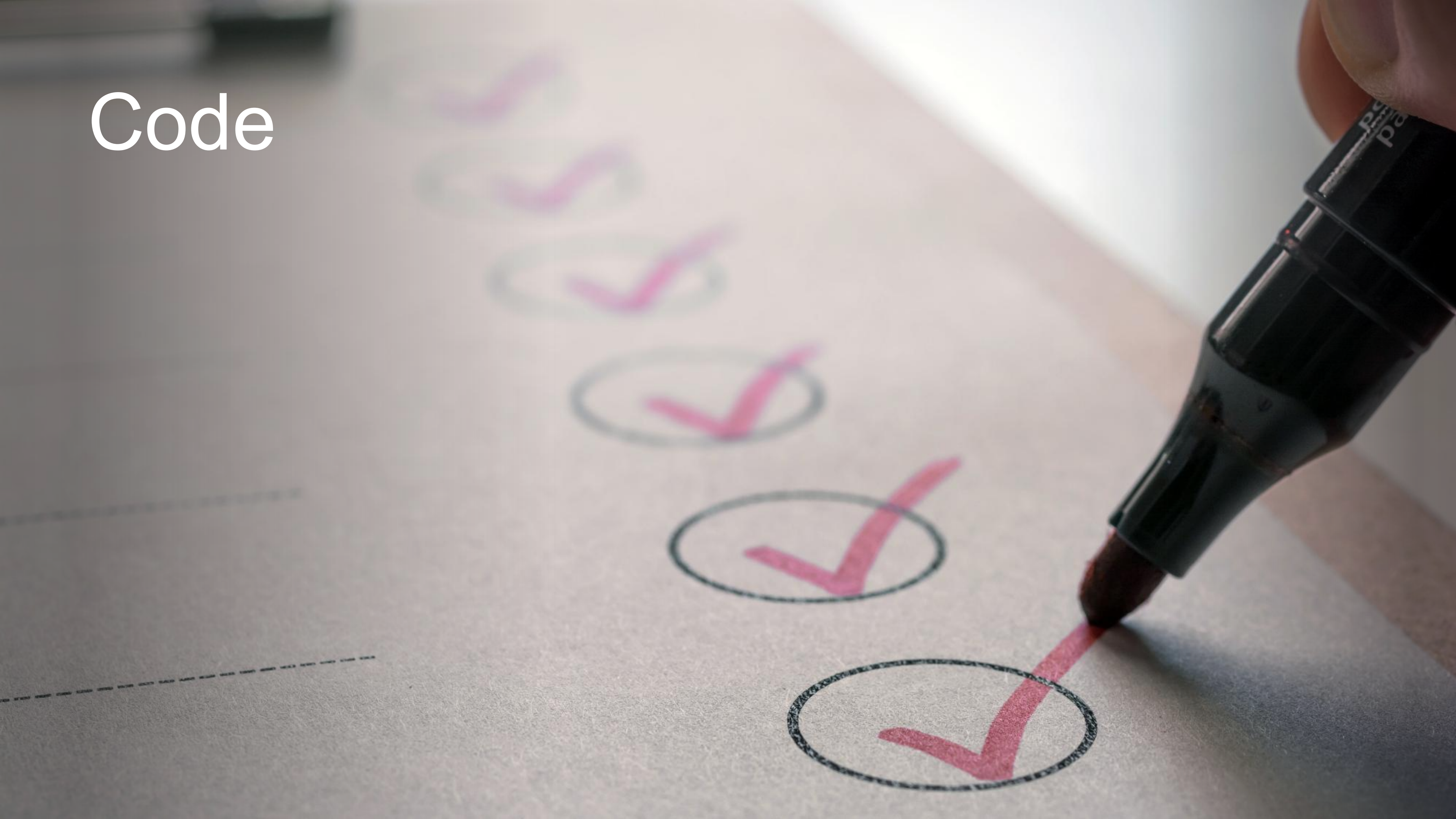
± 15 CFM or ±15% of dwelling unit design values

7. Dwelling-Unit & Common Space Mechanical Vent. Systems ("Vent Systems") [58] & Inlets in Return Duct [59] (National HVAC Design Report Item # indicated in parenthesis)			
7.1 Ventilation manufacturer & model number on installed equipment matches either of the following (check box): [40] ☐ National HVAC Design Report ☐ Written approval received from designer	☐	☐	-
7.2 Rater-measured ventilation rate is within either ± 15 CFM or ±15% of dwelling unit design values (2.7), and meets or exceeds rates required by ASHRAE 62.2-2010. [60]	☐	☐	-
7.3 Measured ventilation rate is within either ± 15 CFM or ±15% of common space design values (2.9), and meets or exceeds rates required by ASHRAE 62.1-2010 (2.8). [61, 62]	☐	☐	☐

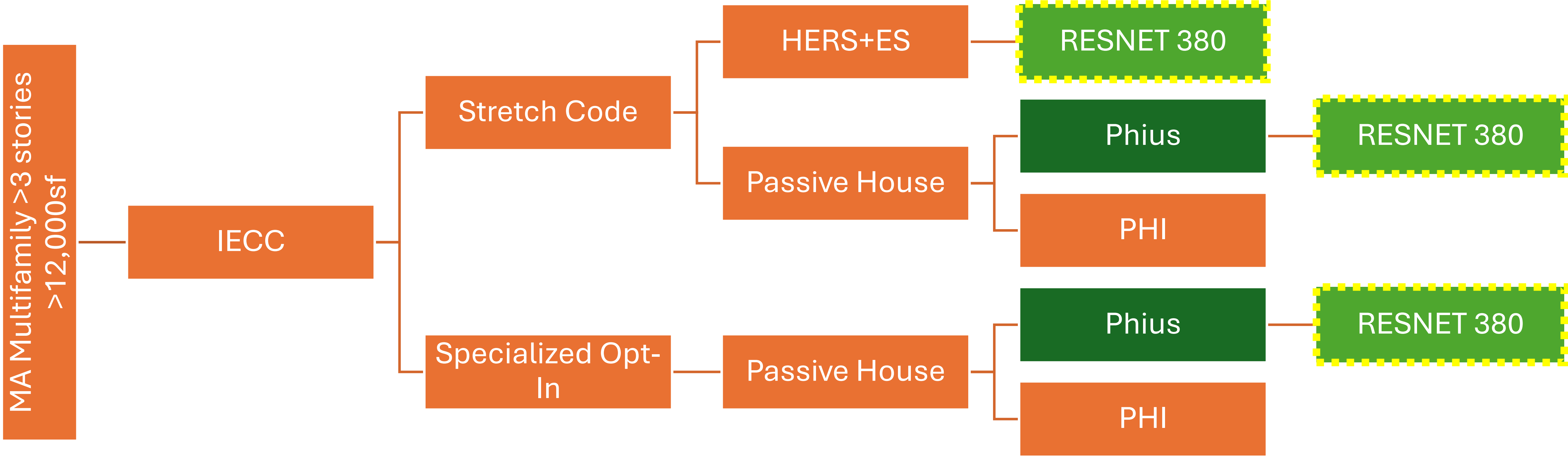
60. The dwelling-unit ventilation air flows and local exhaust air flows shall be determined and documented by a Rater using ANSI / RESNET / ICC 380 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is being certified under. To facilitate testing the air flow of a microwave-integrated exhaust fan, Raters are permitted to tape off all air inlets except at the bottom. However, no correction factors shall be applied to the measured air flow to account for the increased airflow restriction. In Item 7.2, the dwelling-unit ventilation rates required by ASHRAE 62.2-2010 can be calculated using the Multifamily Workbook or the following equation: 0.01 x Conditioned Floor Area + 7.5 x (number of bedrooms + 1). For sleeping units, the following equation must be used: 0.01 x Conditioned Floor Area + 7.5 x (number of beds). Where local codes do not permit dwelling-unit ventilation to exceed ASHRAE 62.2-2010 rates, Rater-measured ventilation rate is permitted to be 0-15 CFM less than rates required by ASHRAE 62.2-2010.

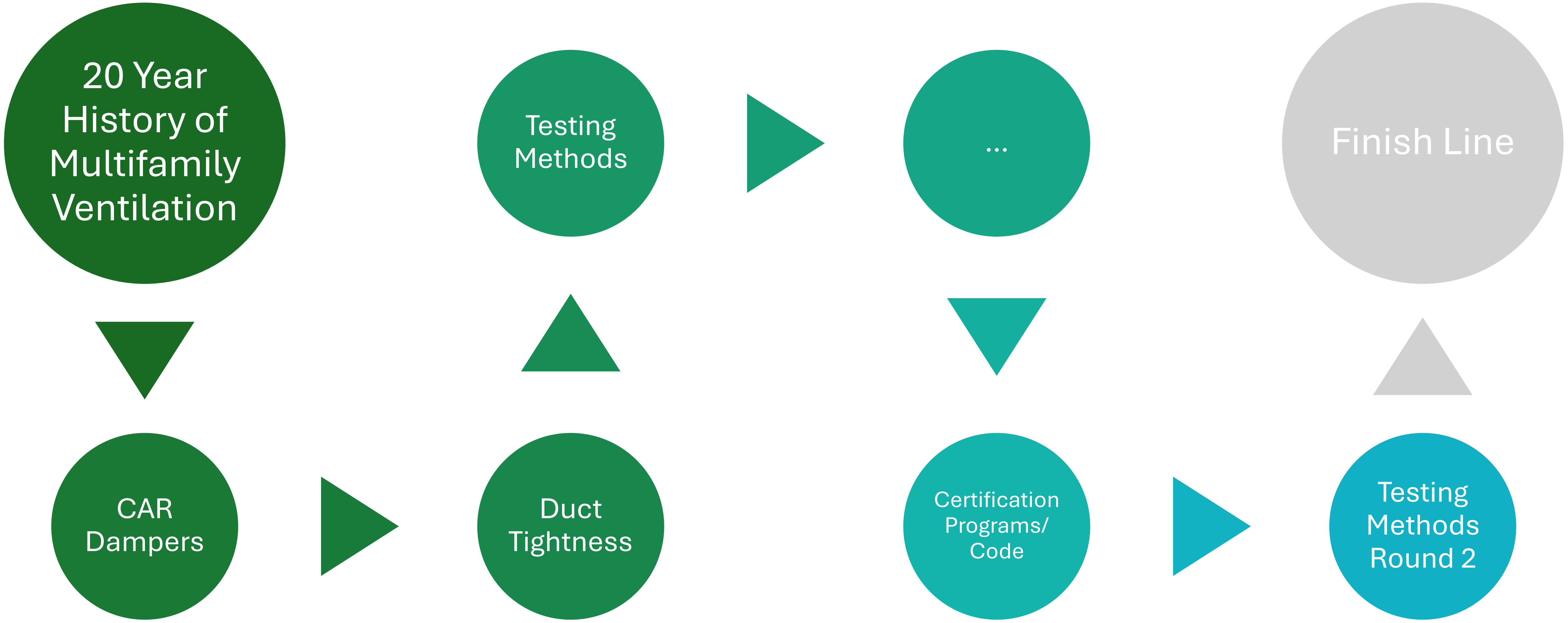
0.01 x Conditioned Floor Area + 7.5 x (number of bedrooms + 1).

Code




Code
HURDLE


MA Multifamily >3 stories >12,000sf
IECC
Stretch Code
Specialized Opt-In
HERS+ES
RESNET 380
Passive House
Phius
RESNET 380
PHI
Passive House
Phius
RESNET 380
PHI


20 Year History of Multifamily Ventilation
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Duct Tightness
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...
Certification Programs/ Code
Testing Methods Round 2
Finish Line

HURDLE

Testing with Hoods

OUTLET NO.	LOCATION	TYPE	DESIGN C.F.M.	ACTUAL SETTING	ACTUAL S.P.	ACTUAL C.F.M.
26	403 LIVING ROOM	SD	40	45	0.90"	26

OUTLET NO.	LOCATION	TYPE	DESIGN C.F.M.	ACTUAL SETTING	ACTUAL S.P.	ACTUAL C.F.M.
7	517 BATHROOM	EG	25	27	0.81"	24
8	517 BATHROOM	EG	25	35	0.79"	26

Bag and Stopwatch

				Bag Inflation Method							Static Pressure Method	TAB Flow Hood Method	
Grille Location	Supply or Exhaust	Design Airflow (CFM)	CAR Setting	Trial 1		Trial 2		Trial 3		Measured Averagve	Diff Pressure (" of w.c)	Airflow CFM	Notes
				Time (Sec)	CFM	Time (sec)	CFM	Time (sec)	CFM	CFM			
Living Room	Supply	40	45	5.1	47.6	4.8	50.7	4.8	50.7	50	0.35	41	Without Grille
Bedroom 1	Supply	15	15	15.5	15.5	15.8	15.2	16.7	14.4	15	0.38	14	Without Grille
Bedroom 2	Supply	15	15	15.9	15.2	15.5	15.5	15.0	16.1	16	0.29	16	Without Grille
Bedroom 3	Supply	15	20	13.4	17.9	14.3	16.9	14.0	17.2	17	0.34	17	Without Grille
Kitchen	Exhaust	35	NONE	5.6	43.2	6.1	39.6	6.1	39.3	41	0.06	29	With Grille, With Filter, NO CAR DAMPER
Bathroom 1	Exhaust	25	40	7.4	32.6	7.4	32.7	7.7	31.2	32	0.20	26	With Grille
Bathroom 2	Exhaust	25	35	8.4	28.8	8.0	30.2	8.4	28.8	29	0.13	24	With Grille

Flow Rate Testing – ANSI/RESNET/ICC 380

Outlet (Supply)

- Powered Flow Hood
- Bag Inflation Device
- Vane Anemometer with Hood

Inlet (Exhaust)

- Powered Flow Hood
- Airflow Resistance Device
- Passive Flow Hood
- Vane Anemometer with Hood

Midstream

- Airflow Measurement Station
- Velocity Pressure Probe
- Hot Wire Anemometer

Flow Rate Testing – ANSI/RESNET/ICC 380

Outlet (Supply)

- Powered Flow Hood
- Bag Inflation Device
- Vane Anemometer with Hood

Inlet (Exhaust)

- Powered Flow Hood
- Airflow Resistance Device
- Passive Flow Hood
- Vane Anemometer with Hood

Midstream

- Airflow Measurement Station
- Velocity Pressure Probe
- Hot Wire Anemometer

Flow Rate Testing – ANSI/RESNET/ICC 380

HURDLE

Outlet (Supply)

- Powered Flow Hood
- Ba[illegible]fl[illegible] Devi[illegible]
- Vane A[illegible]ometer with Hood

Inlet (Exh[illegible])

- [illegible]d Fl[illegible]
- [illegible]rflow [illegible]esistance Device
- Passive Flow Hood
- Vane Anemometer with Hood

Mi[illegible]eam

- Airflow Measurement Station
- Velocity Pressure Probe
- Hot Wire Anemometer

Bag Inflation Device (Bag and Stopwatch)

6.3. Procedure to measure airflow at outlet terminal.

This Section defines procedures to measure the airflow of a mechanical Ventilation system at an outlet terminal. The airflow is permitted to be measured using a powered flow hood (Section 6.3.1), a bag inflation device (Section 6.3.2), or a vane anemometer with hood (Section 6.3.3).

6.3.2. Bag inflation device.

6.3.2.1. Equipment needed.

6.3.2.1.1. Bag inflation device. A flow capture element capable of creating an airtight perimeter seal around the outlet terminal that is connected to a plastic bag of known volume and holding the bag open[67] and a shutter that controls airflow into the bag.

The plastic bag shall be selected such that three or more measurements of a single outlet terminal produce results that are within 20 percent of each other.

The volume of the plastic bag shall be selected such that the bag will completely fill with air from the outlet terminal in the range of 3 to 20 seconds.

6.3.2.1.2. Stopwatch. A stopwatch capable of recording elapsed time +/- 0.1 seconds.

*Excerpts from ANSI/RESNET/ICC 380

Flow Rate Testing – ANSI/RESNET/ICC 380

Outlet (Supply)

- Powered Flow Hood
- Bag Inflation Device
- Vane Anemometer with Hood

Inlet (Exhaust)

- Powered Flow Hood
- Airflow Resistance Device
- Passive Flow Hood
- Vane Anemometer with Hood

Midstream

- Airflow Measurement Station
- Velocity Pressure Probe
- Hot Wire Anemometer

Flow Rate Testing – ANSI/RESNET/ICC 380

Outlet (Supply)

- Powered Flow Hood
- Ba fl Devi
- Vane A ometer with Hood

Inlet (Exh)

- d Fl
- rflow sistance Device
- Passive Flow Hood
- Vane Anemometer with Hood

Mi eam

- Airflow Measurement Station
- Velocity Pressure Probe
- Hot Wire Anemometer

HURDLE

6.4 Procedure to measure airflow midstream in the Ventilation duct. This Section defines procedures to measure the airflow of a mechanical Ventilation system midstream in the Ventilation duct. The airflow is permitted to be measured using an Airflow Measurement Station (Section 6.4.1), a velocity pressure probe (Section 6.4.2), or a hot wire anemometer (Section 6.4.3).

6.4.1 Airflow measurement station.

6.4.1.1 Equipment needed.

6.4.1.1.1 Airflow measurement station. A permanently installed airflow measurement instrument capable of measuring average velocity pressure across a duct diameter or static pressure across an in-line aperture of known area. The airflow measurement instrument shall contain a port that allows it to be connected to a manometer. The airflow measurement instrument must have a calculation procedure provided by the manufacturer to convert the measured velocity pressure or static pressure into volumetric airflow with a maximum error of 10 percent or 5 CFM (2.5 L/s), whichever is greater.

6.4.1.1.2 Manometer. A device that is capable of measuring pressure difference with a maximum error of 1 percent of reading or 0.25 Pa (0.0010 in. H_2O), whichever is greater.

*Excerpt from ANSI/RESNET/ICC 380

Iain Walker

Degrees

- PhD – University of Alberta, Edmonton, Canada
- MSc – University of Alberta, Edmonton, Canada
- BSc – University of Alberta, Edmonton, Canada

Leader of Residential Buildings team at LBNL

ASHRAE Fellow

Deputy Department Head for Whole Building Systems Department of BTUS

Leader of DOE core National Laboratory IAQ team

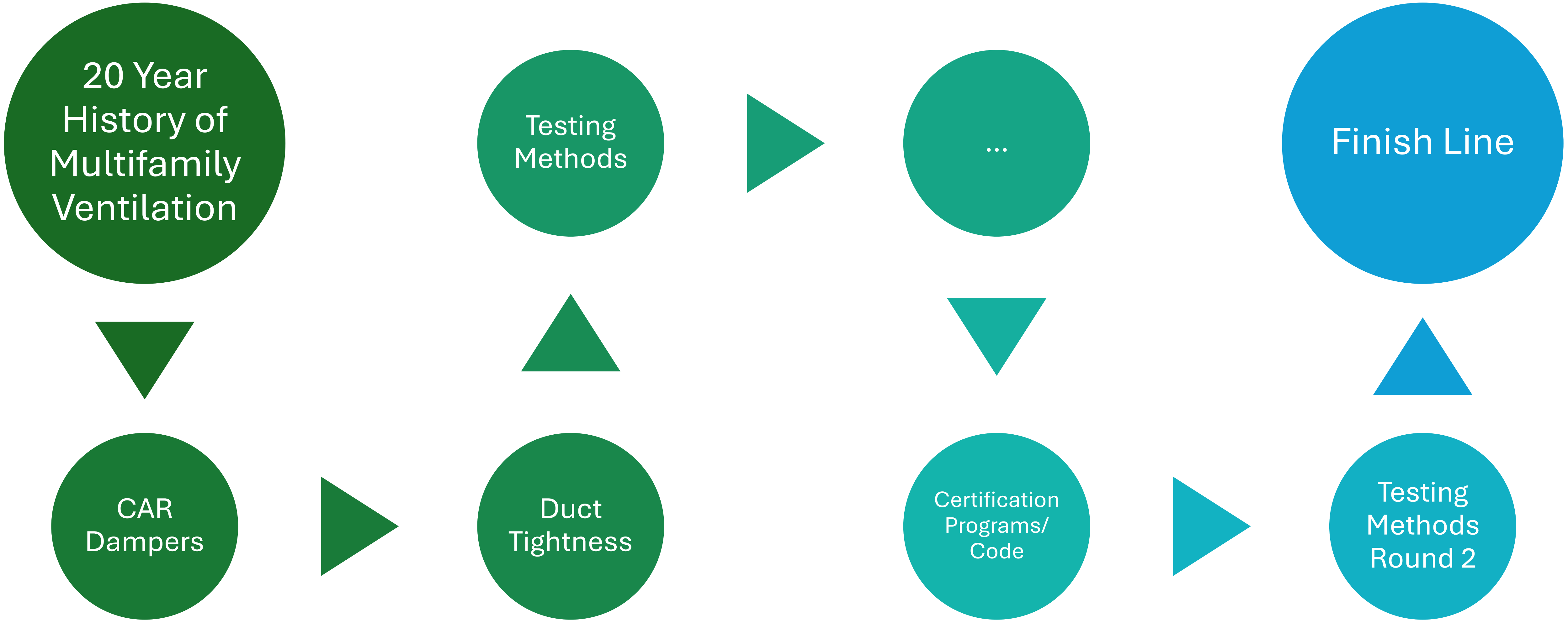
Leader and developer on standards and technical committees for ASHRAE, ASTM, RESNET, IEC, the IEA, and others

Member of RESNET Standards Management Board

Authored over 60 journal articles, 90 conference papers, and 70 research reports.

From: Iain Walker <iswalker@lbl.gov>
Sent: Monday, June 30, 2025 4:21 PM

I think the procedure you are referring to is in section 64, more specifically 6.4.1. In this case the CAR is itself the airflow instrument as it has a calibrated pressure-flow response certified by the manufacturer. This seems reasonable to me, so long as the manufacturer calibration meets the specifiction in 6.4.1 (i.e., max error of 10% or 5 cfm (2.5 L.s)).
- Iain


20 Year History of Multifamily Ventilation
CAR Dampers
Duct Tightness
Testing Methods
...
Certification Programs/ Code
Testing Methods Round 2
Finish Line


FINISH

Needed Improvements

Alternative test methods are understood and acknowledged as useful

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Use various test methods in combination to better assess ventilation system performance

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“Greater than or equal” is removed from Energy Star and Phius

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Alternative test methods are understood and acknowledged as useful

Use various test methods in combination to better assess ventilation system performance

“Greater than or equal” is removed from Energy Star and Phius

Energy Star, Phius, Verifiers stop trying to engineer ventilation systems

Simple Way to Get There

Phius reverts to focus on reducing heating and cooling loads

Simple Way to Get There

Phius reverts to focus on reducing heating and cooling loads

Phius drops all co-requisite programs and returns to being a standalone program

Simple Way to Get There

Phius reverts to focus on reducing heating and cooling loads

Phius drops all co-requisite programs and returns to being a standalone program

Phius drops 3rd party verification of ventilation systems

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