



GUARDED TESTING

Dr. Randy Van Straaten

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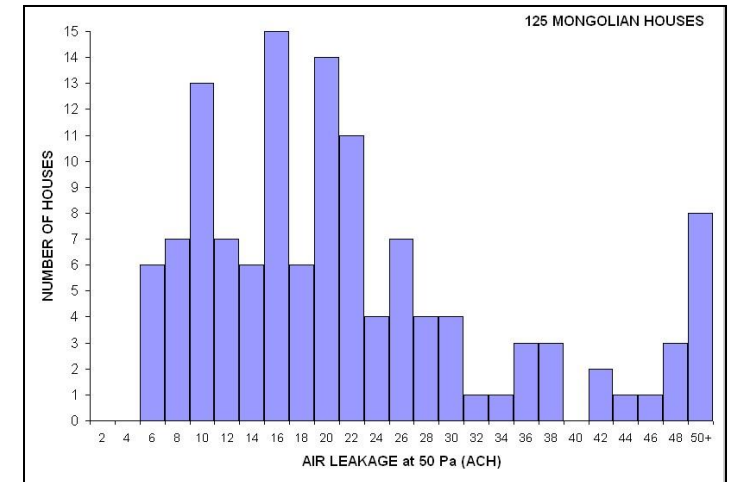
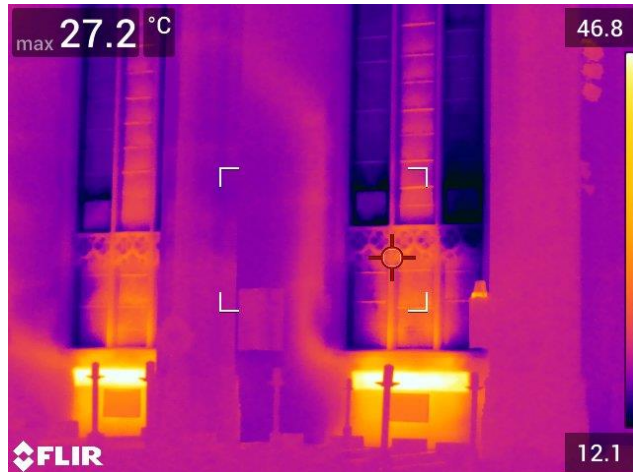
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EXAMPLE BUILDING

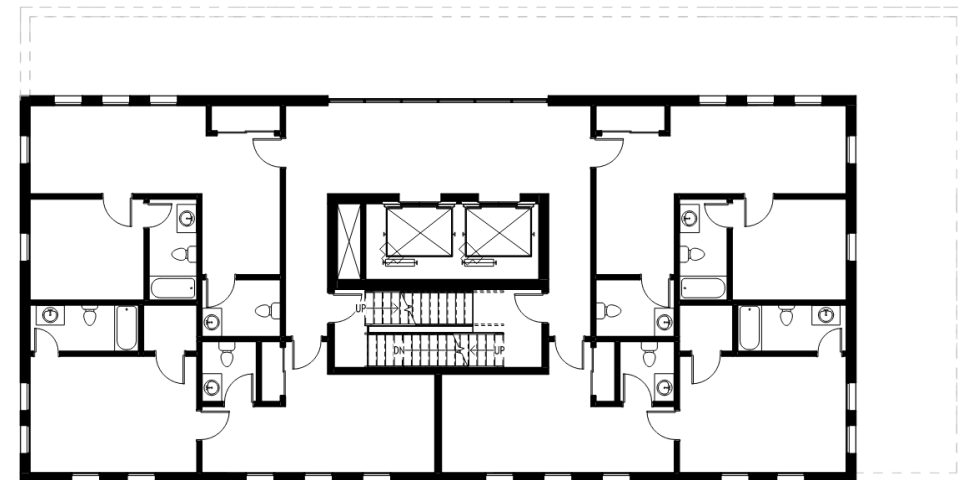
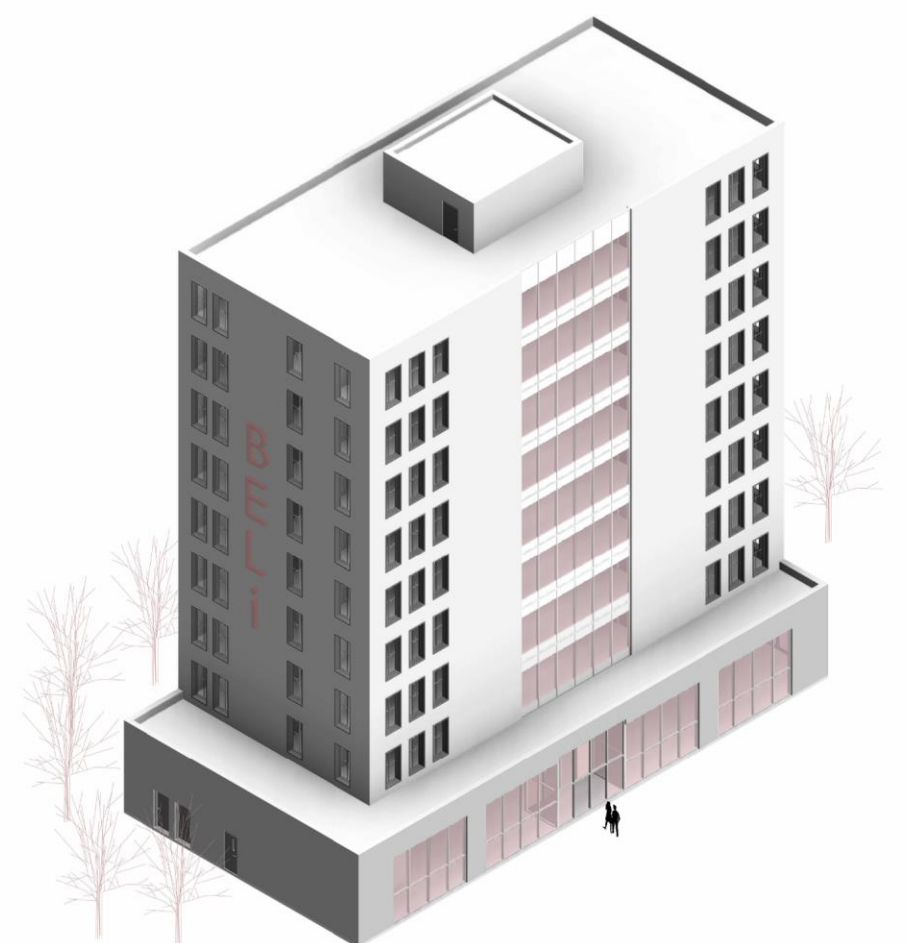


Amrit Mangat



University of Waterloo

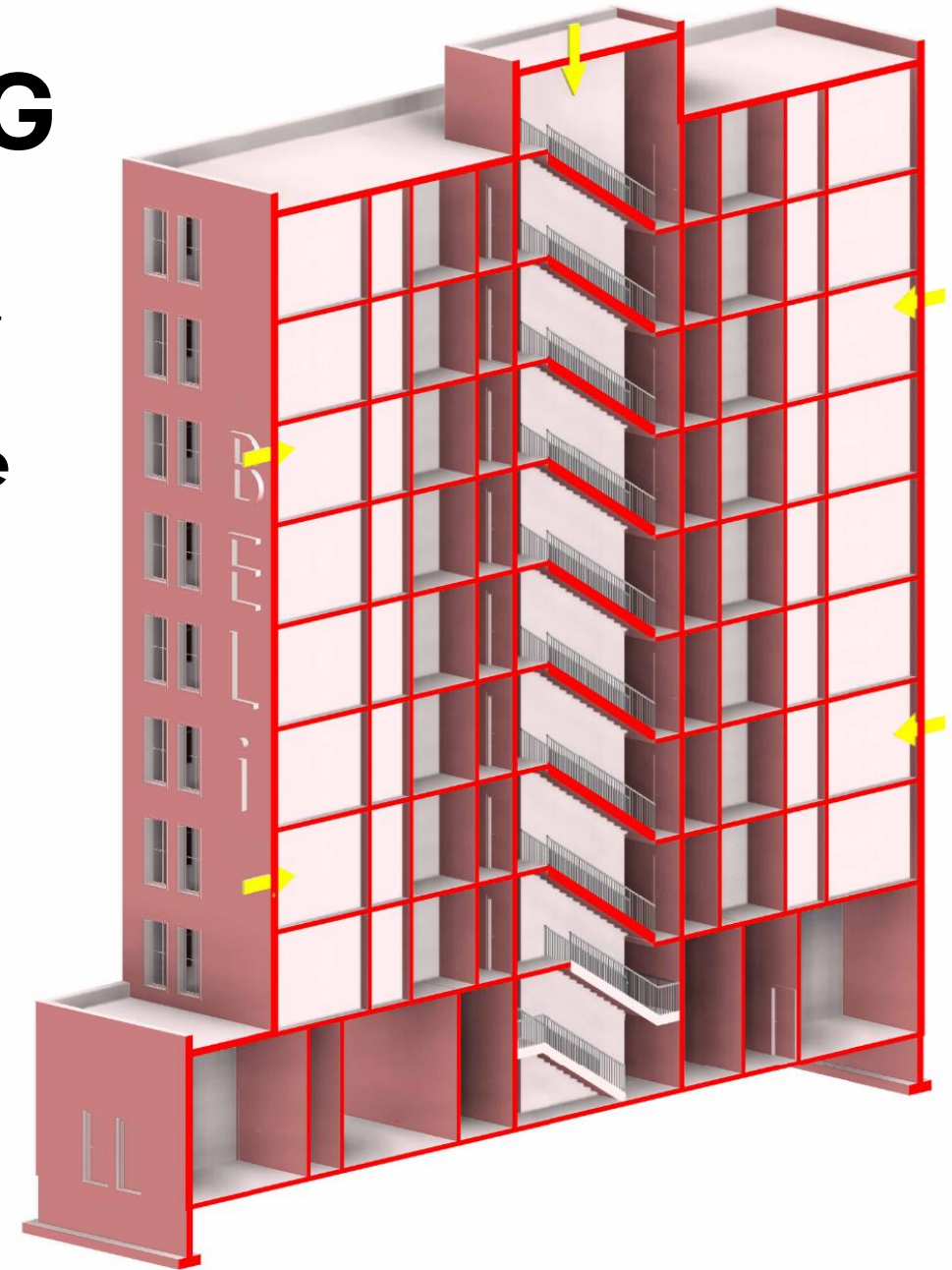
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TESTING LARGE BUILDING

Whole Building Air Tightness includes all building envelope boundaries in one test

Preferred method of measuring envelope air tightness



LIMITATIONS

However, this becomes impractical for large buildings.

1. Phased completion



LIMITATIONS

Can be impractical for large buildings.

1. Phased completion
2. Stack effort

Hence, for testing large buildings you need:

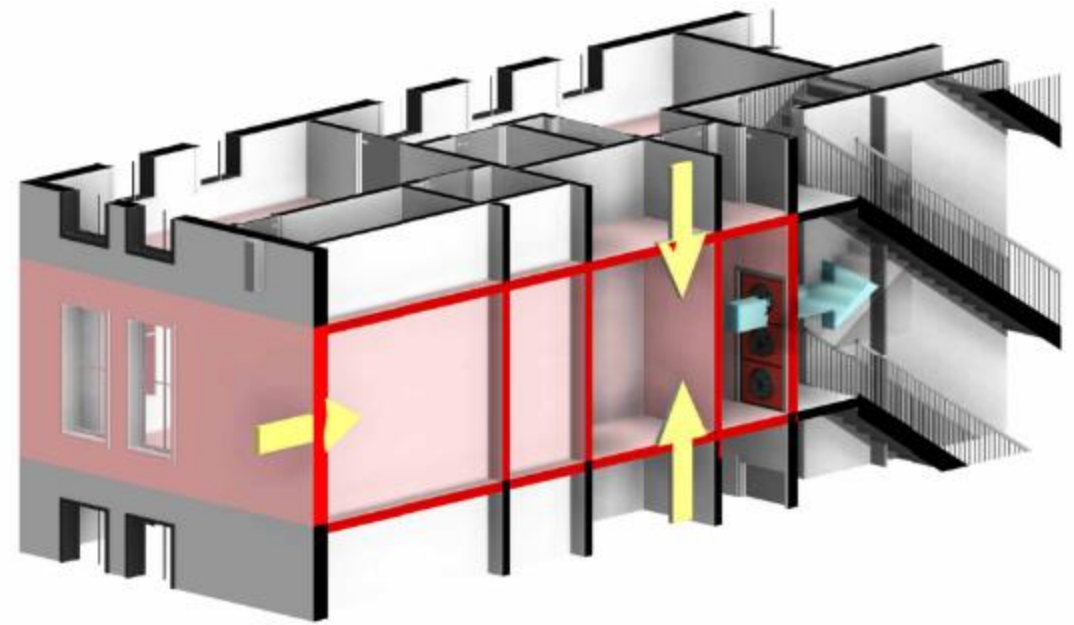
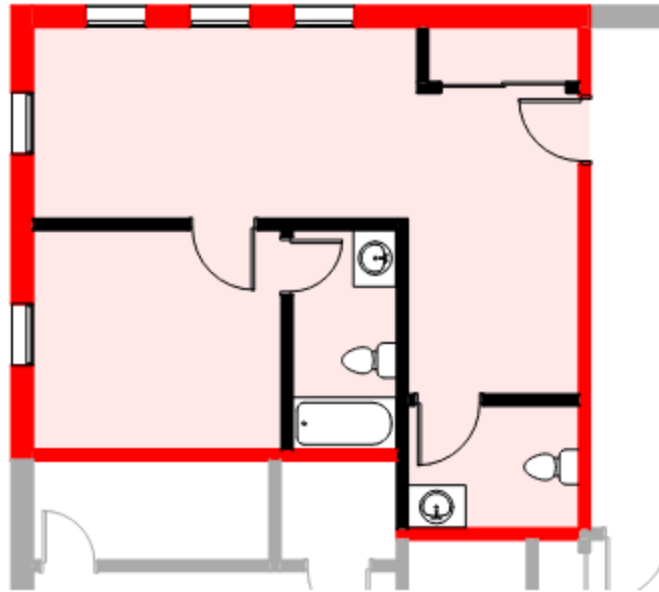
- good weather and
- a period when air barrier installation is completed but building is not occupied

Other options?



SUITE TESTING

TEST ZONE

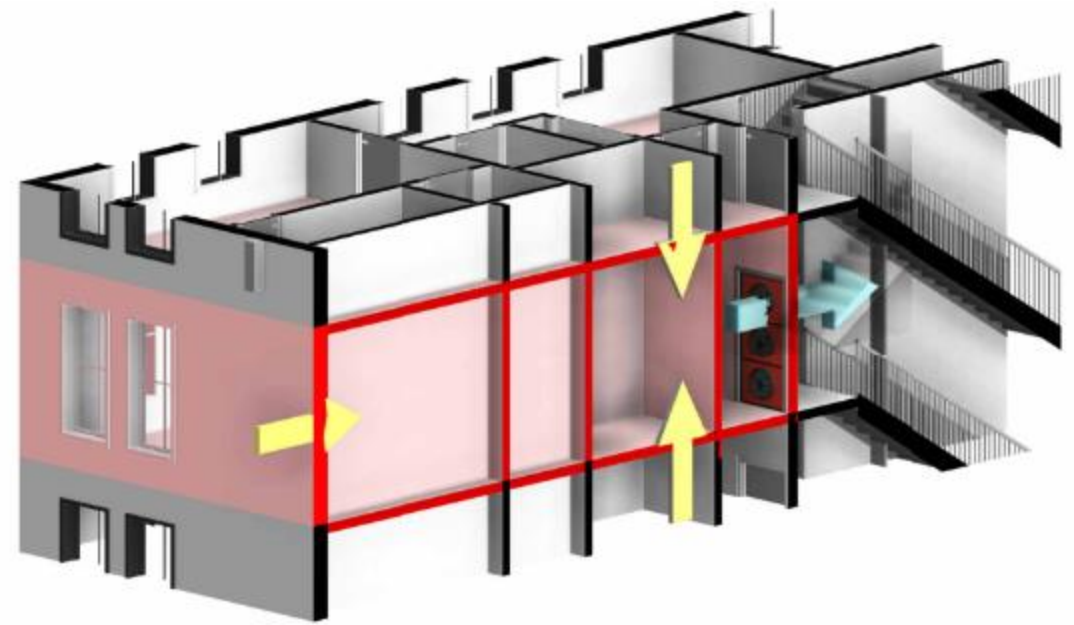


Suite Test: the test boundary will be all elements of the building enclosure and demising assemblies surrounding the test zone.

LIMITATIONS

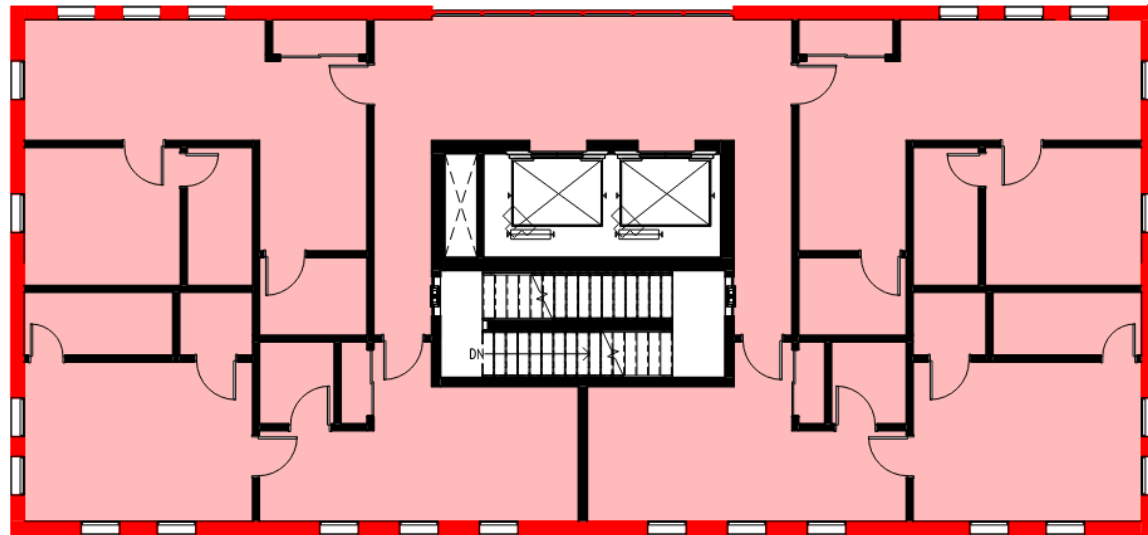
Majority of air leakage through internal boundaries and not the building envelope

- Useful for diagnostics
- Used to assess suite compartmentalization
 - Odour and pollutant control
 - Noise control

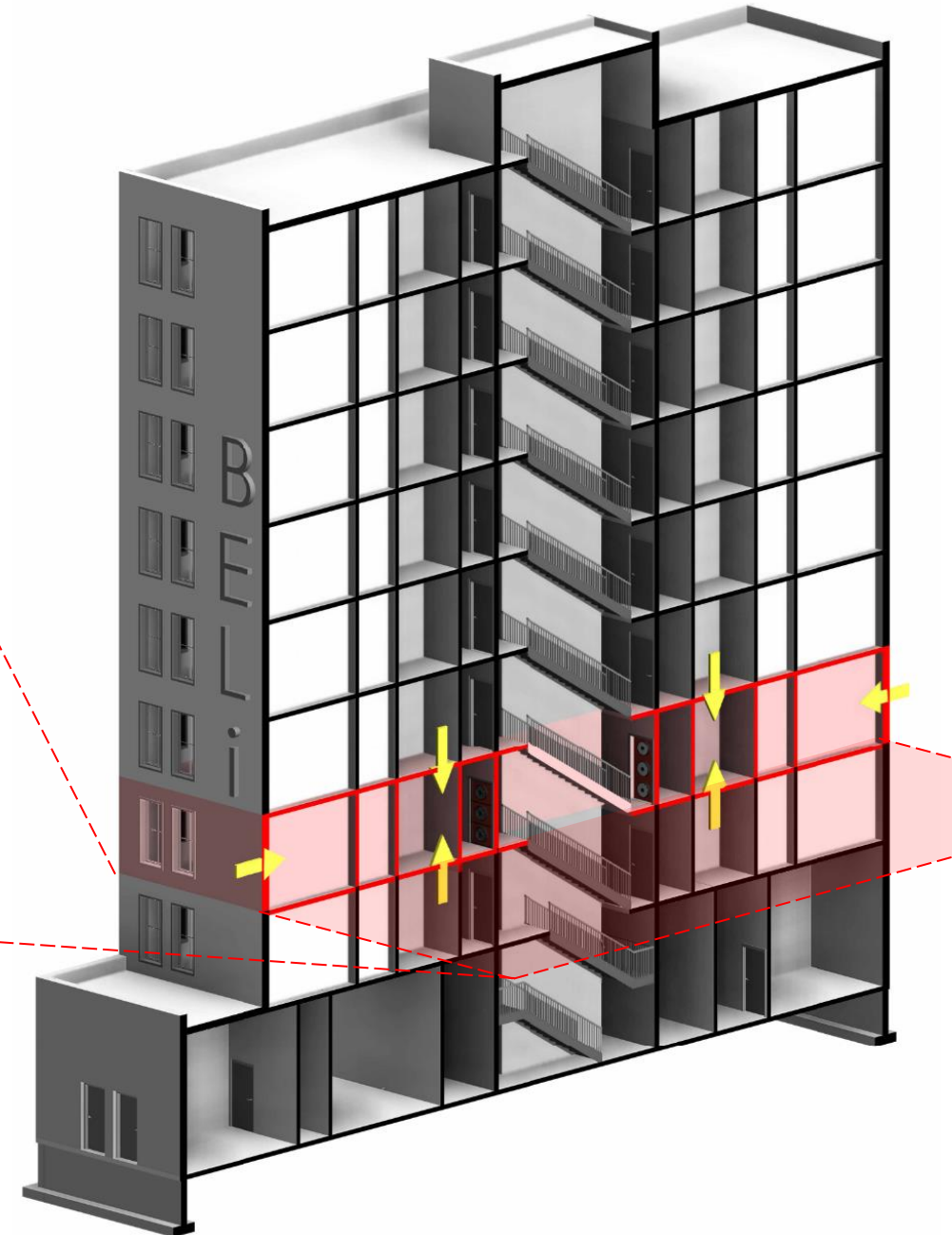


SINGLE FLOOR TESTING

TEST ZONE

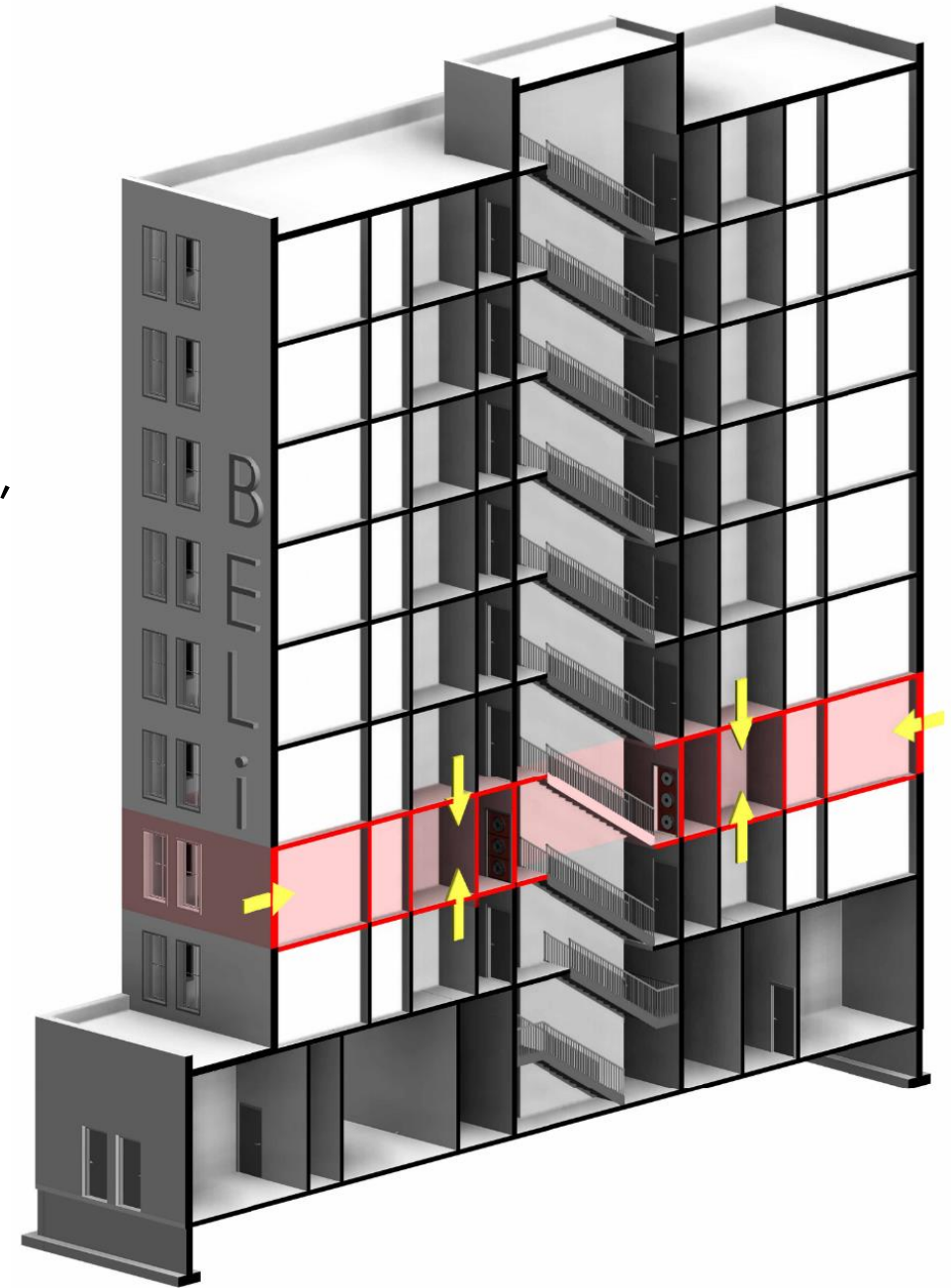


Single-floor test: the test boundary will be building enclosure and demising assemblies surrounding the test zone.



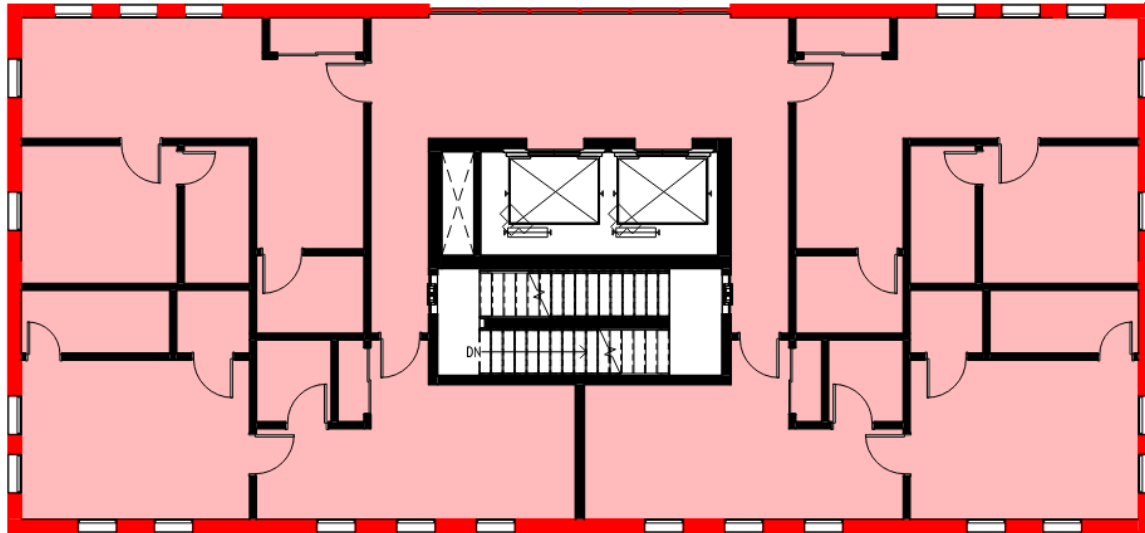
LIMITATIONS

- Air leakage through floor assemblies can dominate
- Air leakage through bypasses (stairwell, elevators, service runs) can dominate

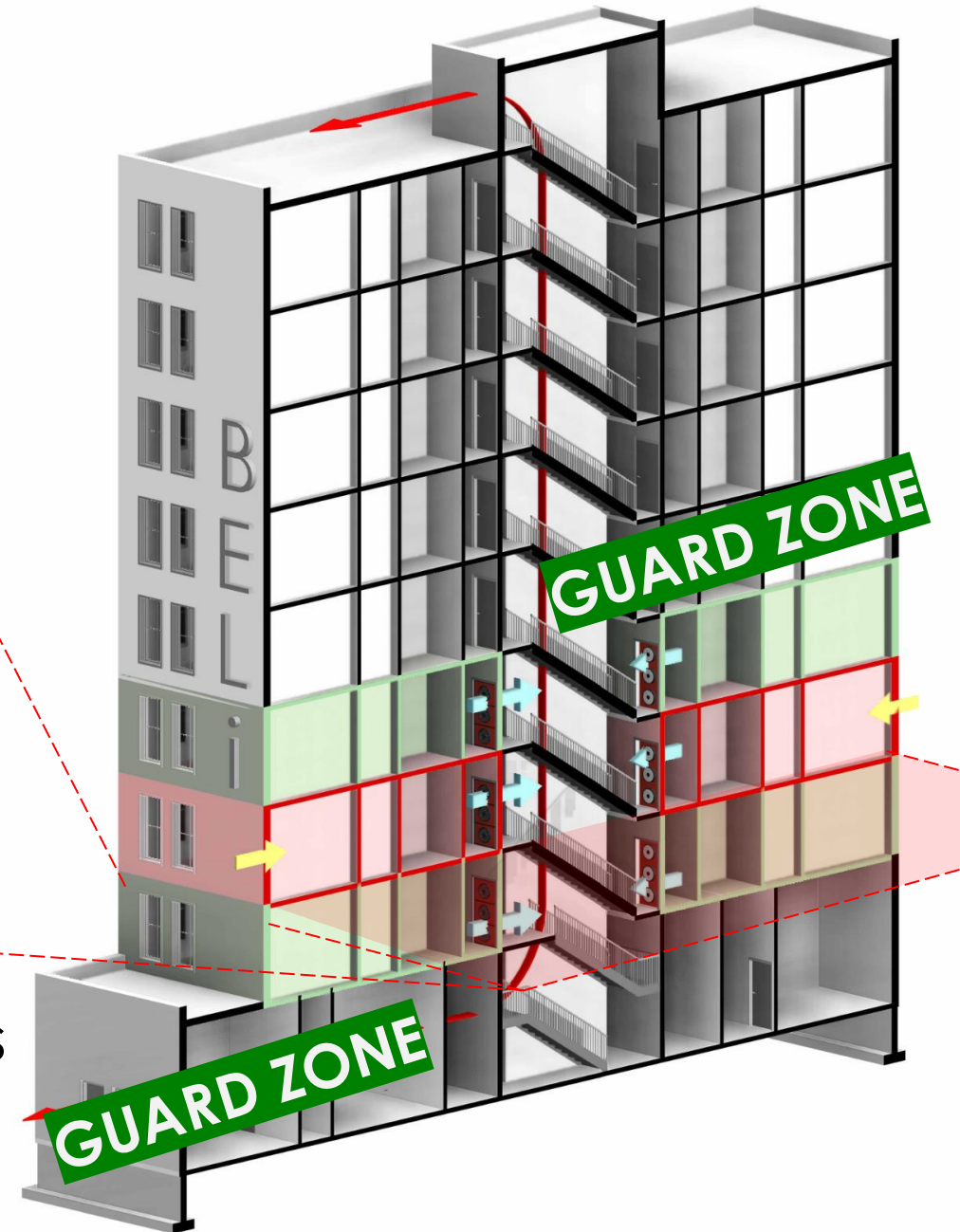


GUARDED TESTING

TEST ZONE

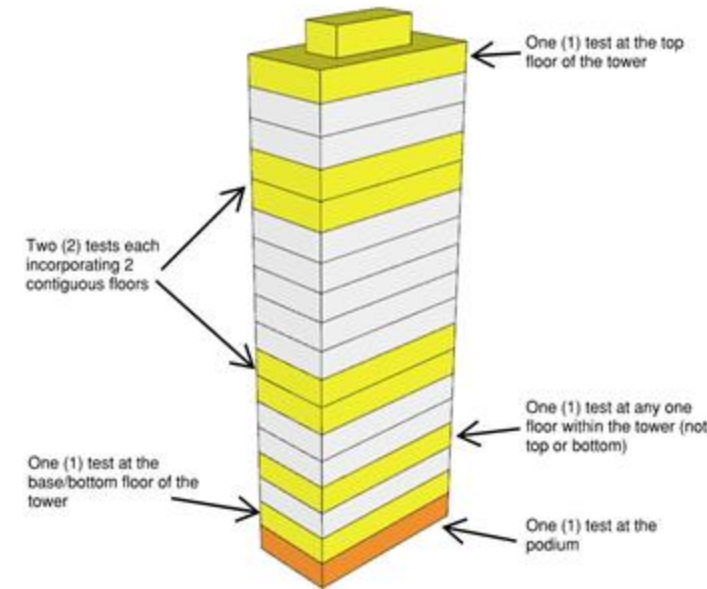


Guarded Test: maintain adjacent spaces at test pressure



REFERENCES IN STANDARDS

- **Toronto Green Standard** - allowed **if whole building is not feasible**. Sampling protocol.
- **ASTM E-3158** - test single zone condition ... As long as the pressure differential between area A and area B is **less than 10 %** of the induced test pressures.
- **USACE Test Protocol** - internal pressure **uniformity** requirement of no two locations differing more than **10% of the induced envelope pressure**.
- **CAN/CGSB-149.10-2019** - Use the test fan systems to ensure the pressure difference between the adjacent zones and the tested zone is as close to zero as possible, within **3 Pa...**



ASTM E3158 - 18

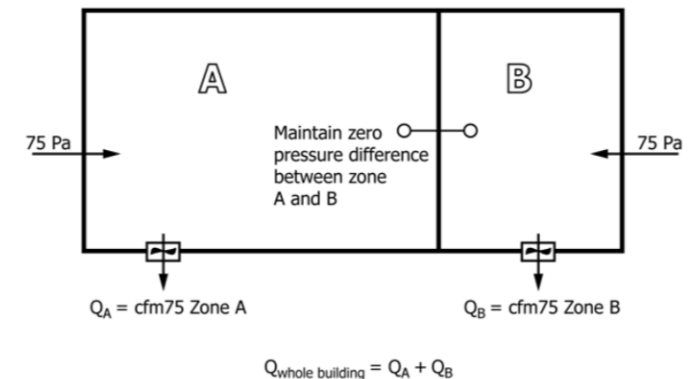
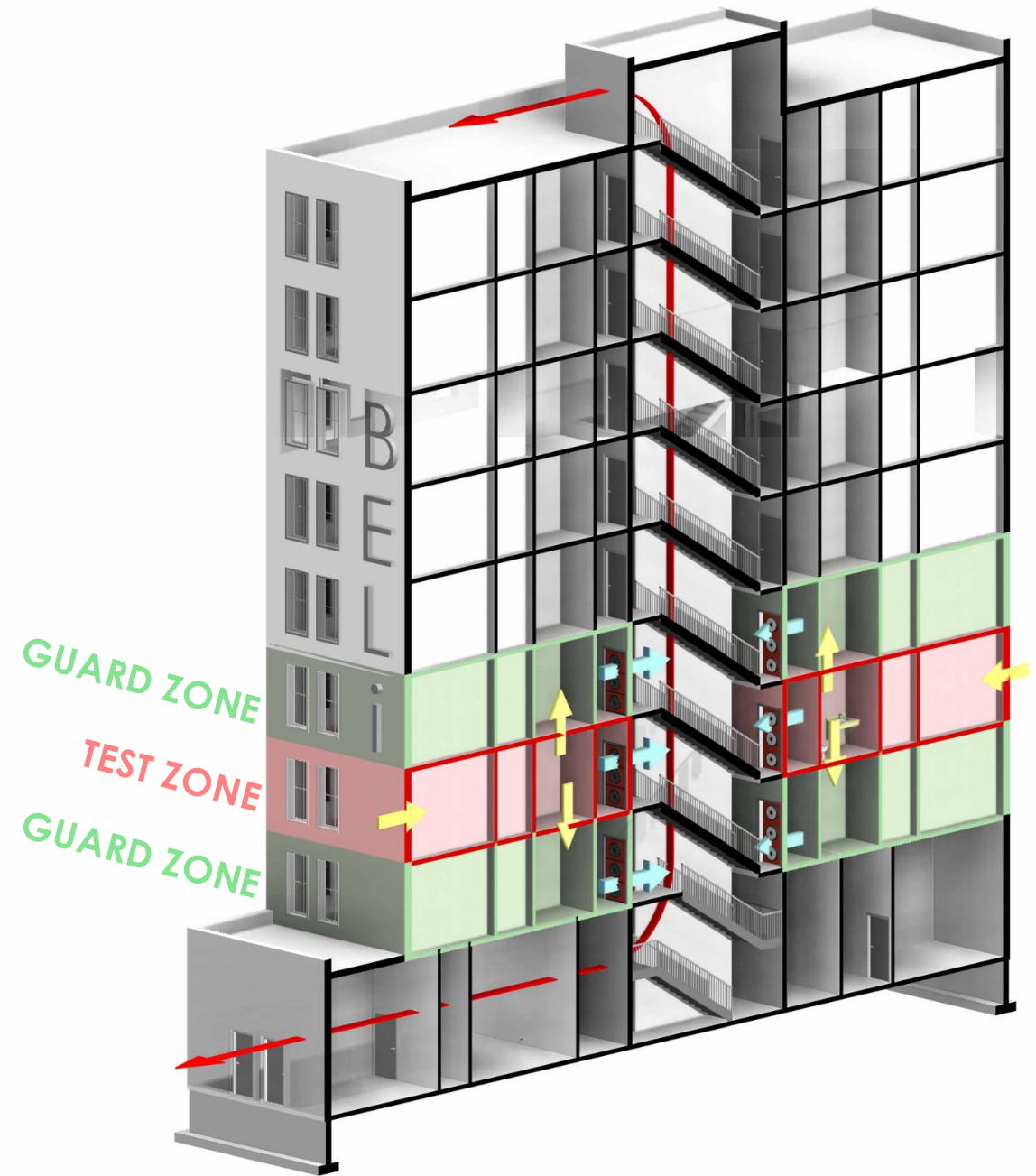


FIG. X1.1 Creating Single Zone Condition from Multiple Zones

LIMITATIONS

1. Guard Error: Slight pressure difference between guard zone and test zone can skew results.



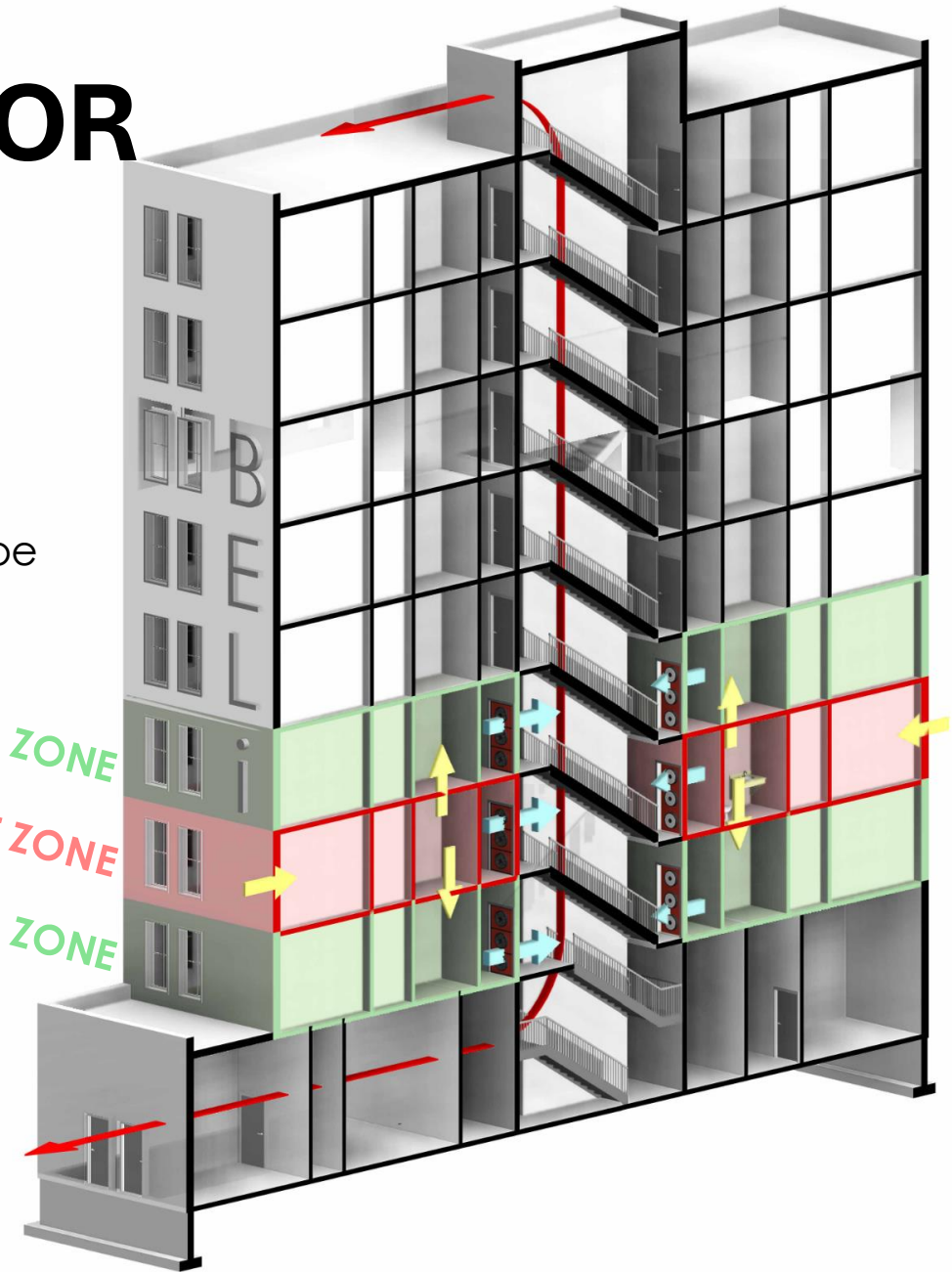
ESTIMATING GUARD ERROR

$$Q_{\text{measured}} = Q_{\text{envelope}} + Q_{\text{guard}}$$

$$Q_{\text{envelope}} = \text{NLR}_{\text{envelope}} \times A_{\text{envelope}} \times \Delta p_{\text{envelope}}$$

$$Q_{\text{guard}} = \text{ELA} \text{ Cd } (2\Delta P_{\text{guard}} / \text{density})^{0.5}$$

$$\% \text{Error} = |Q_{\text{guard}}| / Q_{\text{actual}}$$

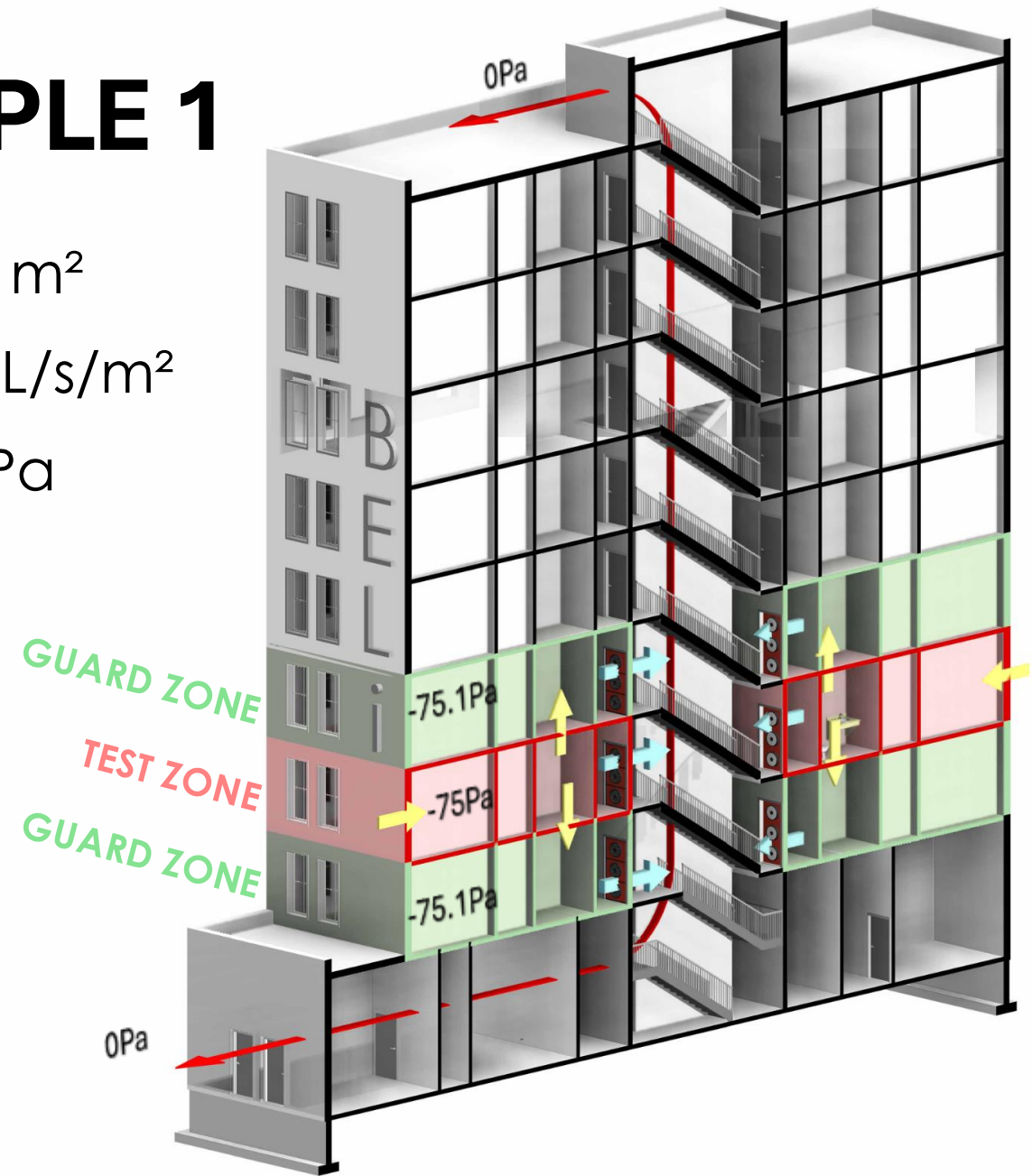


GUARD ERROR EXAMPLE 1

$$\text{Wall}_{\text{area}} = 180 \text{ m}^2 \quad | \quad \text{Floor}_{\text{area}} = 540 \text{ m}^2$$

$$\text{NLR}_{\text{envelope}} = 1 \text{ L/s/m}^2 \quad | \quad \text{NLR}_{\text{guard}} = 2 \text{ L/s/m}^2$$

$$\Delta p_{\text{envelope}} = -75 \text{ Pa} \quad | \quad \Delta p_{\text{guard}} = -0.1 \text{ Pa}$$



GUARD ERROR EXAMPLE 1

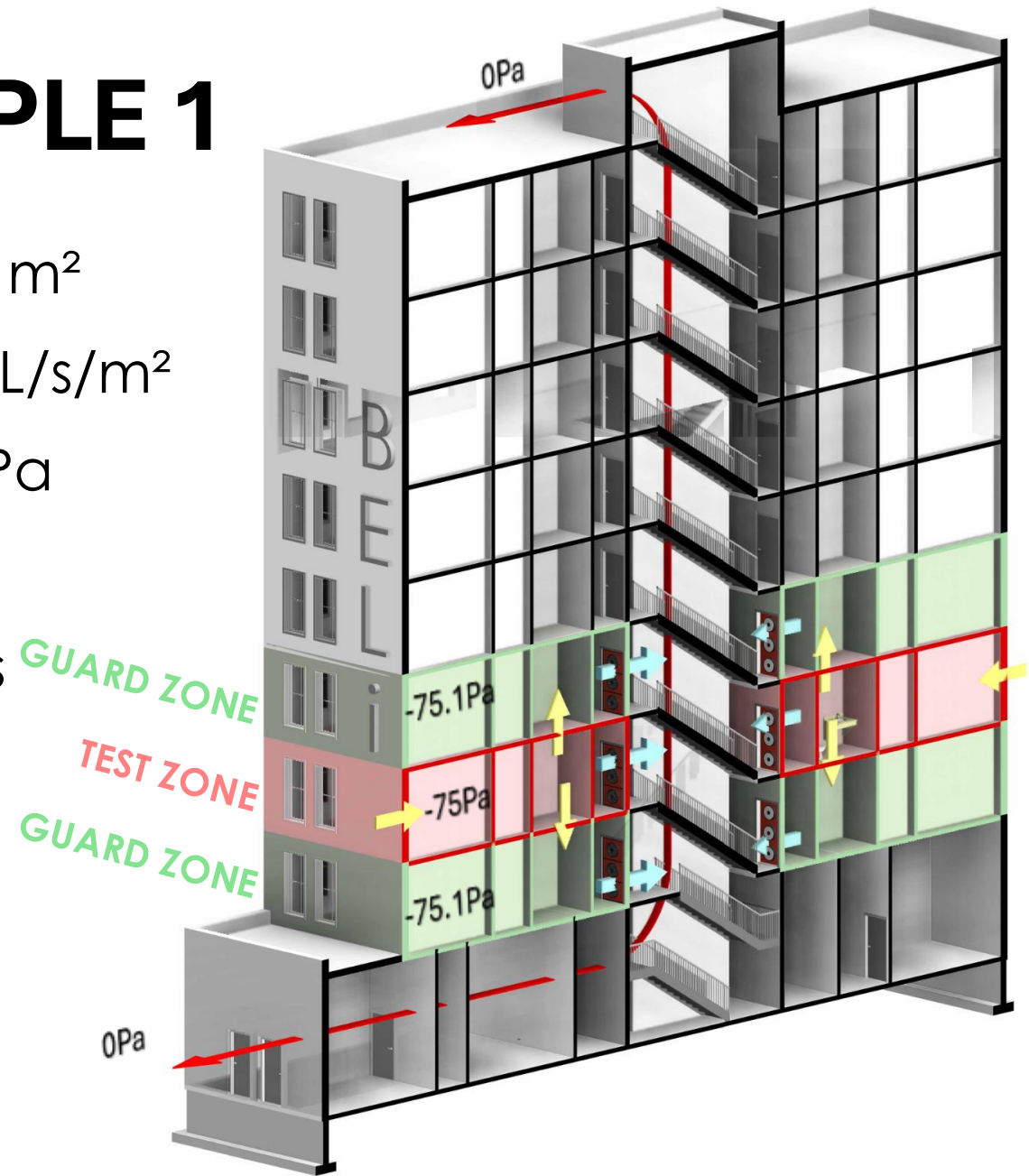
$$\text{Wall}_{\text{area}} = 180 \text{ m}^2 \quad | \quad \text{Floor}_{\text{area}} = 540 \text{ m}^2$$

$$\text{NLR}_{\text{envelope}} = 1 \text{ L/s/m}^2 \quad | \quad \text{NLR}_{\text{guard}} = 2 \text{ L/s/m}^2$$

$$\Delta p_{\text{envelope}} = -75 \text{ Pa} \quad | \quad \Delta p_{\text{guard}} = -0.1 \text{ Pa}$$

$$Q_{\text{envelope}} = 180 \text{ L/s} \quad | \quad Q_{\text{guard}} = -39 \text{ L/s}$$

$$Q_{\text{measured}} = 141 \text{ L/s}$$



GUARD ERROR EXAMPLE 1

$$\text{Wall}_{\text{area}} = 180 \text{ m}^2 \quad | \quad \text{Floor}_{\text{area}} = 540 \text{ m}^2$$

$$\text{NLR}_{\text{envelope}} = 1 \text{ L/s/m}^2 \quad | \quad \text{NLR}_{\text{guard}} = 2 \text{ L/s/m}^2$$

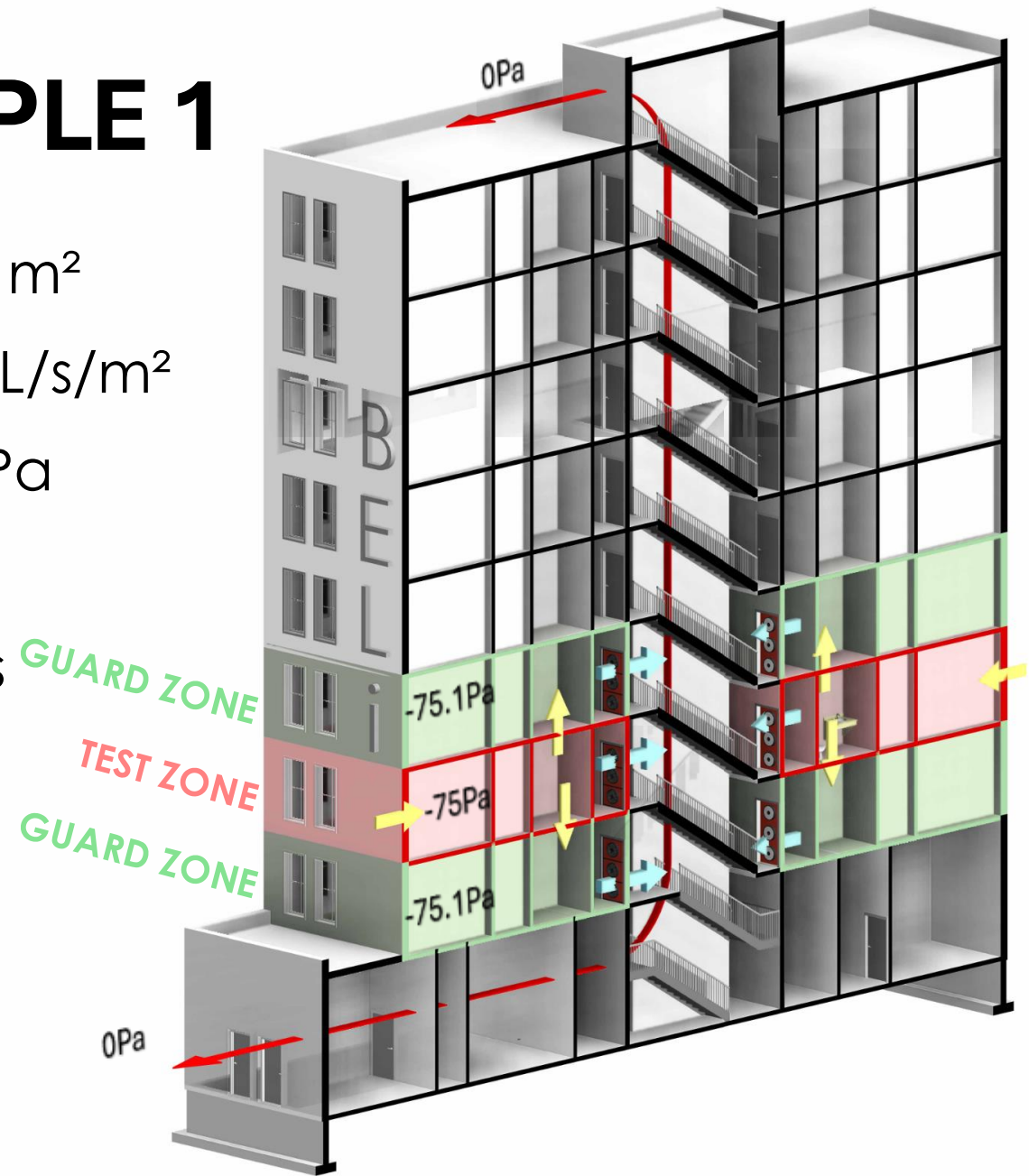
$$\Delta p_{\text{envelope}} = -75 \text{ Pa} \quad | \quad \Delta p_{\text{guard}} = -0.1 \text{ Pa}$$

$$Q_{\text{envelope}} = 180 \text{ L/s} \quad | \quad Q_{\text{guard}} = -39 \text{ L/s}$$

$$Q_{\text{measured}} = 141 \text{ L/s}$$

$$\text{NLR}_{\text{measured}} = 0.78 \text{ L/s/m}^2$$

Error = 22 % low **CHEATING?**



GUARD ERROR EXAMPLE 2

$$\text{Floor}_{\text{area}} = 540 \text{ m}^2 \quad | \quad \text{Wall}_{\text{area}} = 180 \text{ m}^2$$

$$\text{NLR}_{\text{envelope}} = 1 \text{ L/s/m}^2 \quad | \quad \text{NLR}_{\text{guard}} = 2 \text{ L/s/m}^2$$

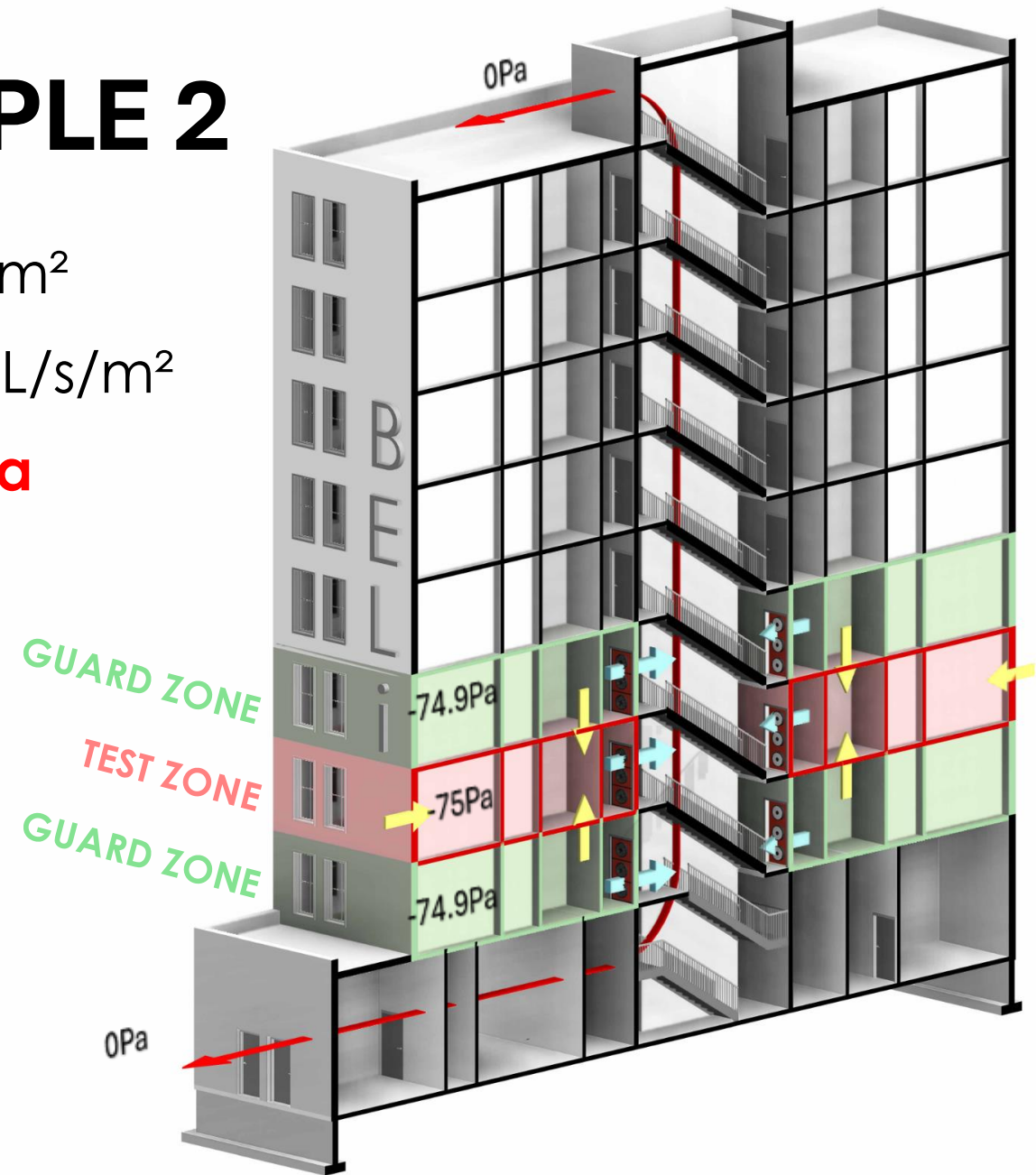
$$\Delta p_{\text{envelope}} = -75 \text{ Pa} \quad | \quad \Delta p_{\text{guard}} = 0.1 \text{ Pa}$$

$$Q_{\text{envelope}} = 180 \text{ L/s} \quad | \quad Q_{\text{guard}} = 39 \text{ L/s}$$

$$Q_{\text{measured}} = 219 \text{ L/s}$$

$$\text{NLR}_{\text{measured}} = 1.22 \text{ L/s/m}^2$$

Error = 22 % high **PROBLEM?**



GUARD ERROR EXAMPLE 2

$$\text{Floor}_{\text{area}} = 540 \text{ m}^2 \mid \text{Wall}_{\text{area}} = 180 \text{ m}^2$$

$$\text{NLR}_{\text{envelope}} = 1 \text{ L/s/m}^2 \mid \text{NLR}_{\text{guard}} = 1 \text{ L/s/m}^2$$

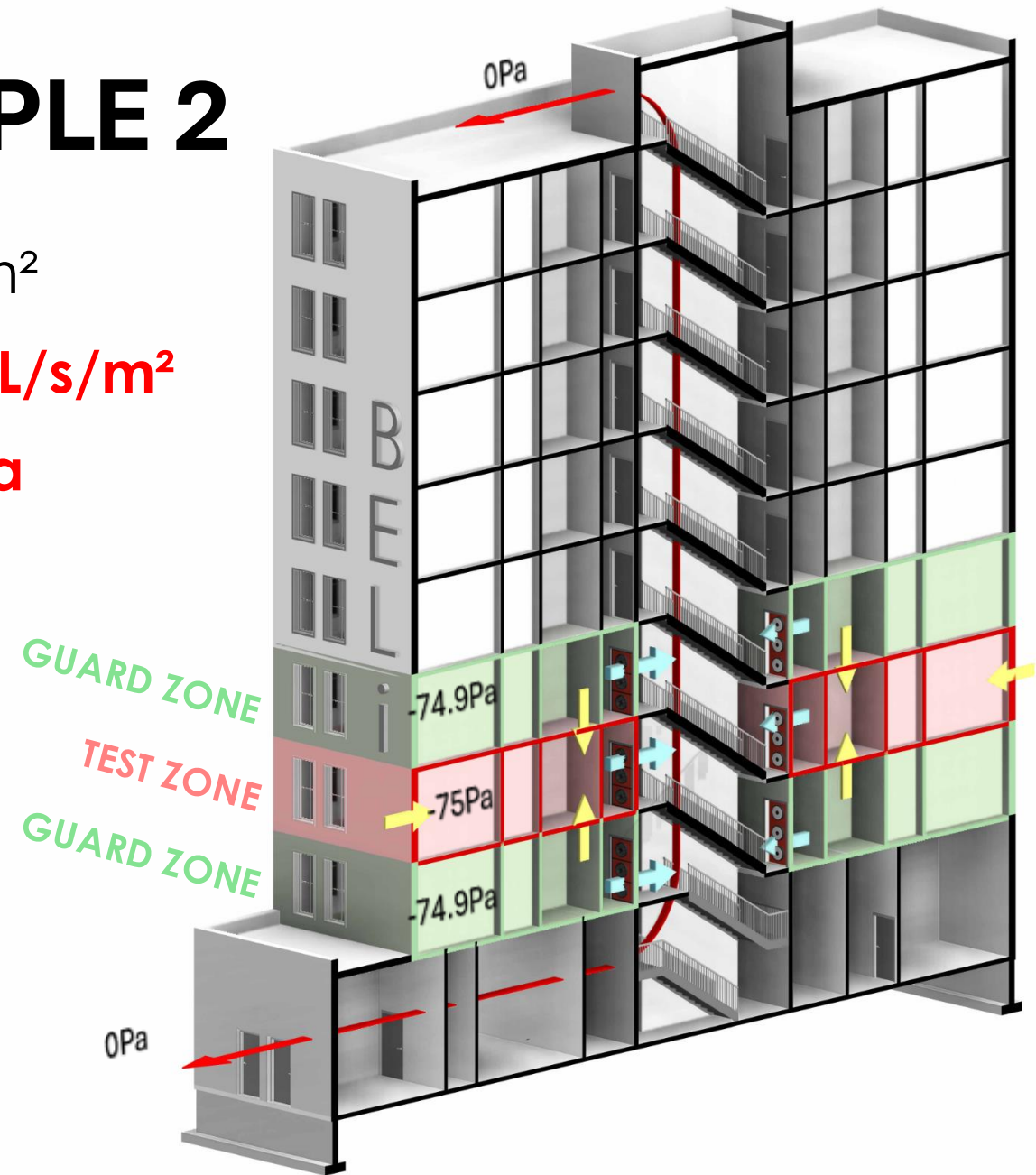
$$\Delta p_{\text{envelope}} = -75 \text{ Pa} \mid \Delta p_{\text{guard}} = 0.1 \text{ Pa}$$

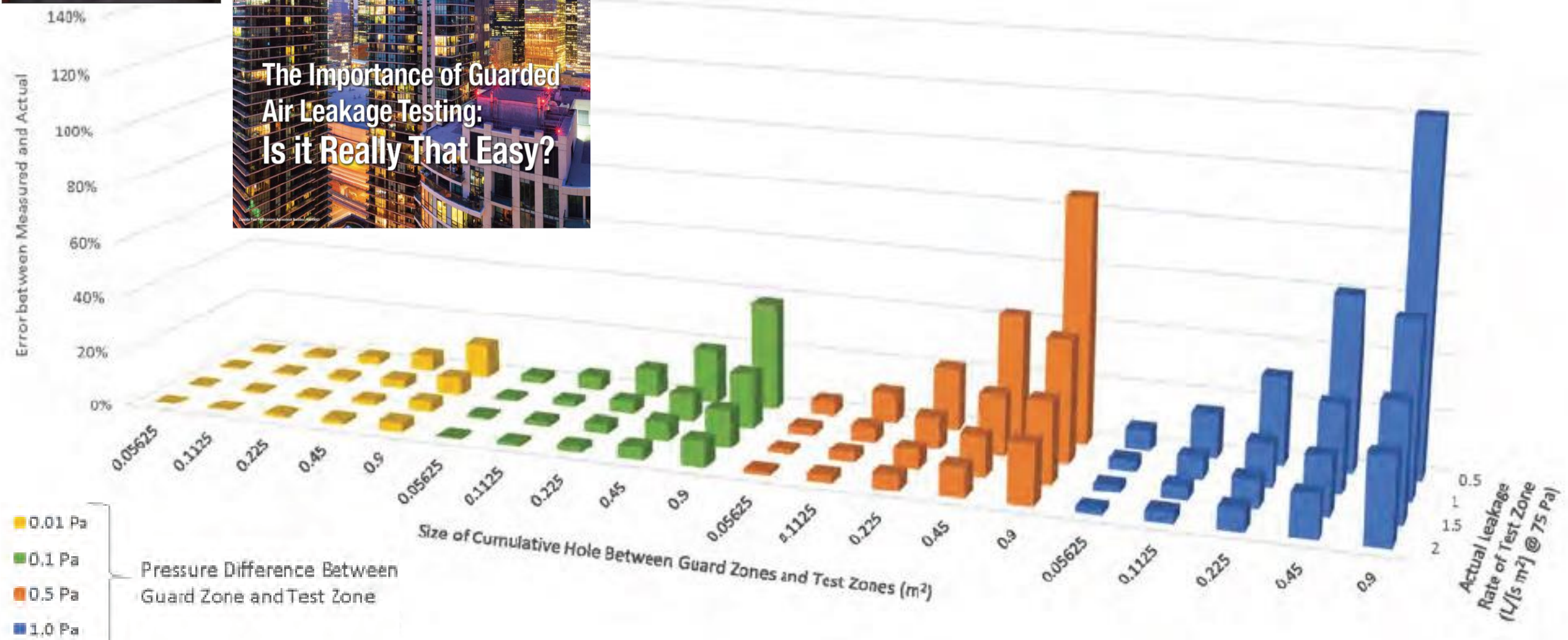
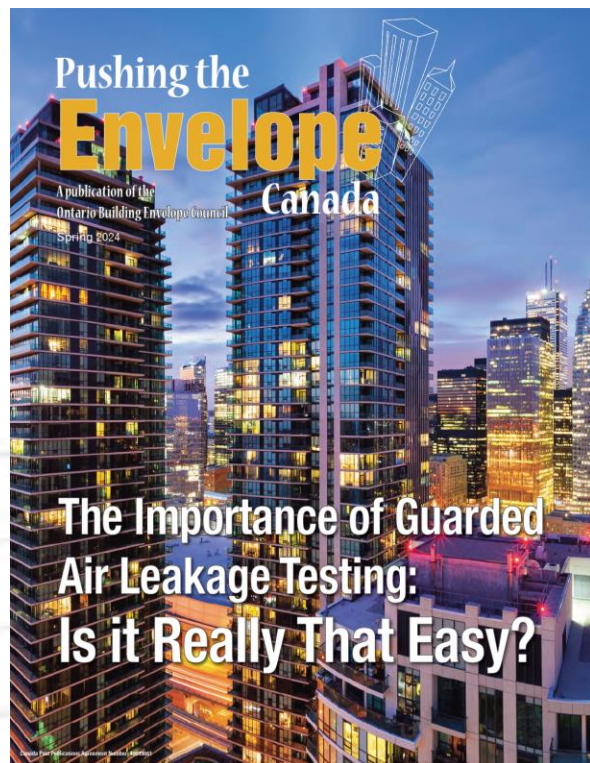
$$Q_{\text{envelope}} = 180 \text{ L/s} \mid Q_{\text{guard}} = 20 \text{ L/s}$$

$$Q_{\text{measured}} = 200 \text{ L/s}$$

$$\text{NLR}_{\text{measured}} = 1.11 \text{ L/s/m}^2$$

$$\text{Error} = 11 \% \text{ high } \text{BETTER}$$







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Air Leakage Testing of High Rise Buildings: Limitations and Alternate Approaches

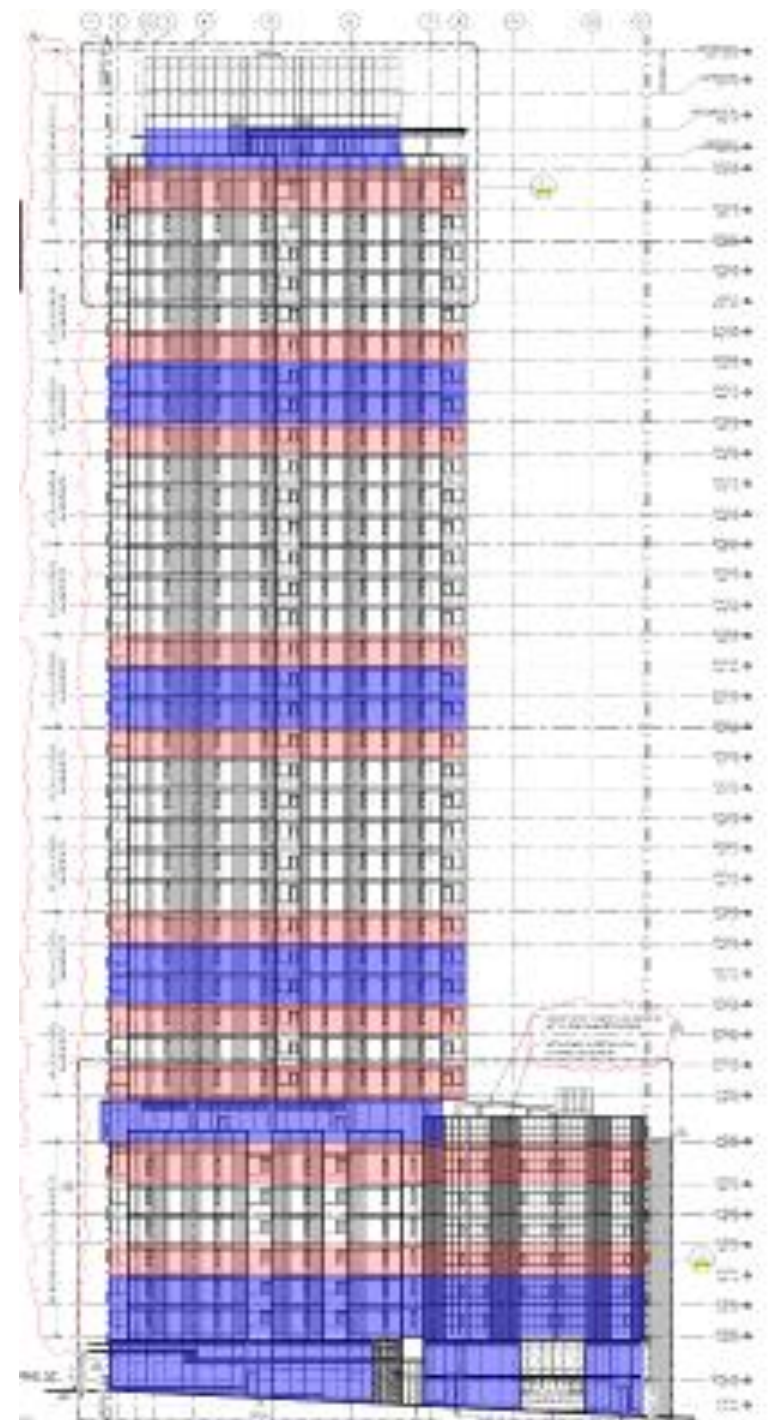
Denali Jones

RDH Building Science



Test Zone	Description	Date Tested	Envelope Area
A	Level 1	1/29/2018	26,696
B	Levels 2-3	10/28/2017	37,066
C	Level 8	12/16/2017	11,350
D	Level 12-13	12/2/2017	14,585
E	Level 21-22	12/2/2017	14,585
F	Level 31-32	12/16/2017	14,585
G	Level 39	1/27/2018	13,232

Test Condition	Zone A cfm/ft ²	Zone B cfm/ft ²	Zone C cfm/ft ²	Zone D cfm/ft ²	Zone E cfm/ft ²	Zone F cfm/ft ²	Zone G cfm/ft ²
Depressurize:	0.161	0.170	0.271	0.177	0.184	0.132	0.228
Pressurize:	0.167	0.233	0.304	0.259	0.182	0.127	0.254
Average:	0.164	0.202	0.288	0.218	0.183	0.129	0.241

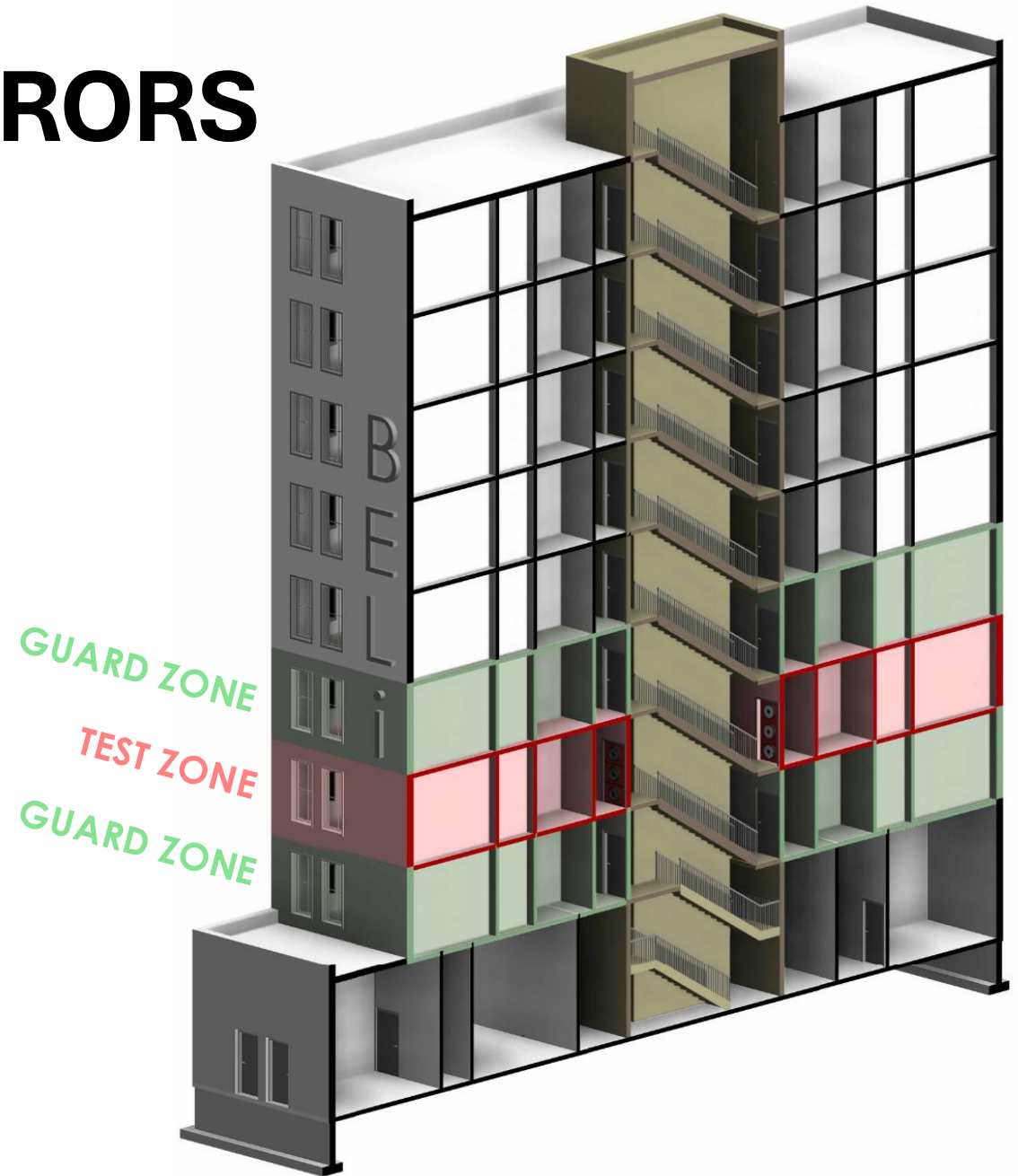


FUTURE STUDY OF ERRORS

2. Uneven Guard Pressures
3. $P_{\text{Zone By Pass}}$ not at Neutral Pressure
4. Leakage Thru Zone By Pass
5. Different $P_{\text{Zone By Pass}}$ Pressures
6. Floor Sampling Limitations
7. Envelope area when bypass zones have exterior walls

MORE ERRORS

EMAIL TO RANDY@BELI-ENG.COM?



TAKE AWAYS

Avoid guarded testing Talk clients into whole building air testing and uses zone or guarded tests as last resort

If you have to do a **guarded test**

- **Be conservative** - make sure the guard is at a lesser magnitude pressure than the test
- **Minimize error** - Seal between the guarded and test zones as best as possible
- **Minimize error** – Test multiple floors at a time to maximize envelope area captured in test
- **Avoid guarding testing** - If you seal between the guarded and test zones really well than you don't have to try guarding