Washington State Energy Code HVAC Requirements

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Energy Code Support

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  - www.energy.wsu.edu/code
  - Gary Nordeen, Luke Howard, Emily Salzberg, Tanya Beavers
- Non-residential
  - Northwest Energy Efficiency Council
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Purpose of this class

- Introduction to duct sealing & testing requirements for the 2009 WSEC.
- Basic understanding of the purpose of duct sealing & testing.
- Discussion of benefits of moving ducts to the inside.

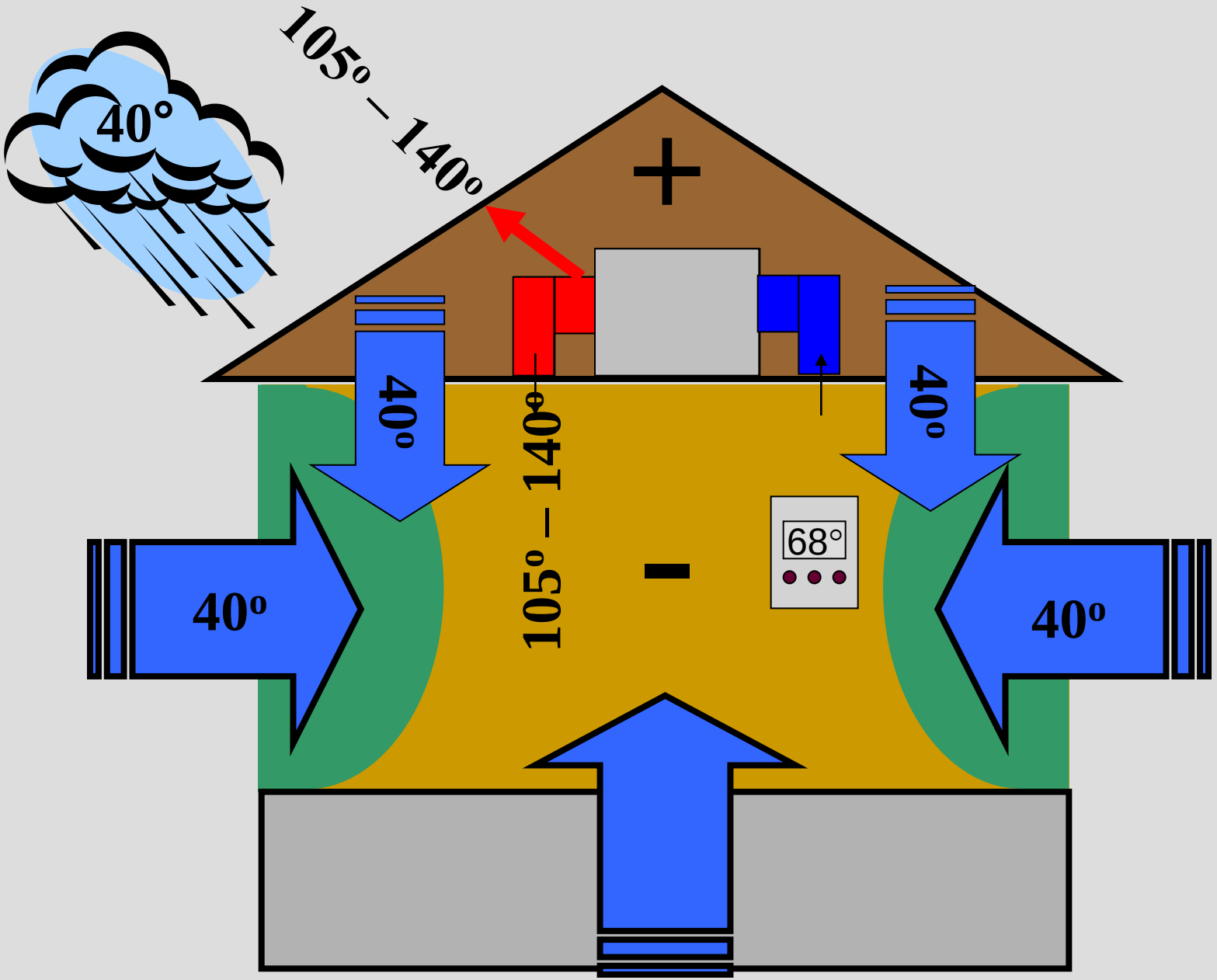
Note: this class does not provide qualification for ENERGY STAR, PTCS, tax credits or other beyond code programs.

Why Do We Seal Ducts?

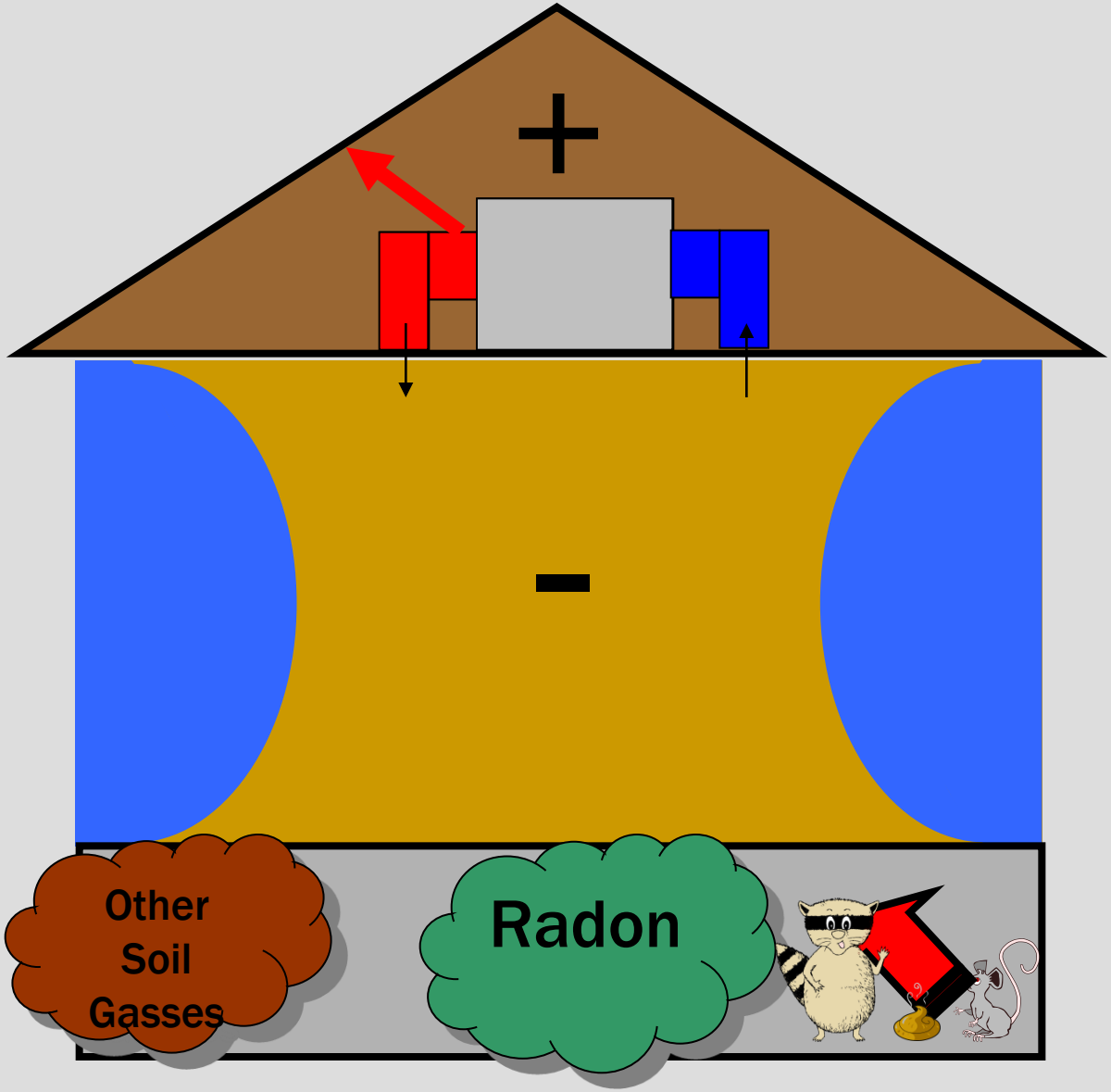
- Health & Safety
- Comfort
- Energy Savings
- More Durable Buildings

Implications of leaky ducts

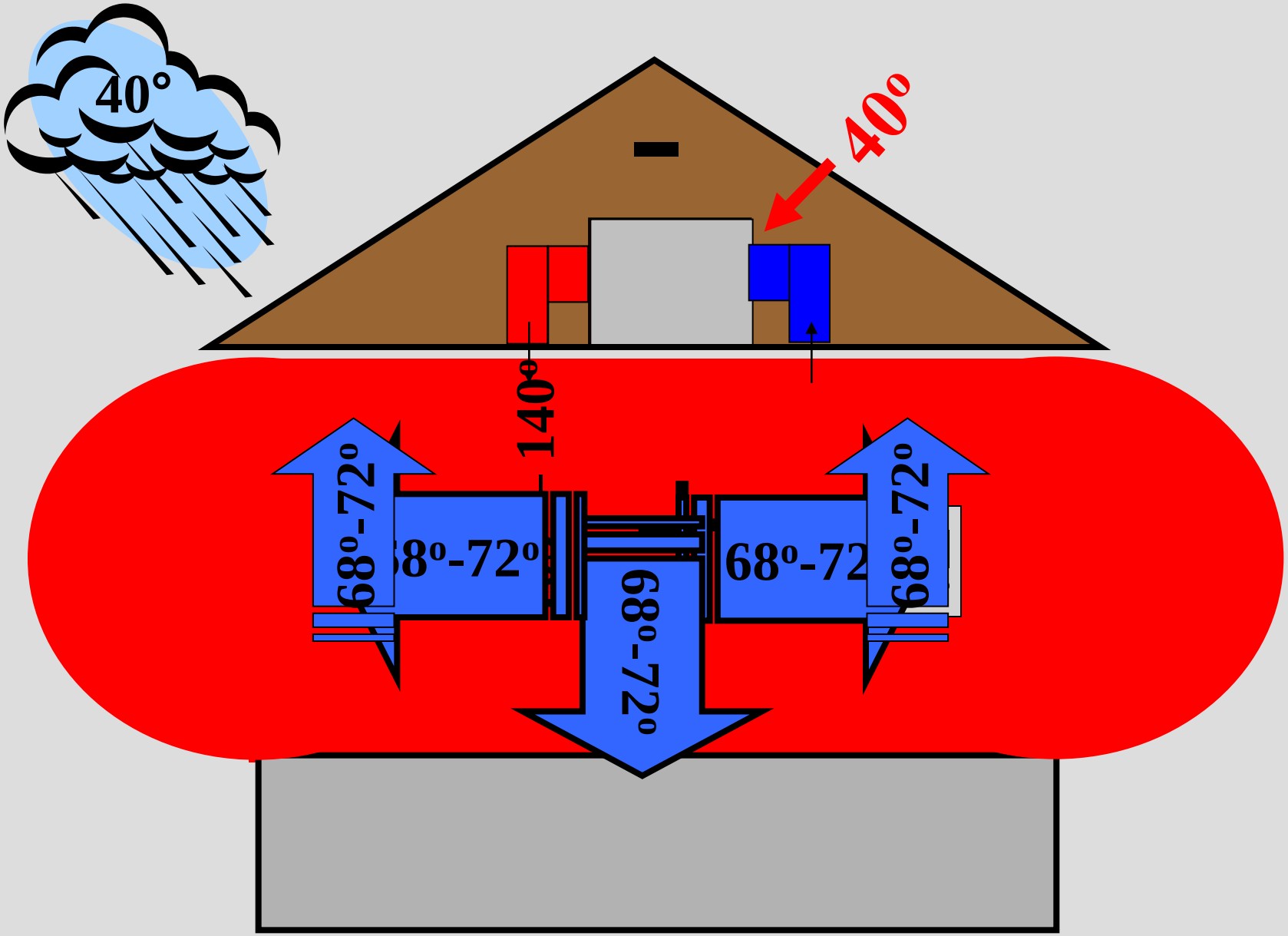
- Leaky ducts typically raise heating and cooling costs **20% - 40%**
- This figure may **double** if the ducts are not insulated
- A conservative estimate is ducts waste over $10 billion in energy in SFR’s alone



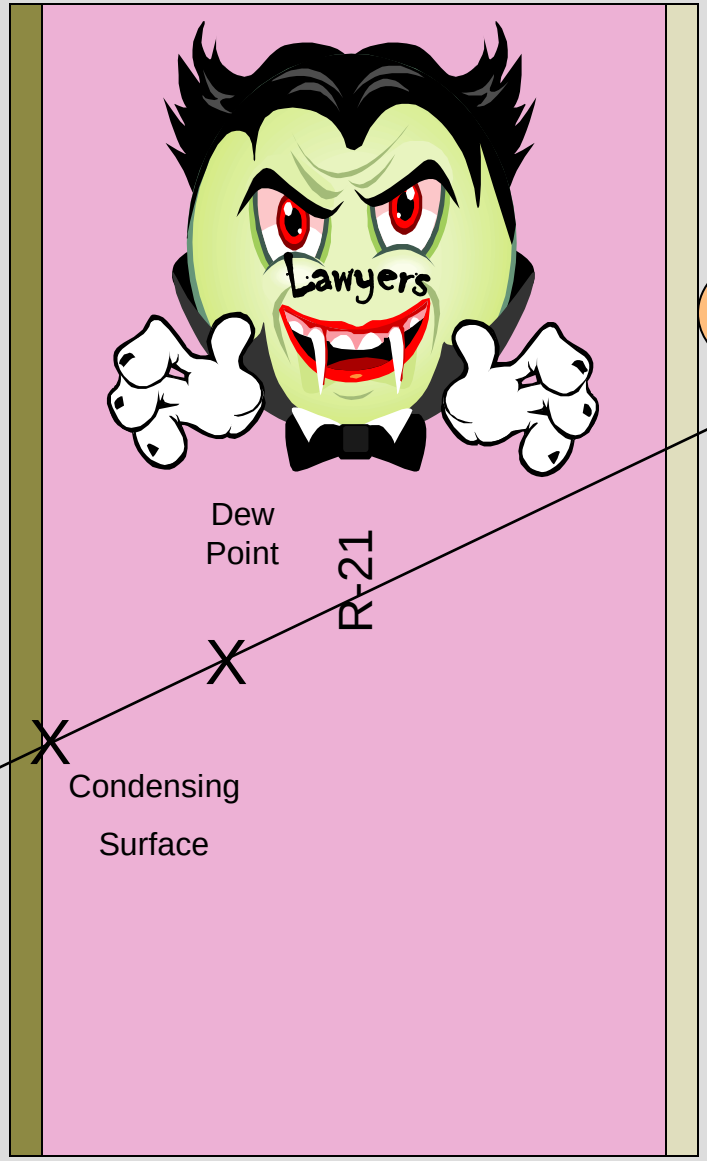
Duct System Supply Leakage



Where is the air coming from?



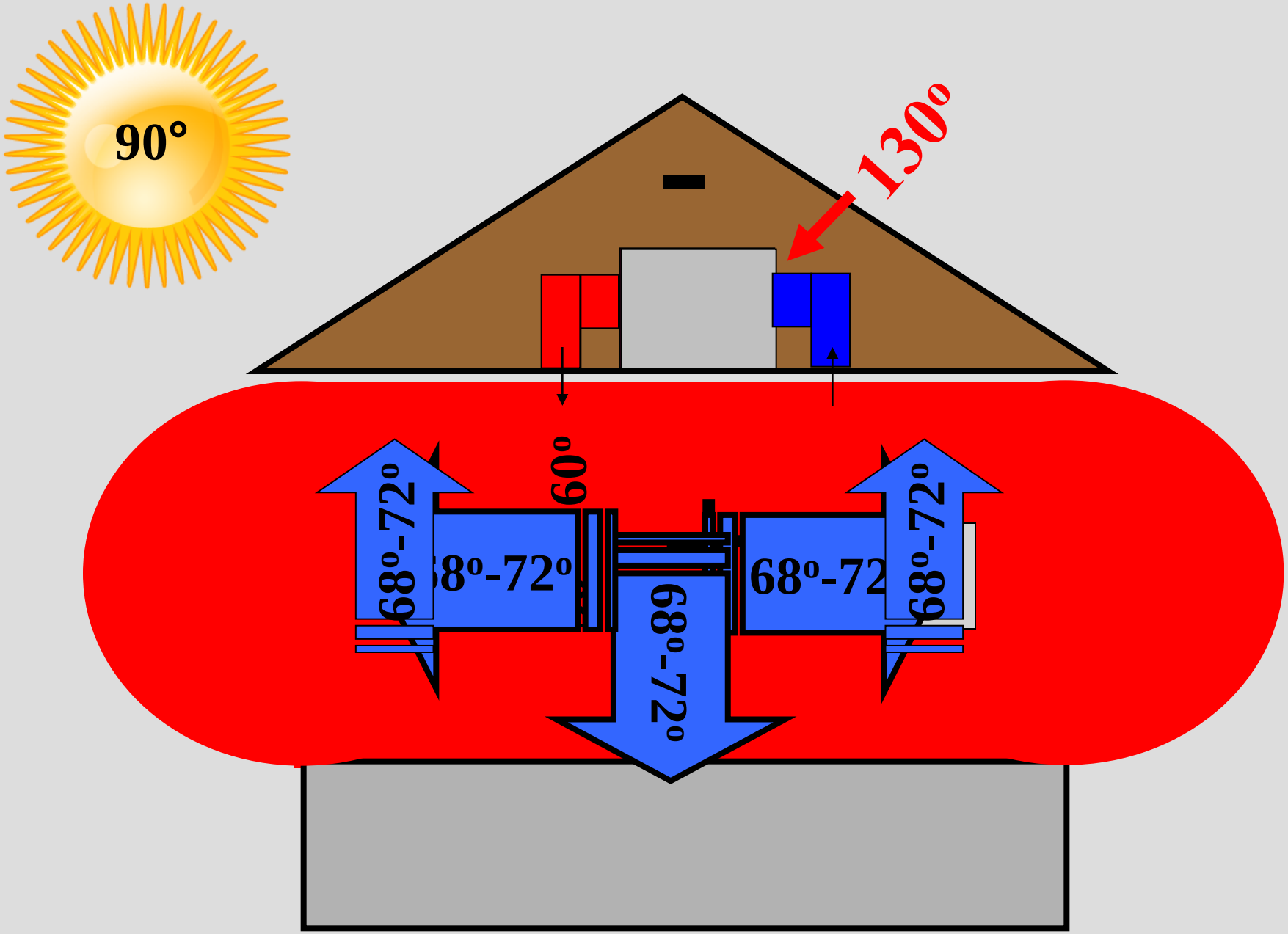
Duct System Return Leakage in Heating Season



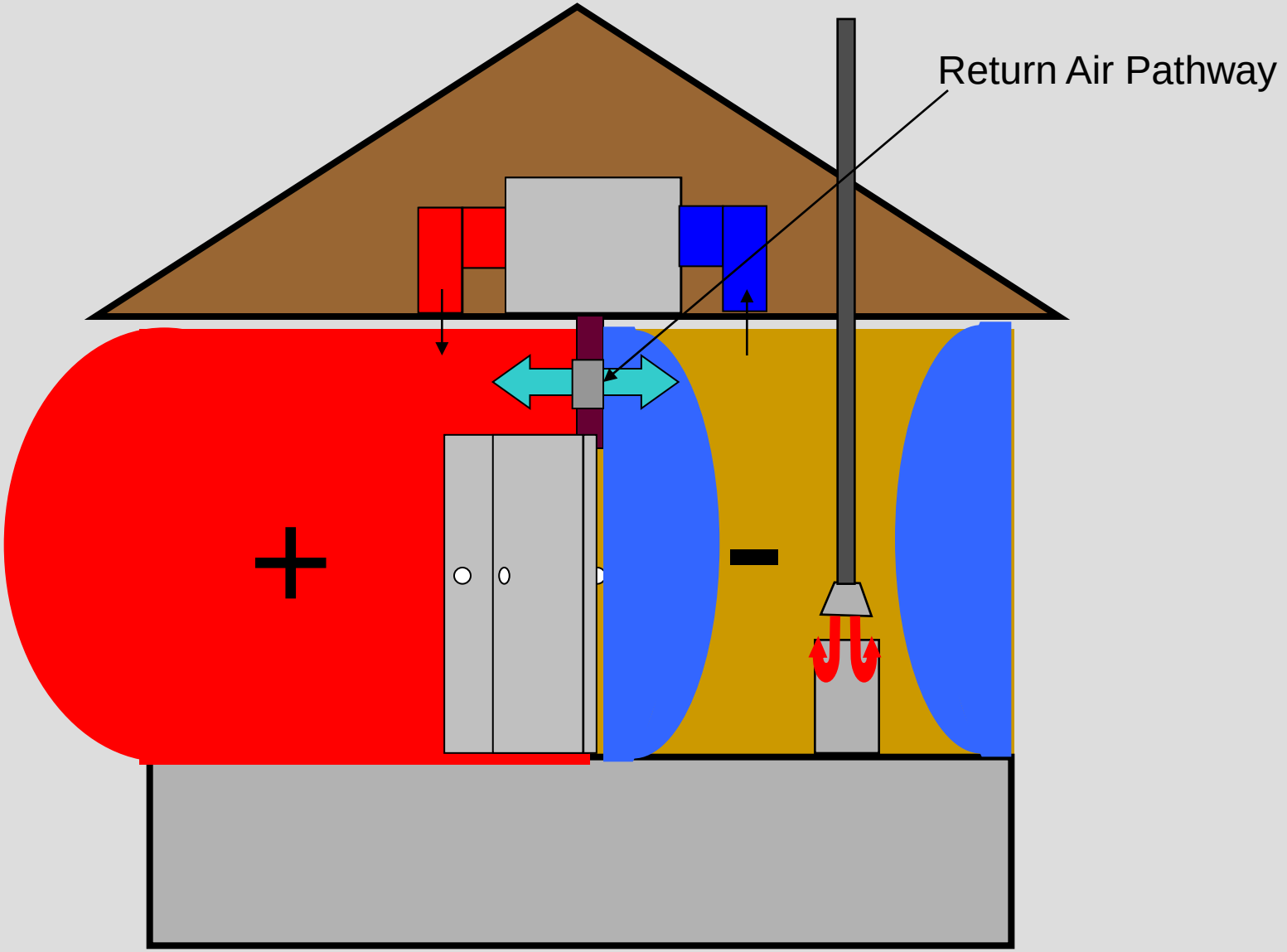
Warm,
moist air

Outside – 30^0

Inside – 70^0



Duct System Return Leakage in Cooling Season



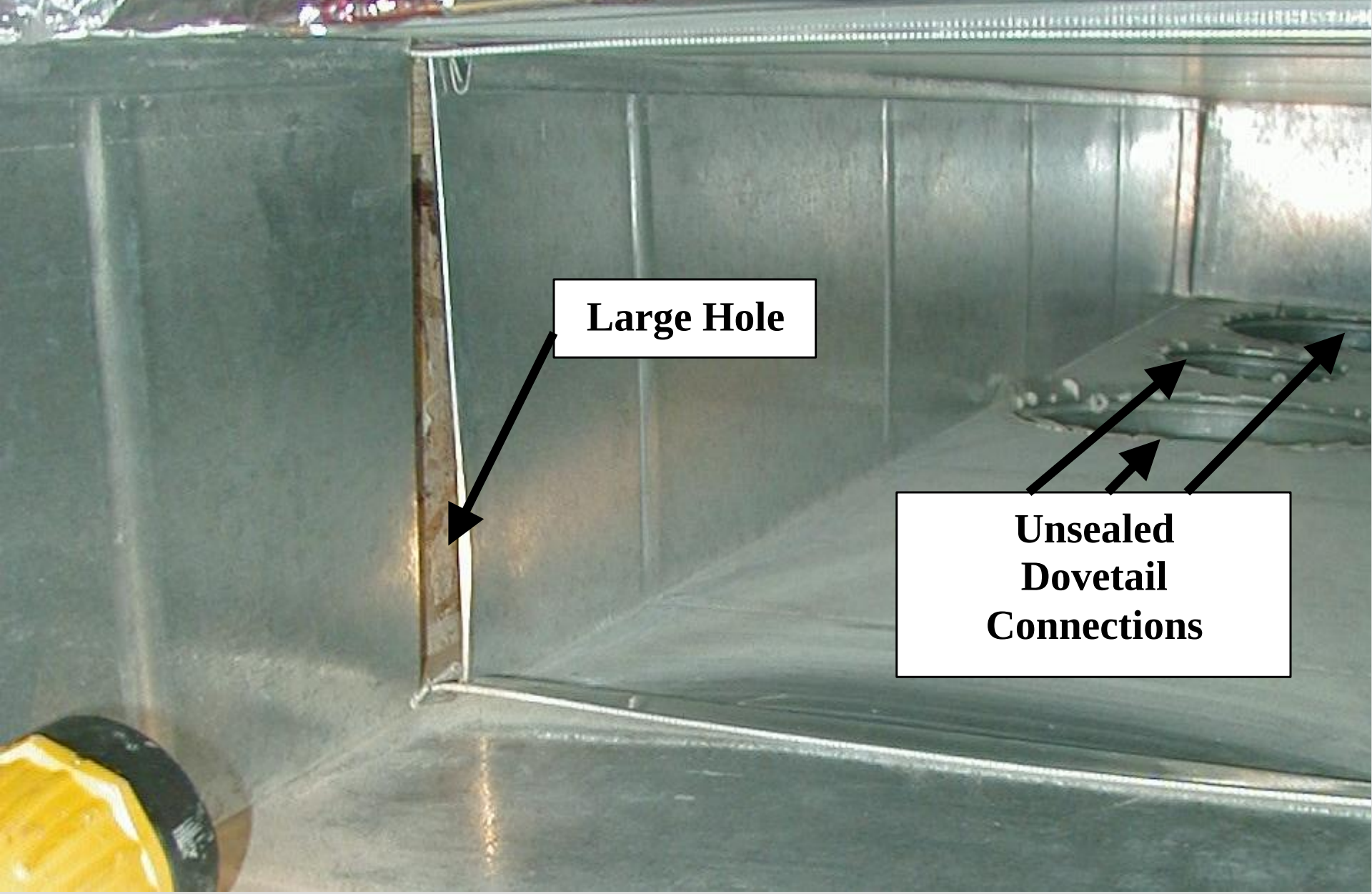
Unbalanced System Balanced System

Leakage & Energy Loss

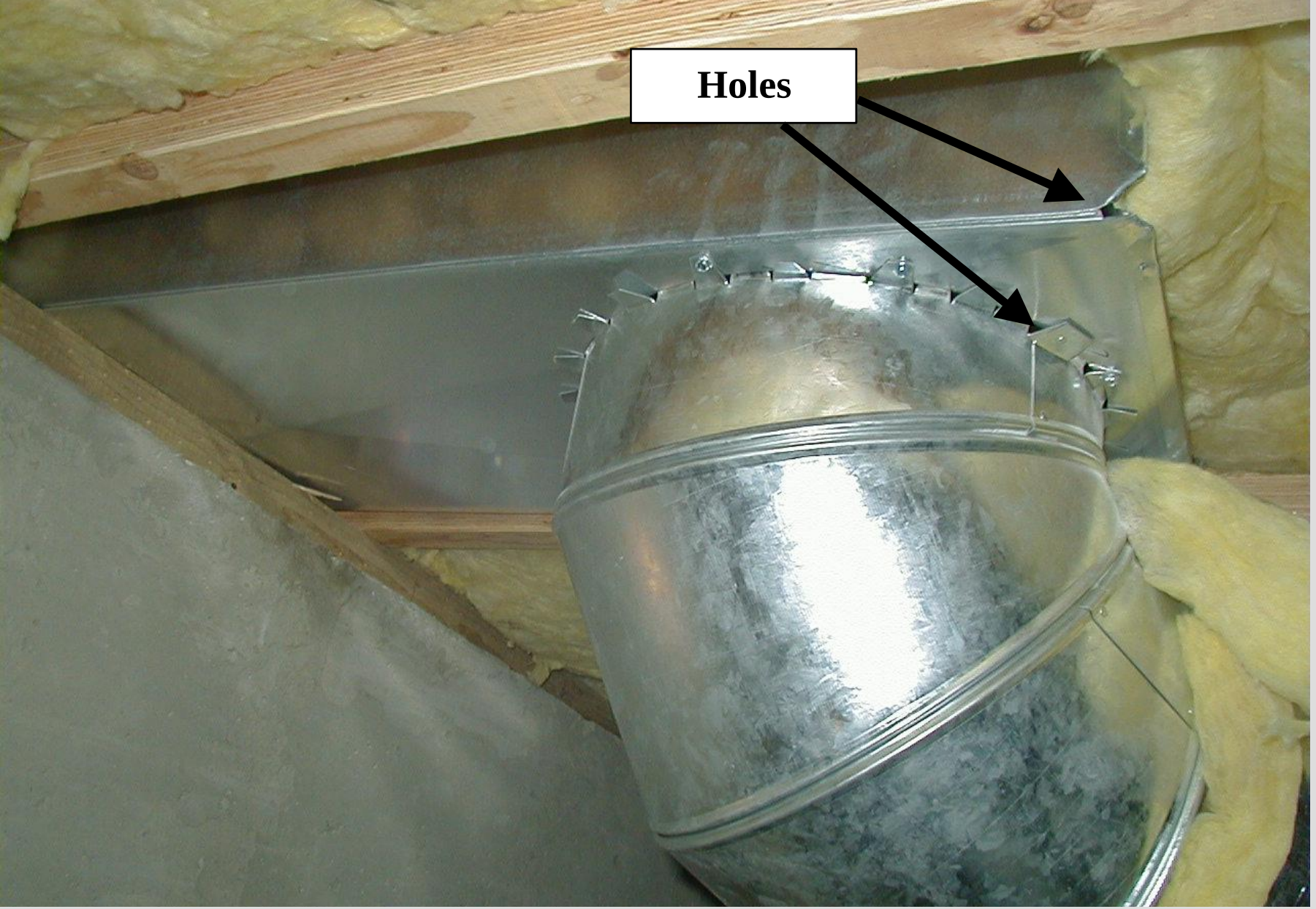
- The hole needs to be connected to the outside
- Heat loss is proportional to temperature and pressure differences
- Holes that see high pressures and high temperature differences are most important for energy savings
  - **Heating Climates** this is the supply side near the air handler
  - **Cooling climates** this is the return side near the air handler

System Deficiencies

Hole at Dovetail Connection


Large Hole
Unsealed
Dovetail
Connections


Large hole where down drafting furnace connects to supply plenum


Holes

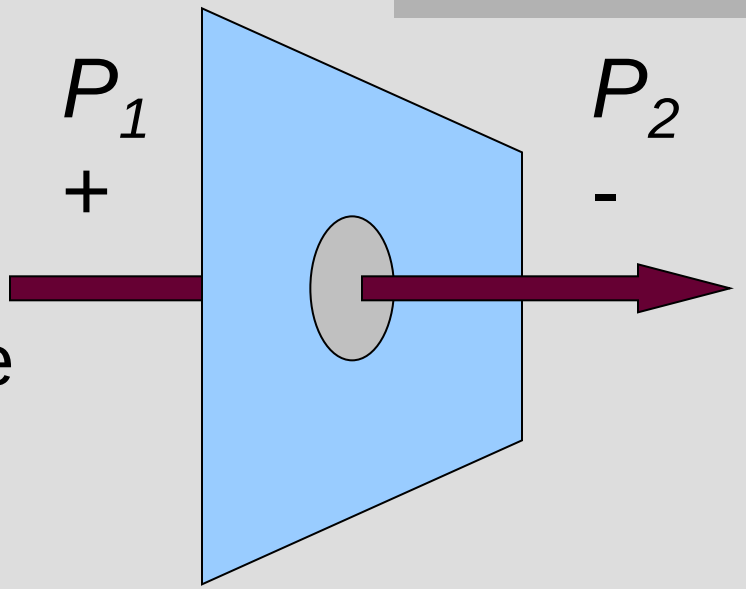
Terminology

- **CFM**: Cubic Feet per Minute
- **Pa**: Pascals
- **Conditioned Floor Area (CFA)**: Square footage of all heated areas
- **Manometer**: Digital pressure reading device
- **Duct Tester**: Equipment used to pressurize ducts
- **Blower Door**: Equipment used to pressurize (or depressurize) a structure

Airflow Basics

- Airflow Requires
  - ***Driving force***

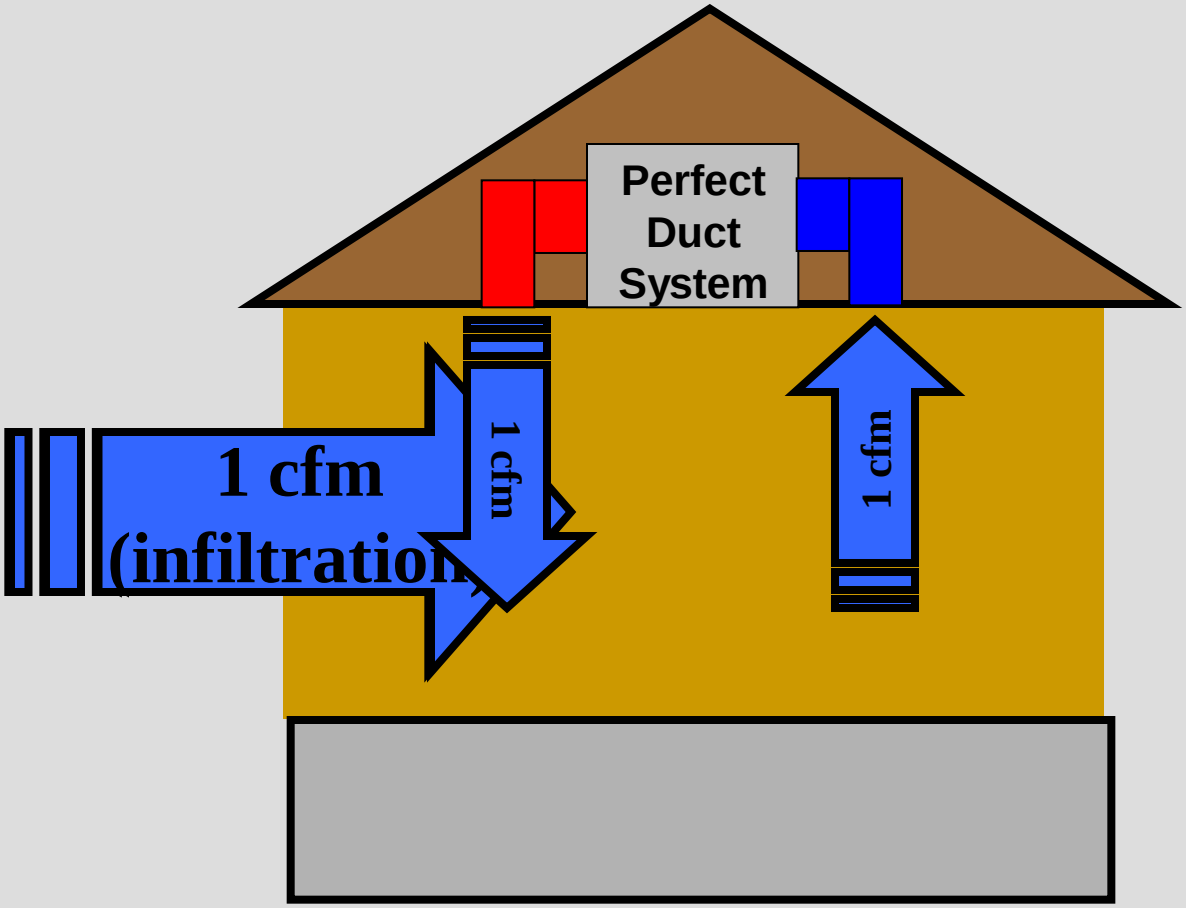
    (pressure or temperature difference)
  - ***A hole***
- Air moves from High to Low pressure areas



$$P_1 - P_2 = \Delta P$$

Airflow ≈ Hole size x ΔP

Air in = Air out

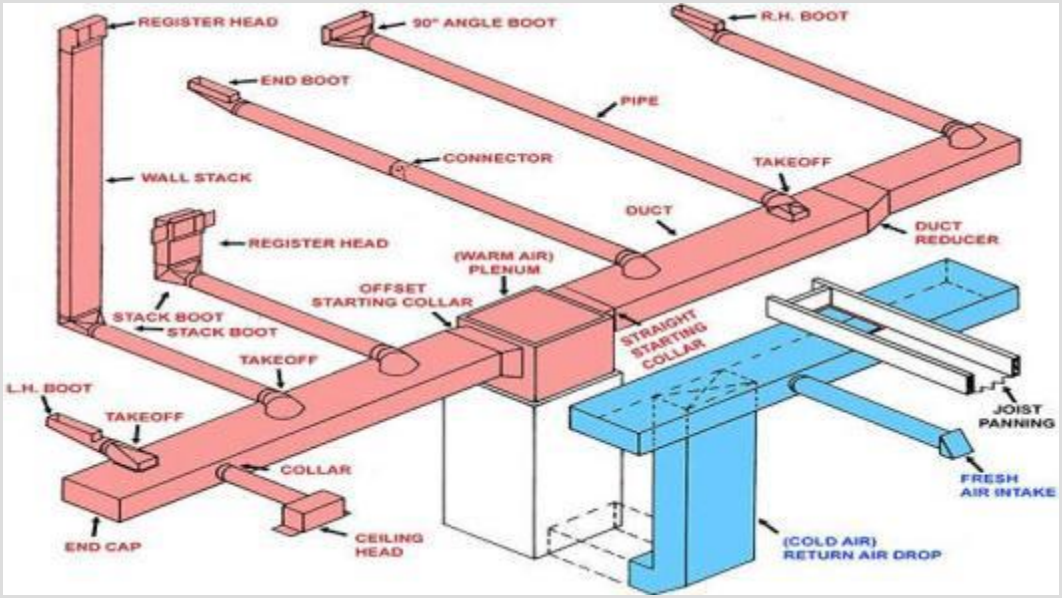


What does the code require?

- Air sealing of all joints & seams on all ducts, air handlers, and filter boxes (See IMC 603.9 or IRC M1601.4).

- Duct testing performed & permanently documented.
  - Signed affidavit (duct tester's responsibility)
  - Test results must be recorded on certificate for new construction (builder's responsibility)

Duct Testing Details



What a duct tester tells us

- *Airflow in = airflow out, so flow through fan = flow through leaks in system.*

- *CFM_{25} is an aggregation of all of the holes throughout the entire duct system – that's all!*
  - *It doesn't tell us where to find the holes*
  - *It doesn't tell us how much the ducts leak under normal operating conditions.*
  - *Without a blower door, it doesn't tell us how much of the holes are connected to the outside.*

Two Duct Test Options:

- ***Total duct leakage*** measures leakage to *both indoors & outdoors*
- ***Duct leakage to the outdoors*** measures *effective duct leakage to the outside*
- Combines a blower door with the duct blower

Both tests provide Cubic Feet per Minute (CFM) duct leakage numbers

Duct Testing Standards:

At Rough-In

- **Total leakage ≤ 6 cfm per 100 sf**

  of conditioned floor area @ 25 Pa for a complete system

- **Total leakage ≤ 4 cfm per 100 sf**

  of conditioned floor area @ 25 Pa if air handler *has not been* installed

Duct Testing *Standards:*

Post Construction

- ***Total leakage test: ≤ 8 cfm per 100 sf***
  of conditioned floor area @ 25 Pa

- ***Leakage to exterior test: ≤ 6 cfm per 100 sf***
  of conditioned floor area @ 25 Pa

Examples:

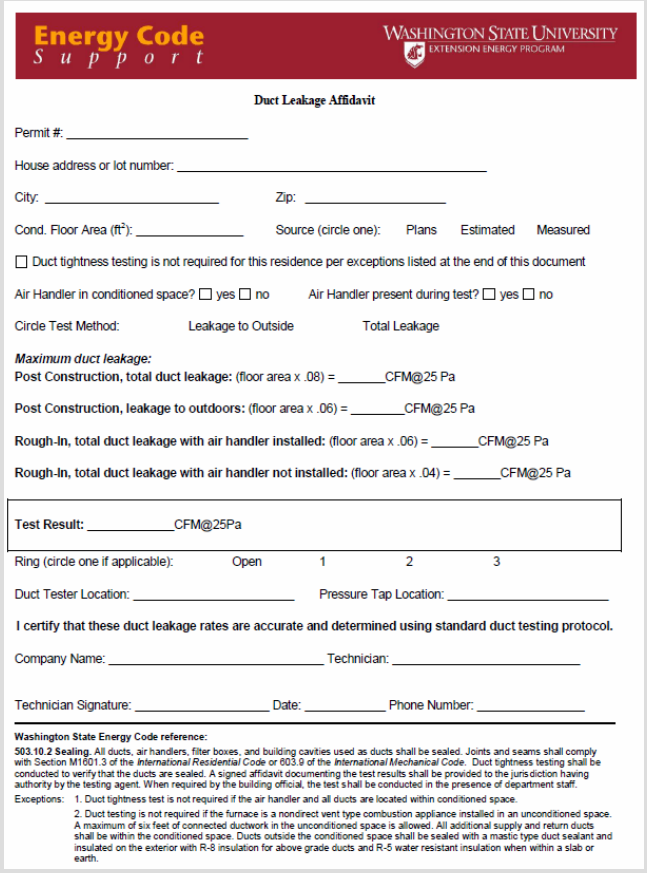
Total leakage

- House size: 2240 Ft^2
- 2240 X **.08** = ***179 CFM*** maximum

Leakage to exterior (requires a blower door)

- House size: 2240 Ft^2
- 2240 X **.06** = ***134 CFM*** maximum

Resources for Standard and Testing



Energy Code Support — Washington State University Extension Energy Program

Duct Leakage Affidavit

Permit #: _____

House address or lot number: _____

City: _____ Zip: _____

Cond. Floor Area (ft²): _____ Source (circle one): Plans Estimated Measured

☐ Duct tightness testing is not required for this residence per exceptions listed at the end of this document

Air Handler in conditioned space? ☐ yes ☐ no Air Handler present during test? ☐ yes ☐ no

Circle Test Method: Leakage to Outside Total Leakage

Maximum duct leakage:

Post Construction, total duct leakage: (floor area x .08) = _____CFM@25 Pa

Post Construction, leakage to outdoors: (floor area x .06) = _____CFM@25 Pa

Rough-In, total duct leakage with air handler installed: (floor area x .06) = _____CFM@25 Pa

Rough-In, total duct leakage with air handler not installed: (floor area x .04) = _____CFM@25 Pa

Test Result: _____CFM@25Pa

Ring (circle one if applicable): Open 1 2 3

Duct Tester Location: _____ Pressure Tap Location: _____

I certify that these duct leakage rates are accurate and determined using standard duct testing protocol.

Company Name: _____ Technician: _____

Technician Signature: _____ Date: _____ Phone Number: _____

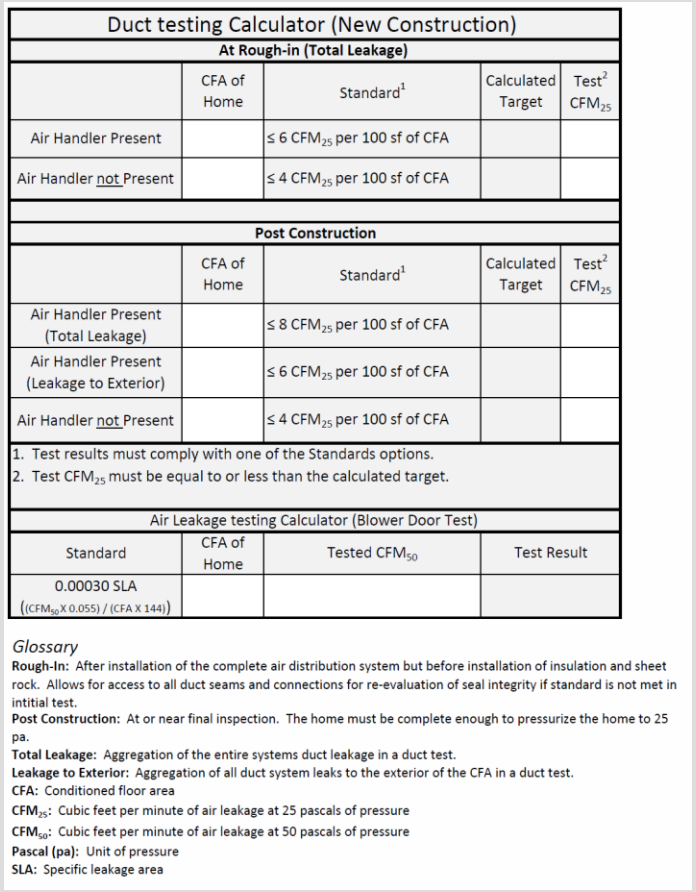
Washington State Energy Code reference:

503.10.2 Sealing. All ducts, air handlers, filter boxes, and building cavities used as ducts shall be sealed. Joints and seams shall comply with Section M1601.3 of the *International Residential Code* or 603.9 of the *International Mechanical Code*. Duct tightness testing shall be conducted to verify that the ducts are sealed. A signed affidavit documenting the test results shall be provided to the jurisdiction having authority by the testing agent. When required by the building official, the test shall be conducted in the presence of department staff.

Exceptions: 1. Duct tightness test is not required if the air handler and all ducts are located within conditioned space.

2. Duct testing is not required if the furnace is a nondirect vent type combustion appliance installed in an unconditioned space. A maximum of six feet of connected ductwork in the unconditioned space is allowed. All additional supply and return ducts shall be within the conditioned space. Ducts outside the conditioned space shall be sealed with a mastic type duct sealant and insulated on the exterior with R-8 insulation for above grade ducts and R-5 water resistant insulation when within a slab or earth.

Duct Testing Affidavit



Duct testing Calculator (New Construction)

At Rough-in (Total Leakage)

	CFA of Home	Standard[1]	Calculated Target	Test[2] CFM_{25}
Air Handler Present		≤ 6 CFM_{25} per 100 sf of CFA		
Air Handler not Present		≤ 4 CFM_{25} per 100 sf of CFA		

Post Construction

	CFA of Home	Standard[1]	Calculated Target	Test[2] CFM_{25}
Air Handler Present (Total Leakage)		≤ 8 CFM_{25} per 100 sf of CFA		
Air Handler Present (Leakage to Exterior)		≤ 6 CFM_{25} per 100 sf of CFA		
Air Handler not Present		≤ 4 CFM_{25} per 100 sf of CFA		

1. Test results must comply with one of the Standards options.
2. Test CFM_{25} must be equal to or less than the calculated target.

Air Leakage testing Calculator (Blower Door Test)

Standard	CFA of Home	Tested CFM_{50}	Test Result
0.00030 SLA ($(CFM_{50} \times 0.055) / (CFA \times 144)$)			

Glossary

Rough-In: After installation of the complete air distribution system but before installation of insulation and sheet rock. Allows for access to all duct seams and connections for re-evaluation of seal integrity if standard is not met in initial test.

Post Construction: At or near final inspection. The home must be complete enough to pressurize the home to 25 pa.

Total Leakage: Aggregation of the entire systems duct leakage in a duct test.

Leakage to Exterior: Aggregation of all duct system leaks to the exterior of the CFA in a duct test.

CFA: Conditioned floor area

CFM_{25}: Cubic feet per minute of air leakage at 25 pascals of pressure

CFM_{50}: Cubic feet per minute of air leakage at 50 pascals of pressure

Pascal (pa): Unit of pressure

SLA: Specific leakage area

Test Result Calculator

Duct Testing Standards

Exceptions:

Duct tightness test is not required if

- The air handler and all ducts are located within conditioned space.

or

- The furnace is a non-condensing appliance in an unconditioned space with a maximum of 6 feet of ductwork in the unconditioned space*.

Exception Detail:

- The goal is to get condensing equipment inside the conditioned space.
- The code makes an allowance for non-condensing equipment because it is such a large portion of the market.
- A naturally drafted appliance installed inside with combustion air is not in the conditioned space anymore. Mechanical room must then be insulated.

Original

Duck Blaster

Necessary Equipment

- Duct Tester
- Manometer
- Register blocks or “mask”

fan & rings

Set up

- Connect duct tester to furnace cabinet or return grill
- Close/seal outside ventilation air openings
- Block (seal) all registers
- *Remove* furnace filter
- Insert static pressure tap
- Program Manometer

Seal Registers to Pressure Test

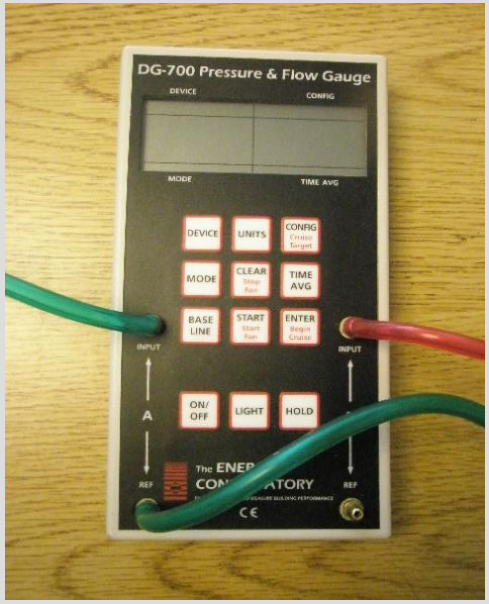
1. Insert **Static Probe** into duct
2. Point toward air flow direction

Bent tubing is *NOT* a Static Pressure Tap

Pressure meter set-up: details

- Meters measure pressures *only*
- Most meters will *convert* pressures into flow rate
- Attention to meter details is critical:

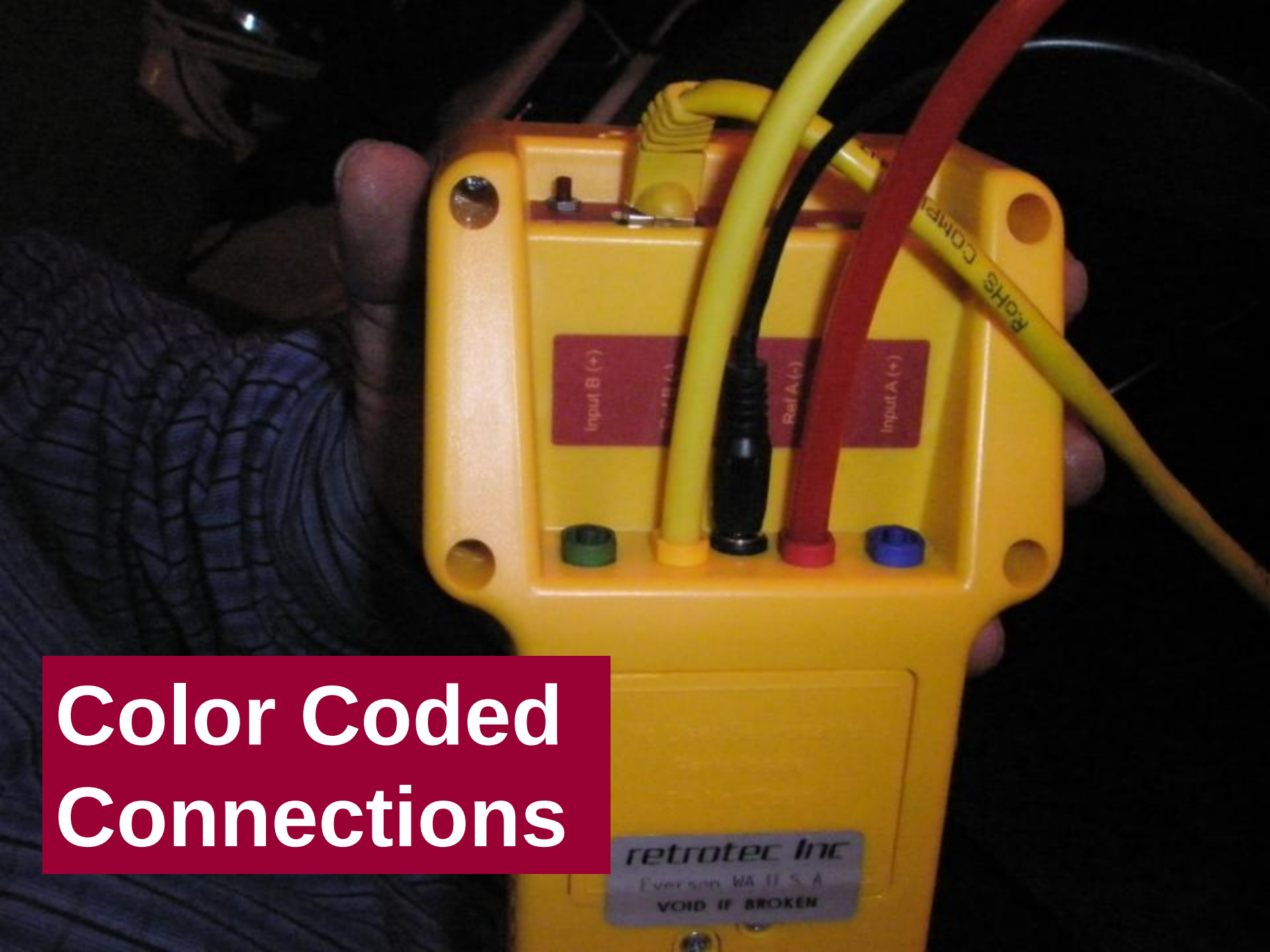
  Garbage in = garbage out



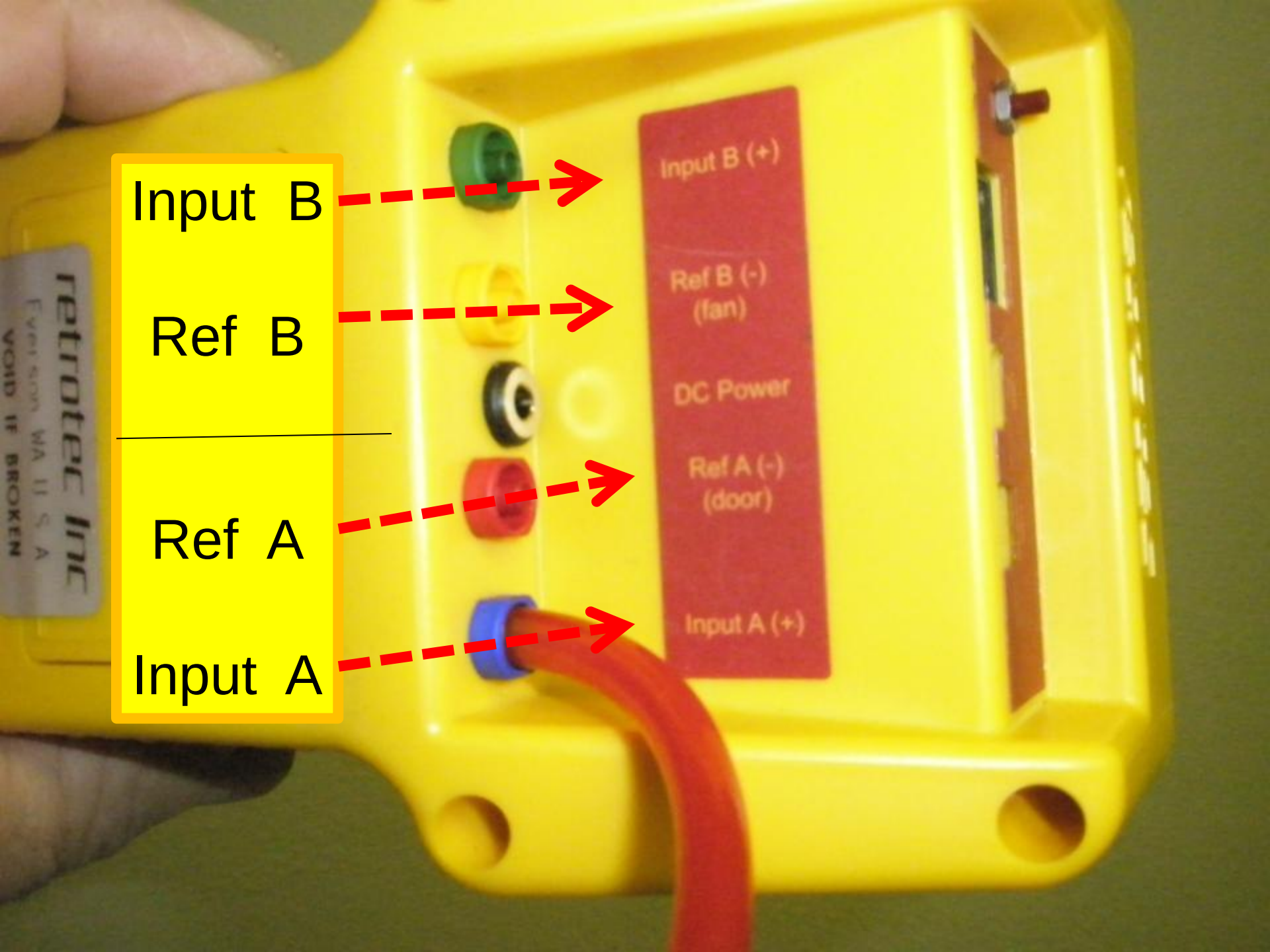
Other Equipment

RetroTec Meter

all the same stuff …



Color Coded Connections

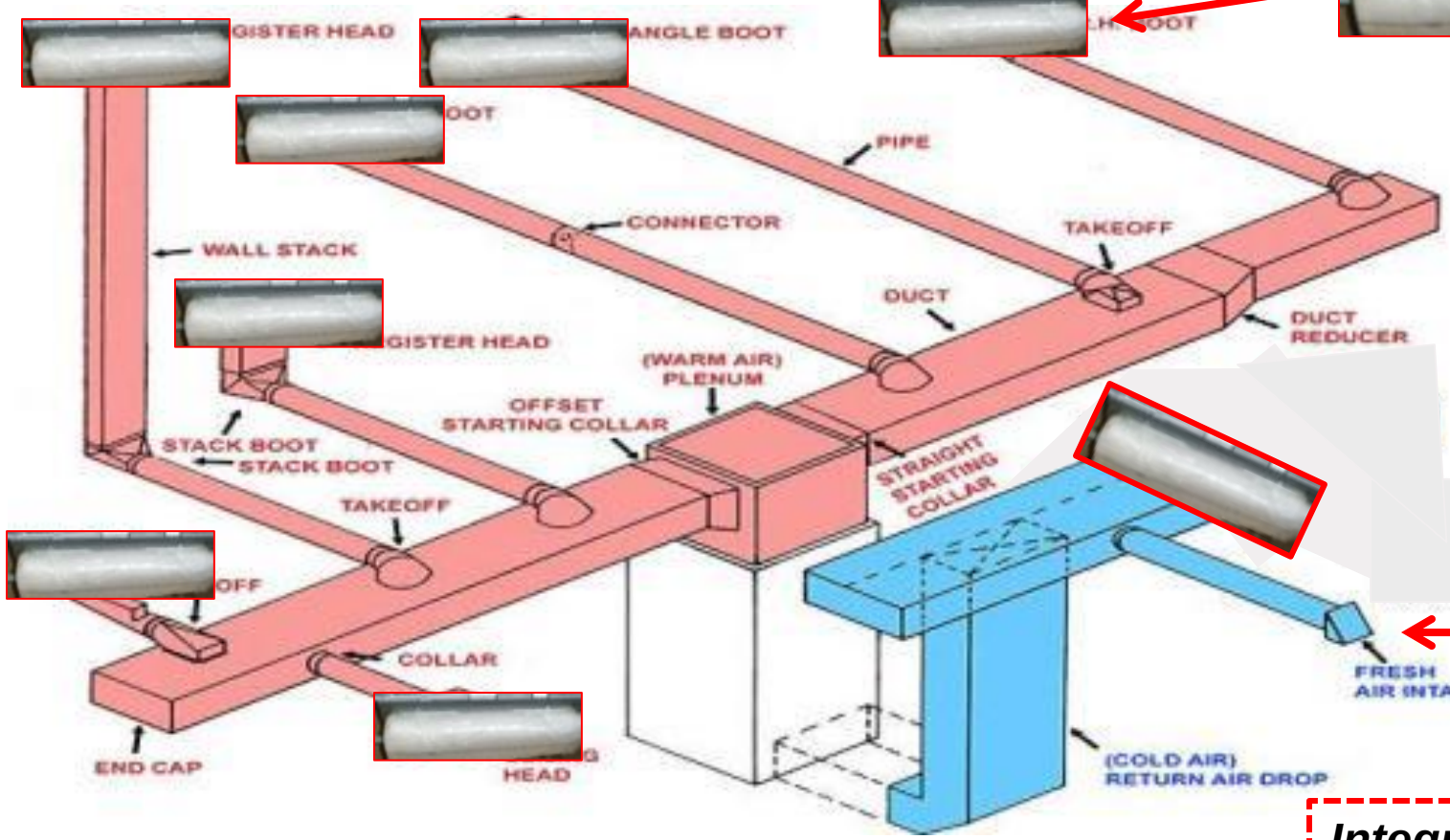

Input B
Ref B
Ref A
Input A
Input B (+)
Ref B (-)
(fan)
DC Power
Ref A (-)
(door)
Input A (+)
retrotec inc
VOID IF BROKEN

Total Duct Leakage Test

Step 1: Seal all registers and grills

Mask or foam blocks

Also: integrated fresh air duct sealed

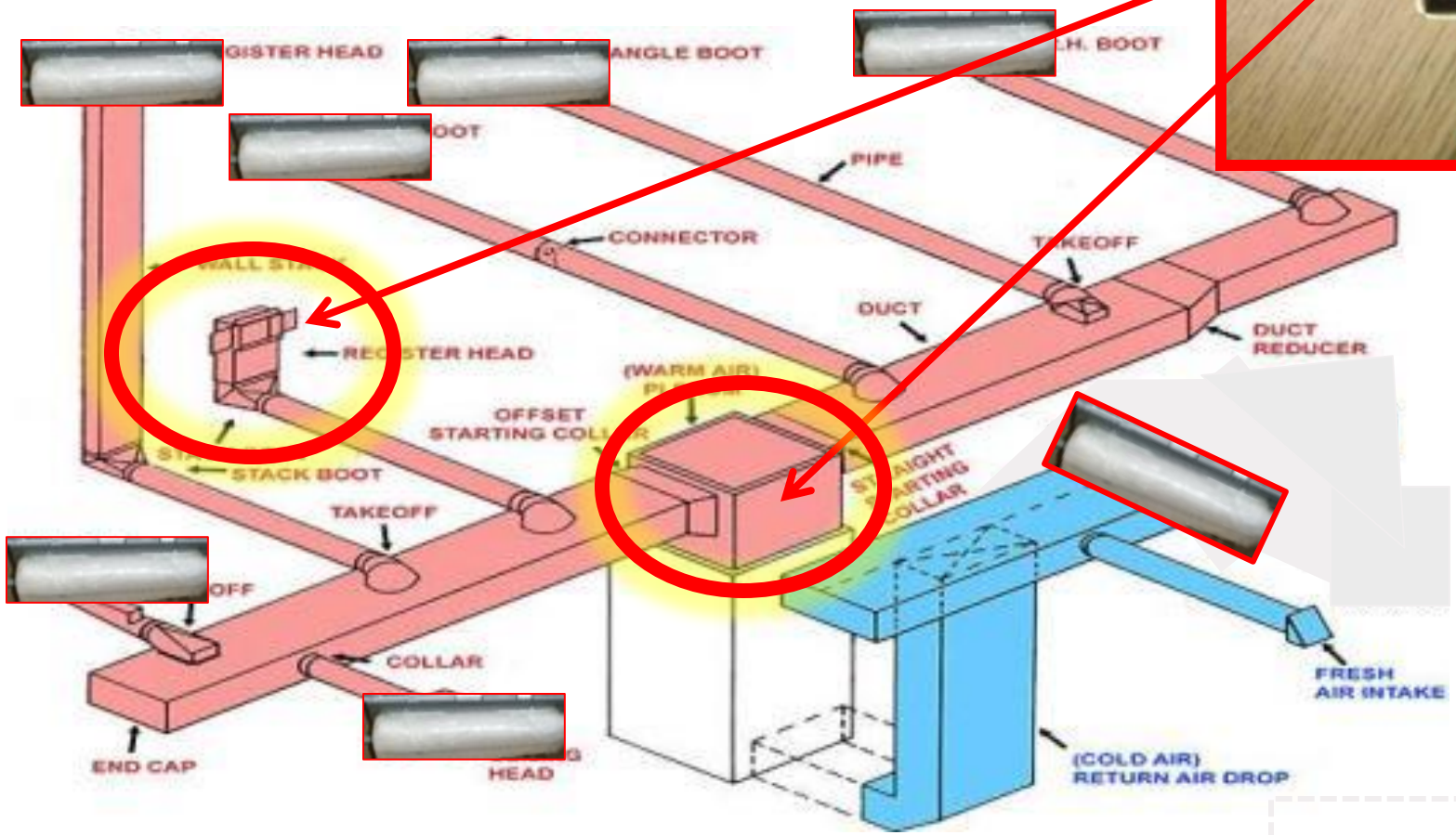


Integrated fresh air duct sealed

Static Pressure Tap

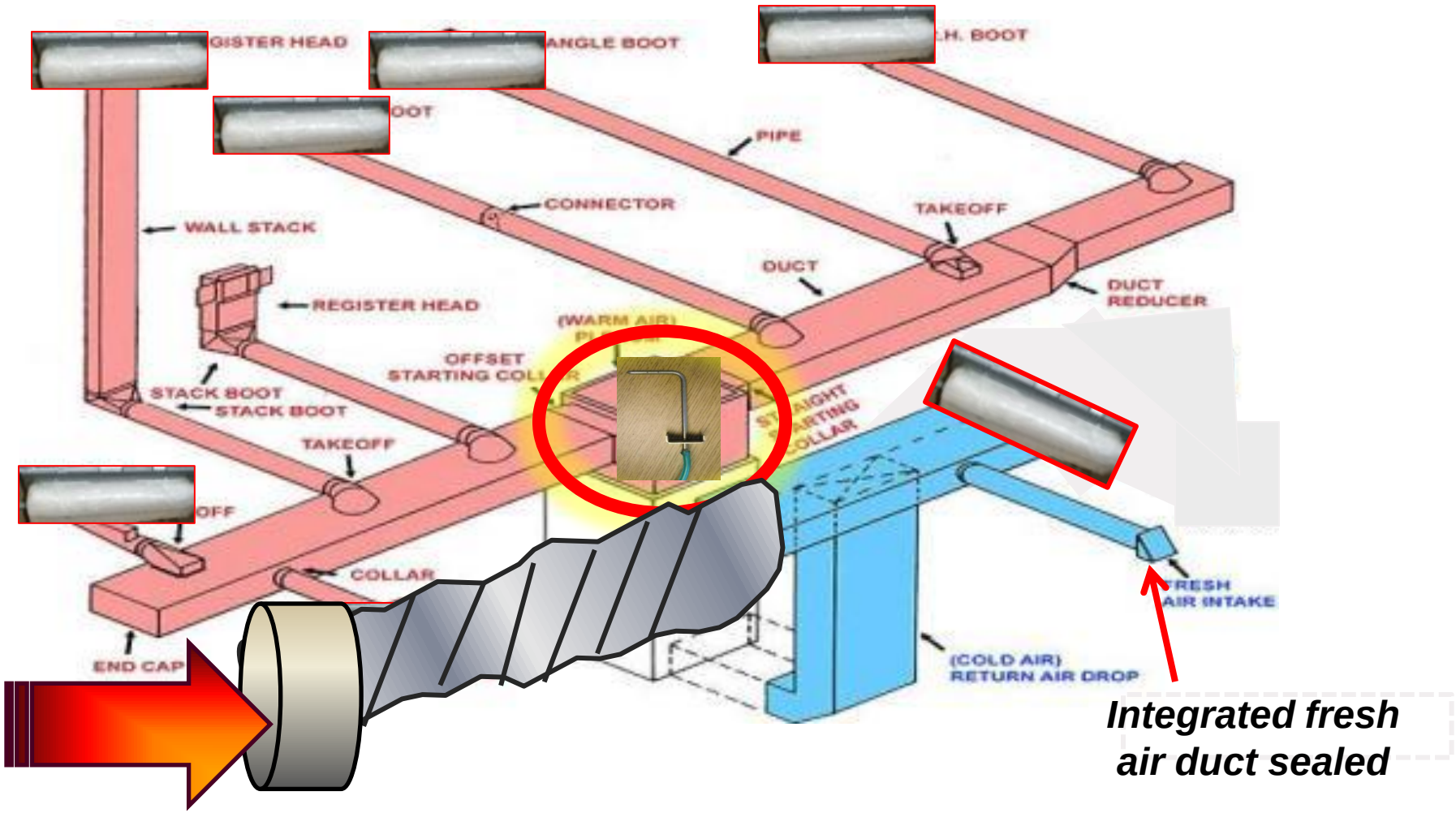
Insert in *Supply Side*

(in or near supply plenum)



Total Duct Leakage Test

Step 3: Connect Duct Blower to System



Integrated fresh air duct sealed

Total Duct Leakage Test

1. Seal all registers and grills
2. Seal fresh air duct and/or HRV
3. Install static pressure tap in supply side
4. Attach duct blower to system
5. Set up pressure gauge
6. Pressurize system to + 25 Pa
7. Record air flow into system @ + 25 Pa
8. Document set-up configurations

Duct Leakage to the *Exterior*

incorporates Blower Door

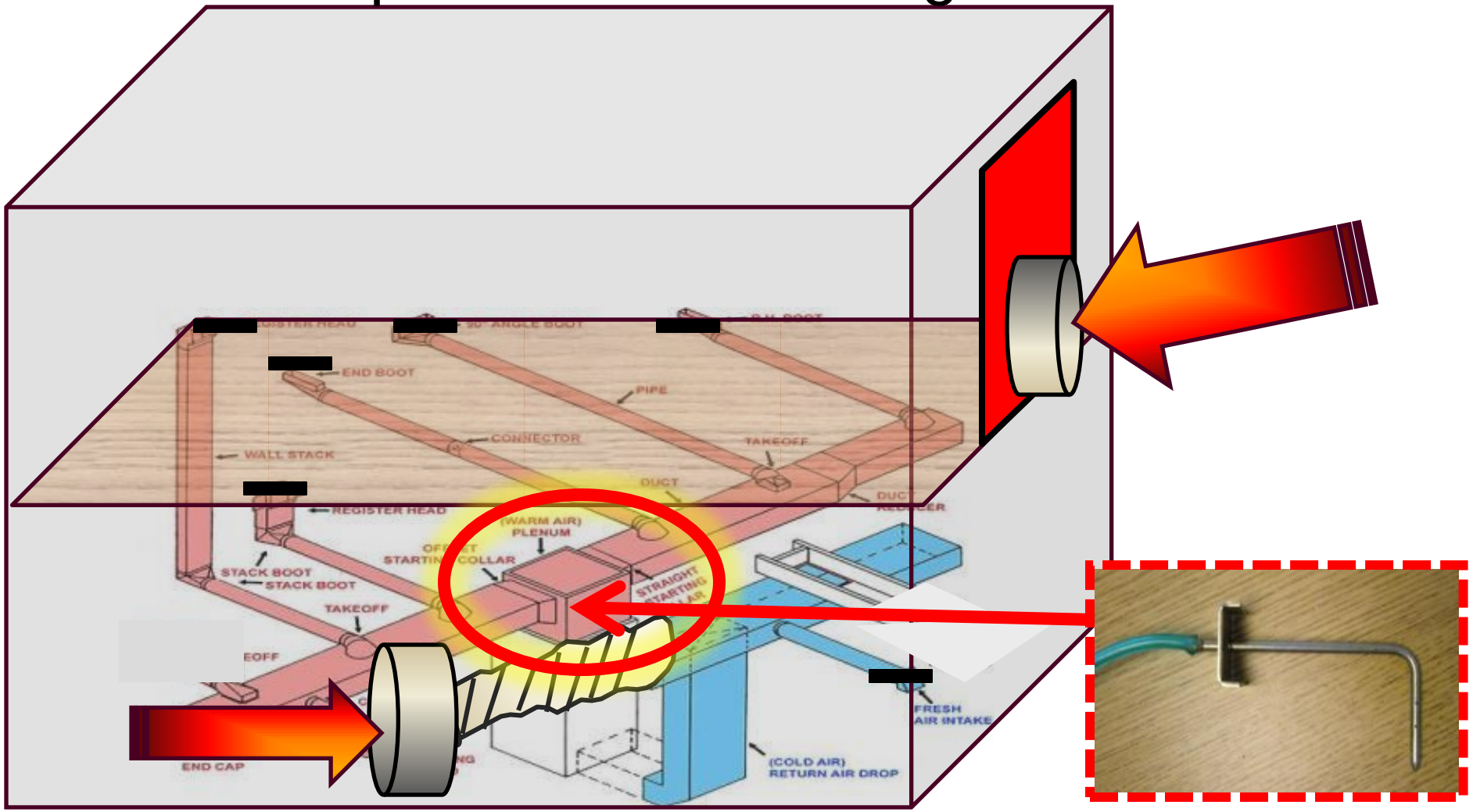
&

Yields duct leakage CFM to the *exterior*

Duct Leakage to the *Exterior*

Seal and pressurize ducts to **+ 25 Pa**

Blower door pressurizes building to **+ 25 Pa**



Duct Leakage to the *Exterior*

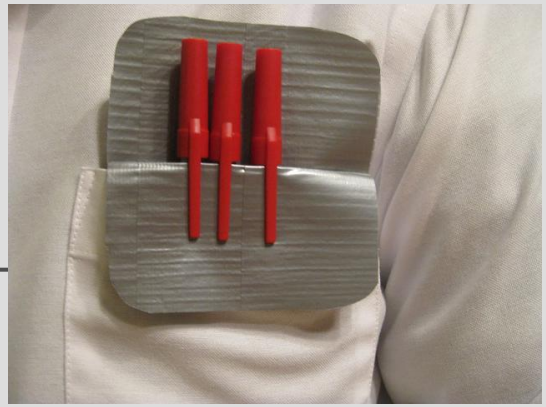
Incorporates Blower Door

1. Seal all registers and grills
2. Seal fresh air duct and/or HRV
3. Install static pressure tap in supply side
4. Attach duct blower to system
5. Install blower door and close-up the house
6. Set up pressure gauges
7. *Pressurize house to +25 Pa (Blower Door)*
8. *Pressurize duct system to +25 Pa (Duct Blower)*
9. Record air flow into system @ +25 Pa
10. Document set-up configurations

Duct Sealants

- All joints, seams and connections shall be fastened and sealed.
  - See IMC 603.9 or IRC M1601.3 for details
  - Closure systems must be installed according to the manufacturer's listing
  - Unlisted duct tape is not permitted as a sealant on any metal ducts

Duct Tape



Duct tape may be used if:

- Installed in accordance with mfg's installation instructions
- Must contain detailed info specific to application on ducts
- Info must contain approved duct materials and surface cleaning requirements

Please let us know if you find this information from any manufacturer!

Eureka! We found one…

TECHNICAL DATA

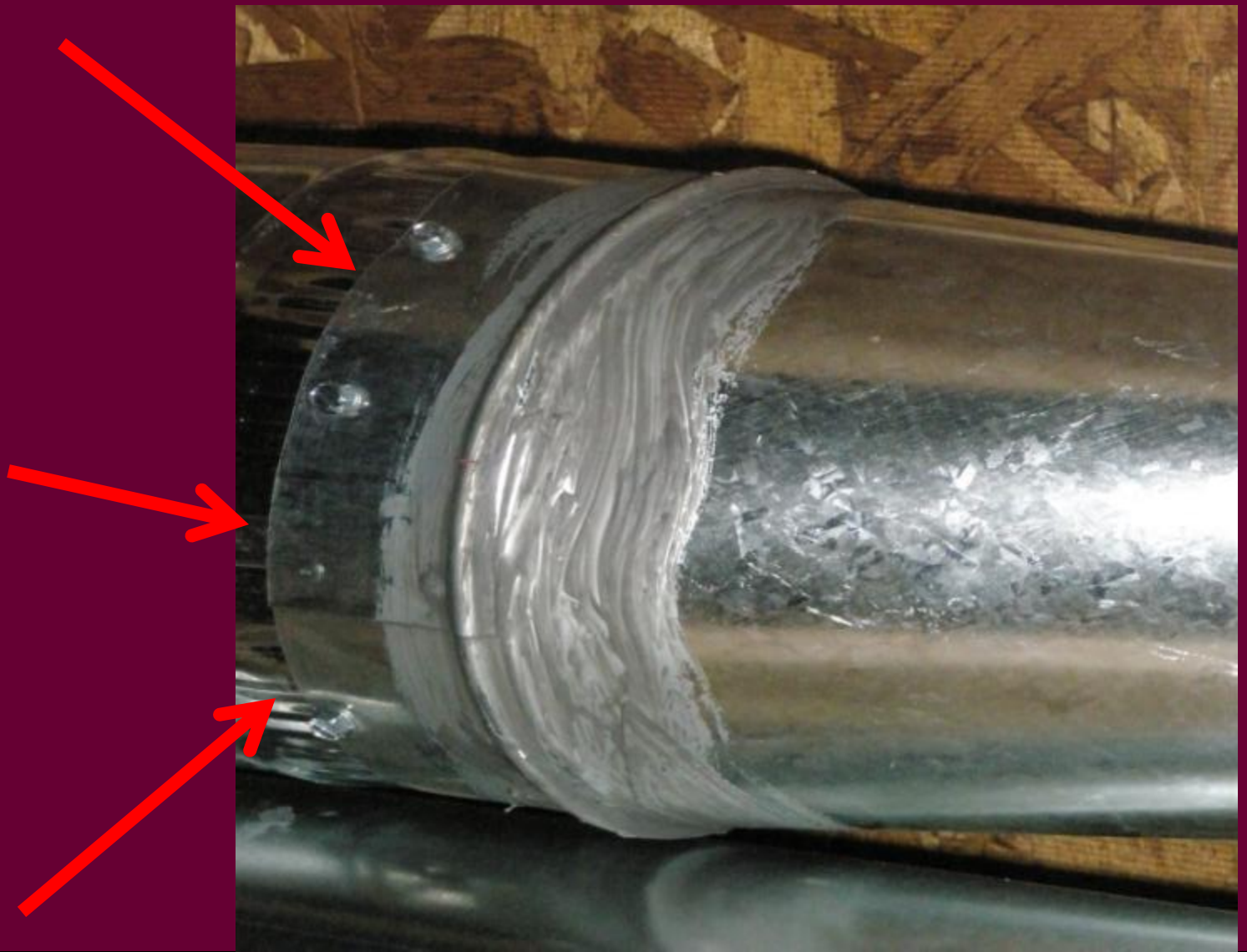
Appearance	Mill finish aluminum substrate with butyl adhesive/sealant
Backing	Aluminum
Thickness	17 mils
Sealant Material	Modified Butyl
Peel Strength	7 lbs. per linear inch
Tensile Strength	20 pli/1400 psi avg.
Flexibility	Excellent, no cracking
Bonding Time	Instant high tack, full bond 24 hours
Time to Test	Immediate
Service Temperature	-20°F. to 200°F.

PRECAUTIONS

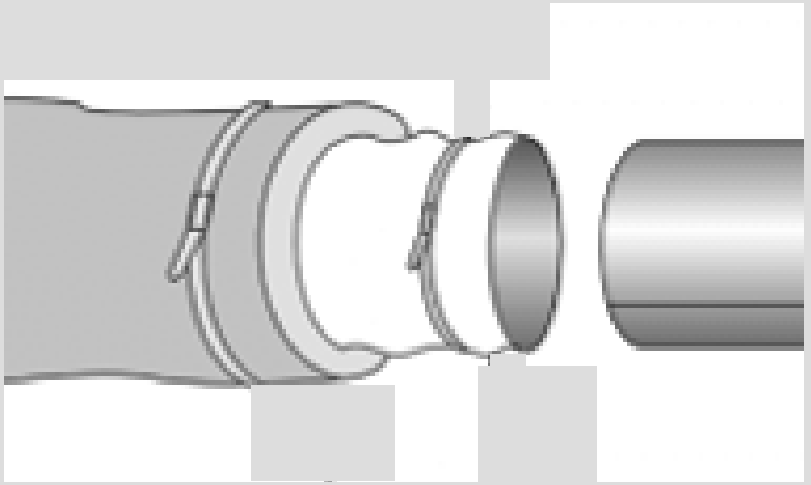
Surfaces must be clean and free of moisture and contamination. Do not apply this product in areas where temperatures will exceed 200°F. Keep out of the reach of children. Review MSDS for safety information prior to use. DO NOT use where acidic or alkaline chemicals are present (ie., lab fume hood, vents, etc.)

For Industrial Professional Use Only.

All Joints Must Be Sealed



Mastic is NOT paint apply “nickel thick”




What do you expect for $850,000?
A good duct system?
© Erin Hamernyik


© Erin Hamernyik


POLYKEN 367


FOR PRES

Don’t do this!

Residential duct insulation

- Attics, crawl spaces, garages require ***R-8***
- In slabs or underground require ***R-5***
- On a roof or exterior of a building require ***R-8 and a weatherproof barrier***

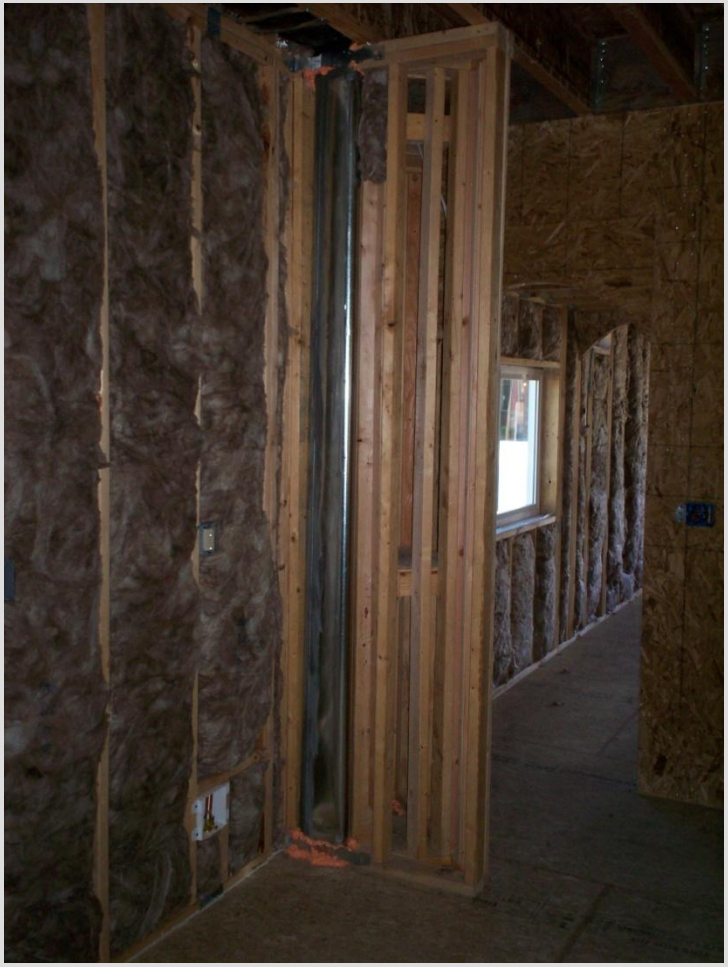
Duct liner

- Typical duct liner requires 2 inches to meet code
- Most duct liner is R-4 per inch

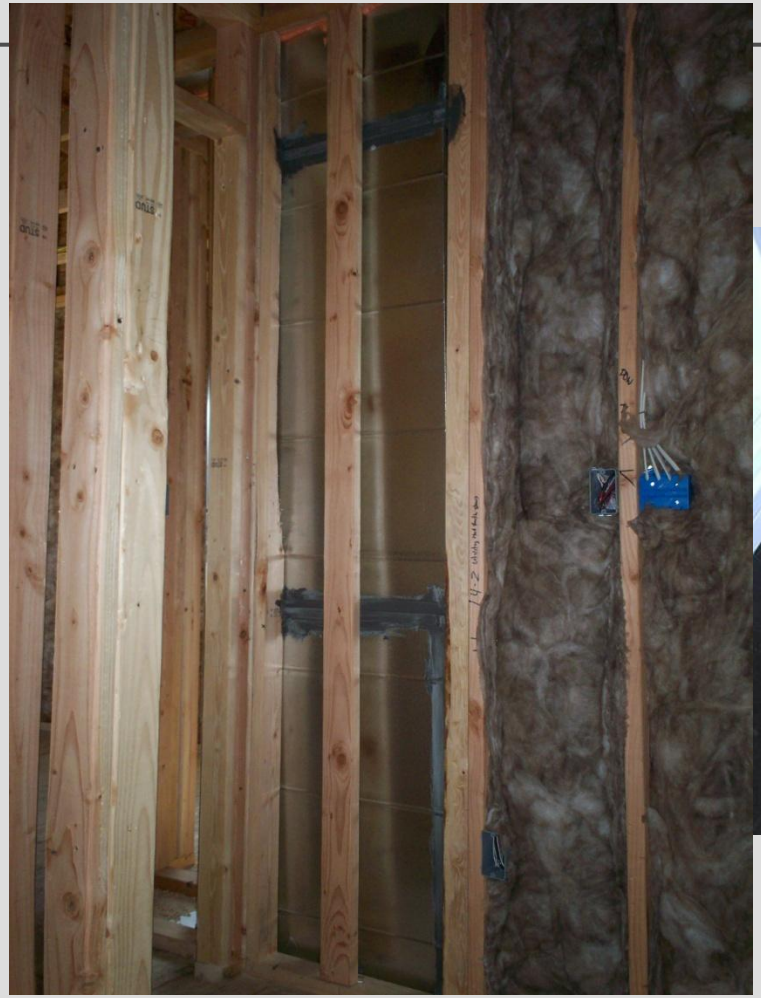
Related code changes

- Installation of ducts in exterior walls, floors, or ceilings shall not displace required insulation.
- Unlined building cavities *may not* be used as ducts.

Ducts in interior walls



Ducted return inside the house



Unlined cavity return

Related code changes (cont.)

- Duct testing required when replacing HVAC equipment, *~~and shall be sealed~~.
  - Includes:
    - Air handler replacement
    - Outdoor condensing unit (AC or HP)
    - Cooling or heating coils
    - Furnace heat exchanger

* The SBCC has issued an emergency rule effective until the end of August requiring duct testing but not sealing

Duct Testing (Existing Houses)

Field Verification Compliance Options

- ~~Maximum leakage rates:~~
  - ~~8% CFA for *Total duct leakage*~~
  - ~~6% CFA for *Leakage to exterior*~~

~~or~~

- ~~Post installation duct leakage reduced by 50%~~

~~or~~

- ~~Verification by 3rd party inspector that all accessible leaks have been sealed~~
- SBCC's emergency rule requires testing results be documented on required affidavit with copies submitted to the building department and homeowner

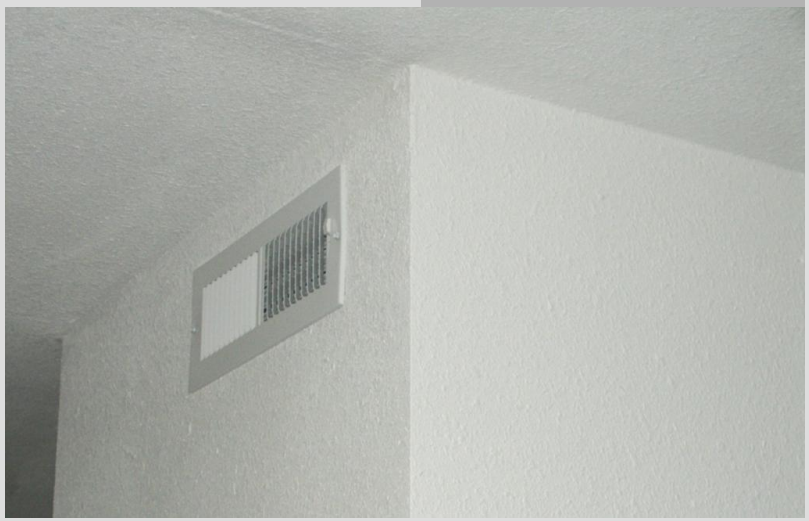
Duct testing standards are posted at:

www.energy.wsu.edu/code

Exceptions for Existing Houses:

- Ducts with less than 40 lineal feet in unconditioned spaces
- Ducts that have been previously tested
- Ducts containing asbestos

A Better Way:
Move the Ducts Inside!



- **Habitat for Humanity**
- **First WA Energy Star**
- **All Duct Inside**
- **1000 FT2**
- **All Electric < $40/month**

Ducts in Dropped Ceiling in Hall

After Drywall

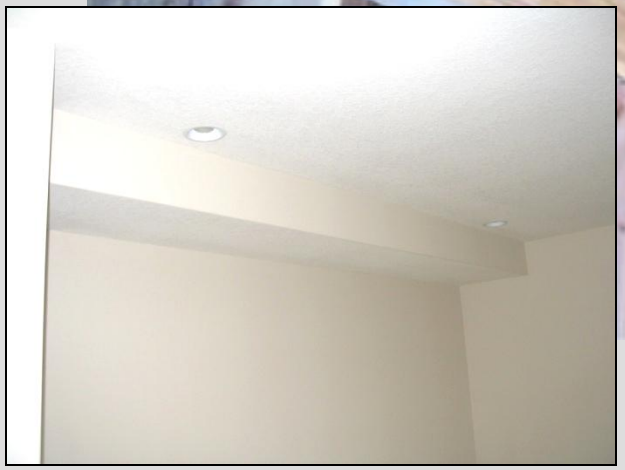
Air Handler Inside

Supply Register In Wall

Dropped Soffit with Duct in Bathroom

Vancouver Demonstration

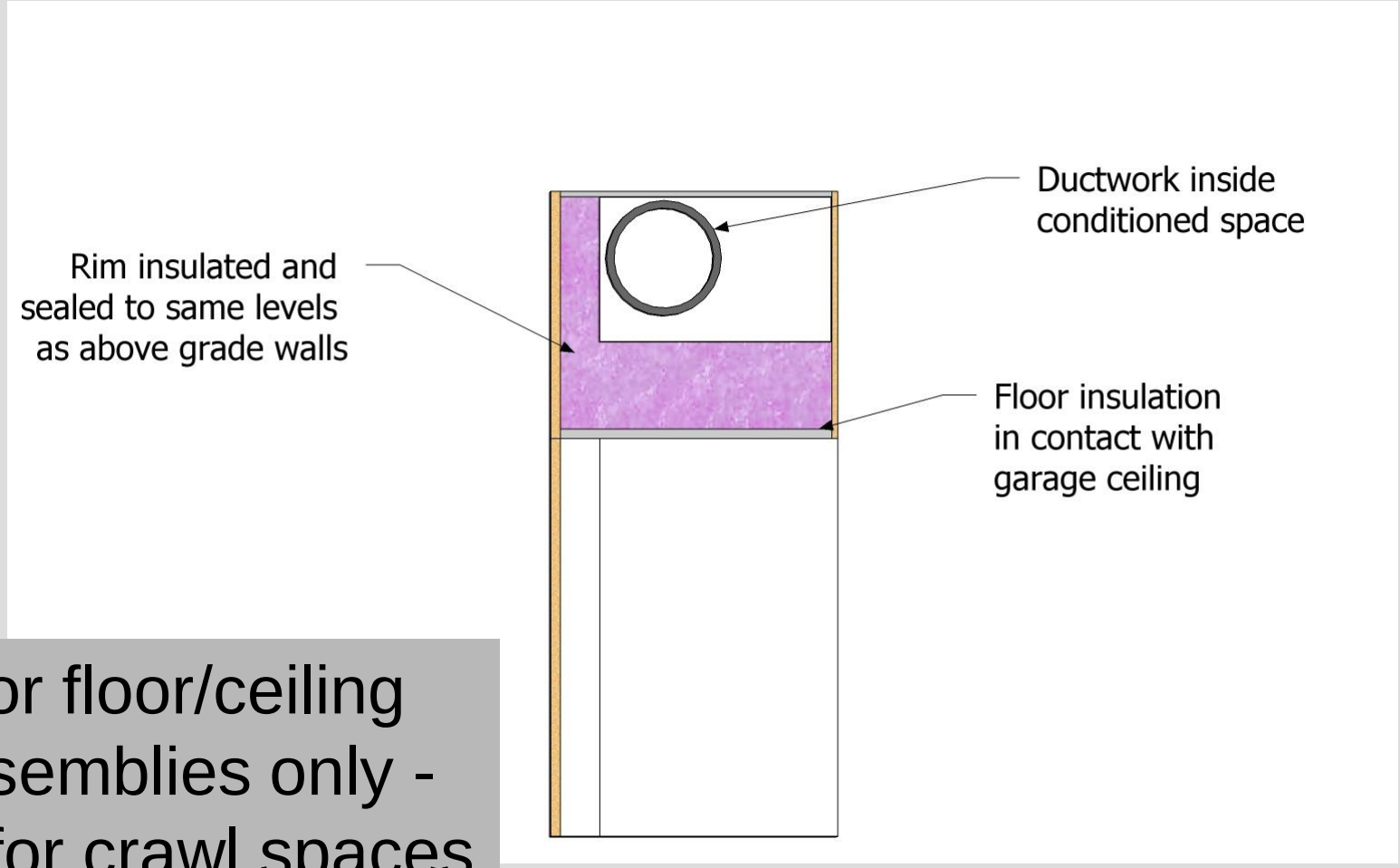
Duct Between Floors



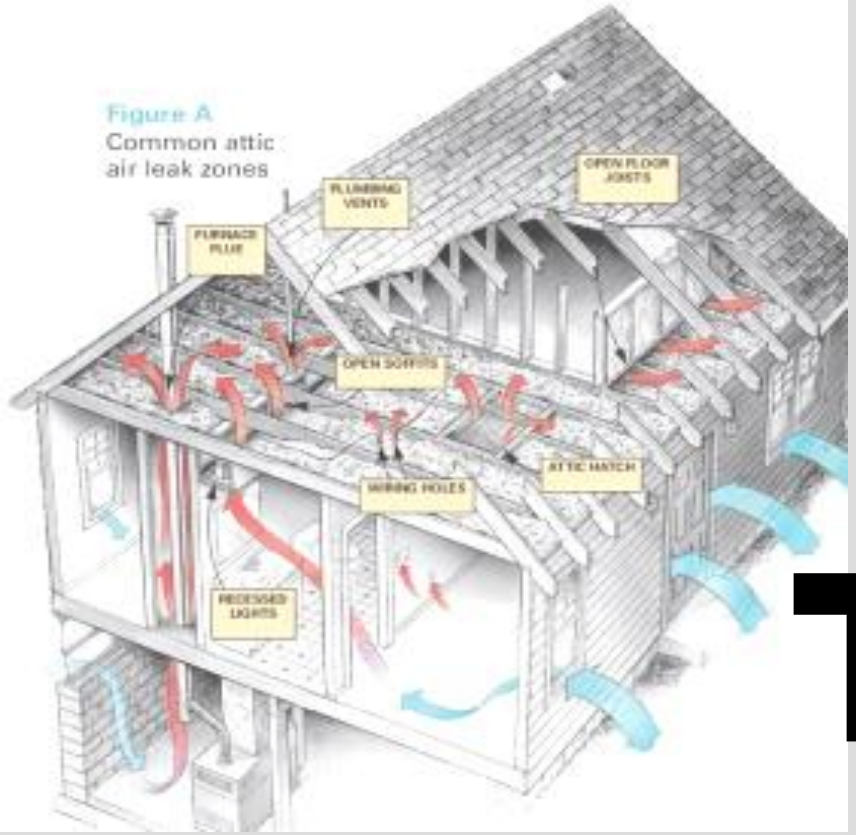
Ducts between floors

High efficiency furnace
inside the structure

Insulation in Substantial Contact Exception (502.1.4.7)



For floor/ceiling assemblies only - not for crawl spaces



Testing House Tightness

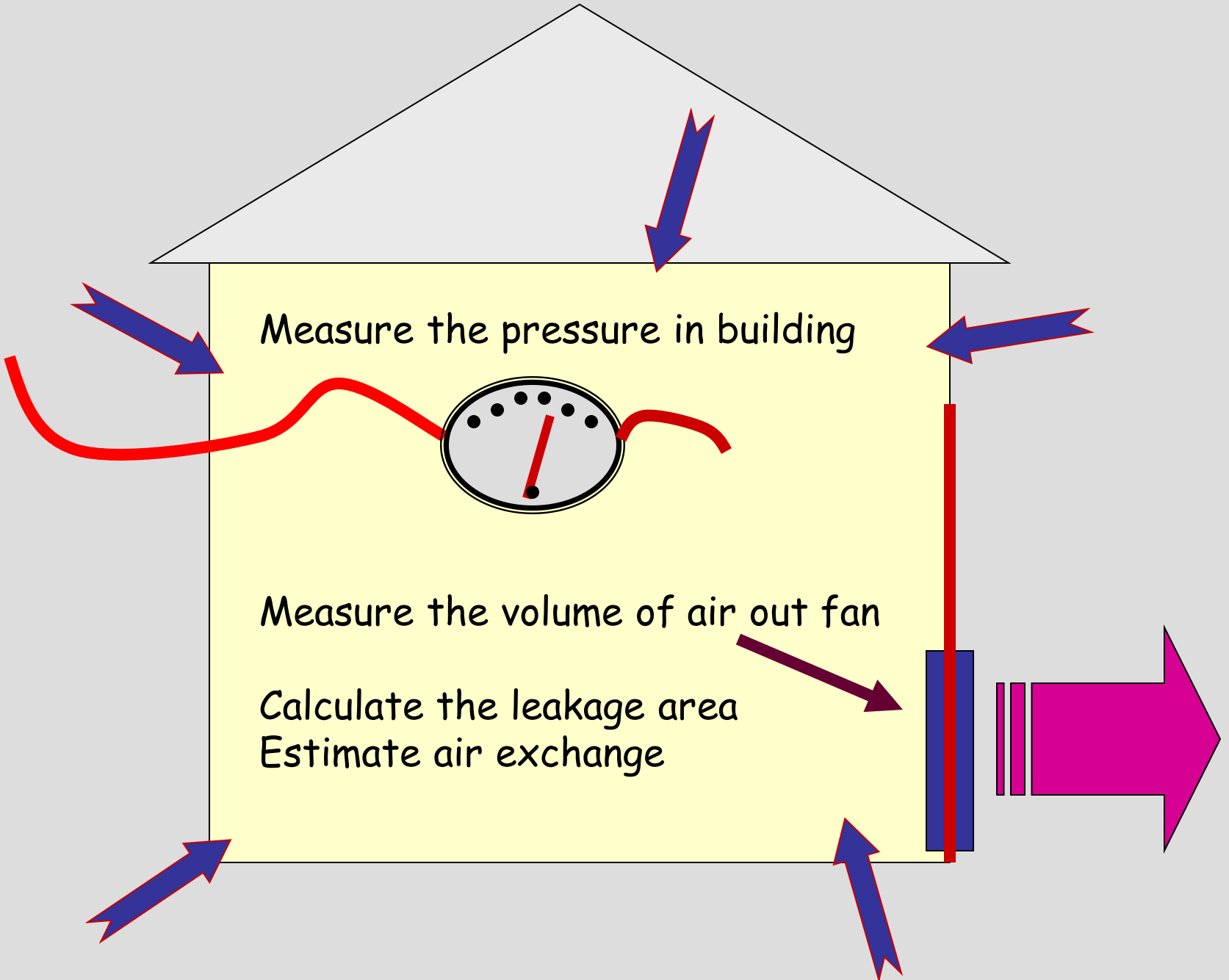
House Air Leakage Testing

Building Air Leakage/Tightness Testing

Closed house condition
Blower door creates *negative pressure*
Measure house pressure + air flow out

Use - 50 pascal pressure

High air flow @ 50 pascals = large air leakage
Low air flow @ 50 pascals = small air leakage


Measure the pressure in building
Measure the volume of air out fan
Calculate the leakage area
Estimate air exchange

Necessary Equipment

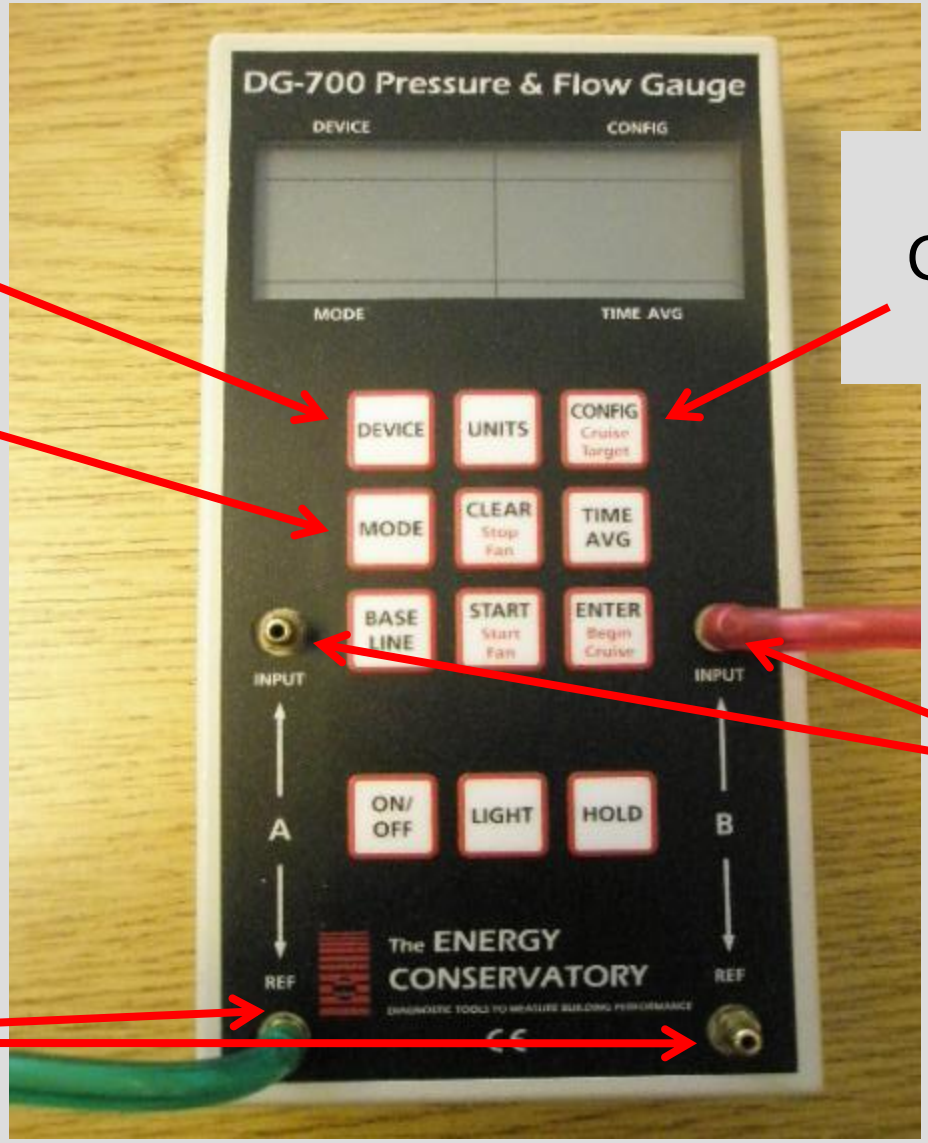
- Blower door
  - Fan
  - Panel
  - Frame

- Manometer

Set-up

- Assemble frame, place nylon canvas over frame secure in exterior door frame.
- Insert fan in panel
- Connect tubing to manometer, fan and exterior
- Properly program manometer
- Depressurize to -50Pa and record CFM

DG-700 Pressure & Flow Meter



Device Select

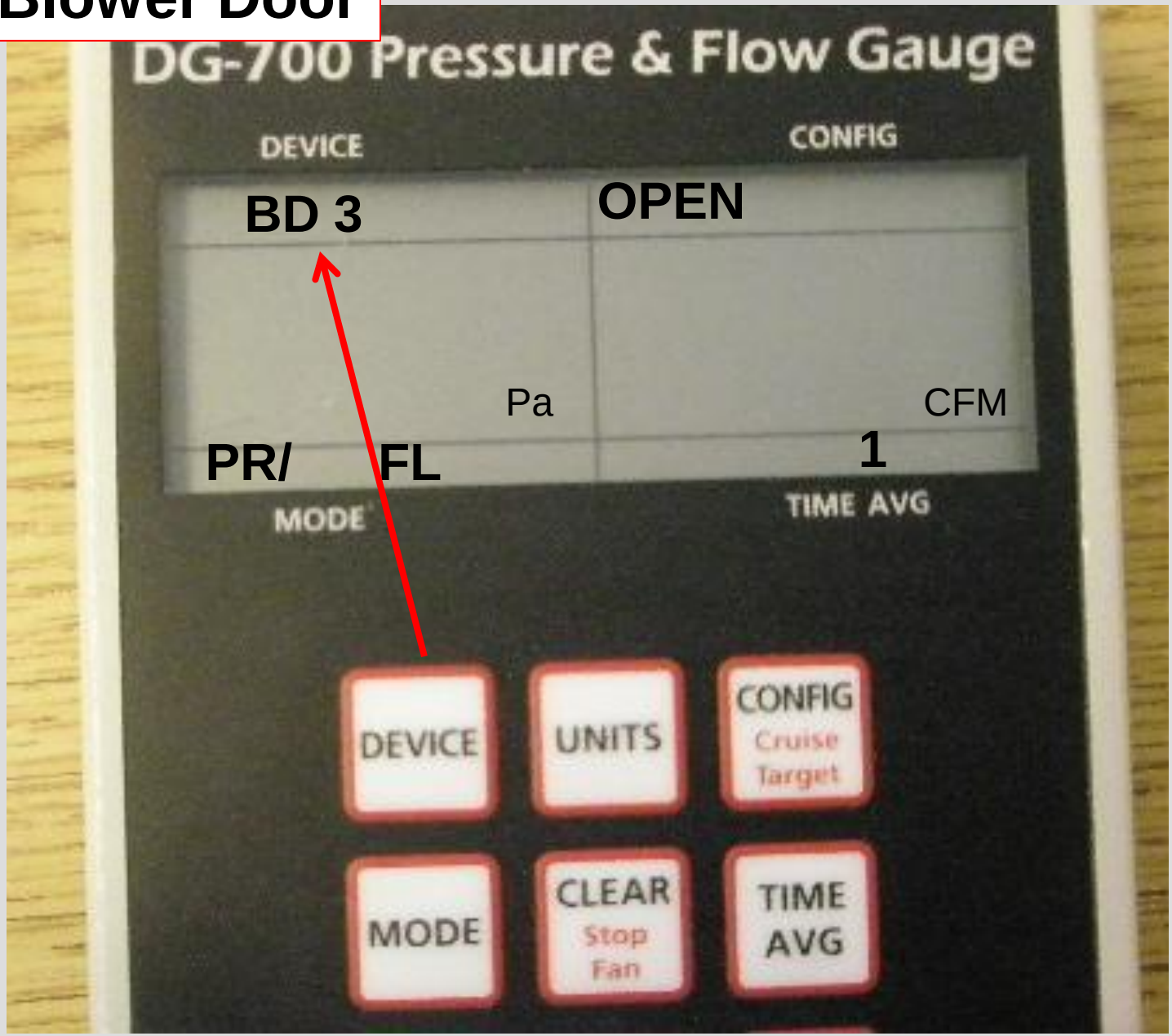
Mode Select

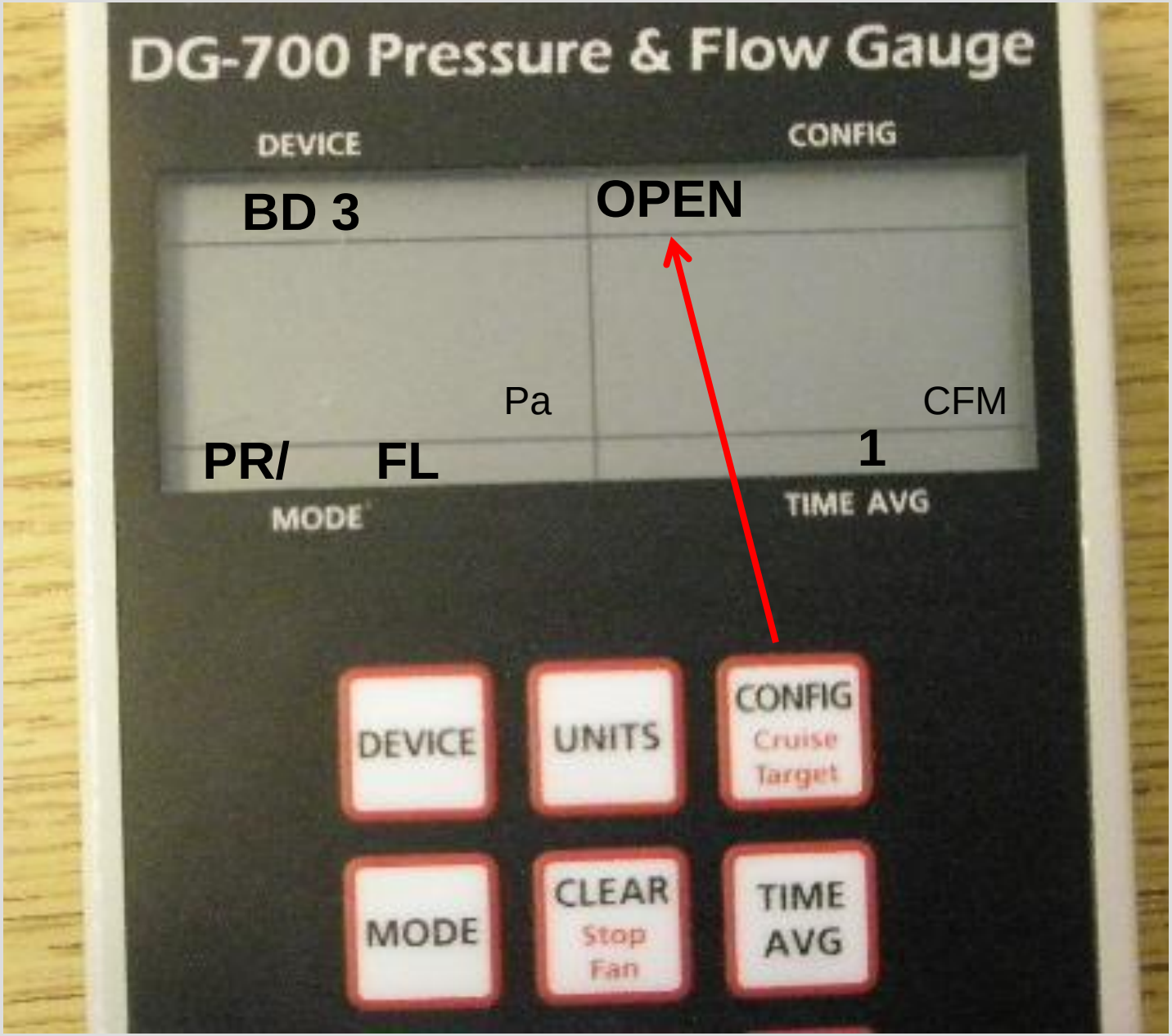
Device Configuration Select

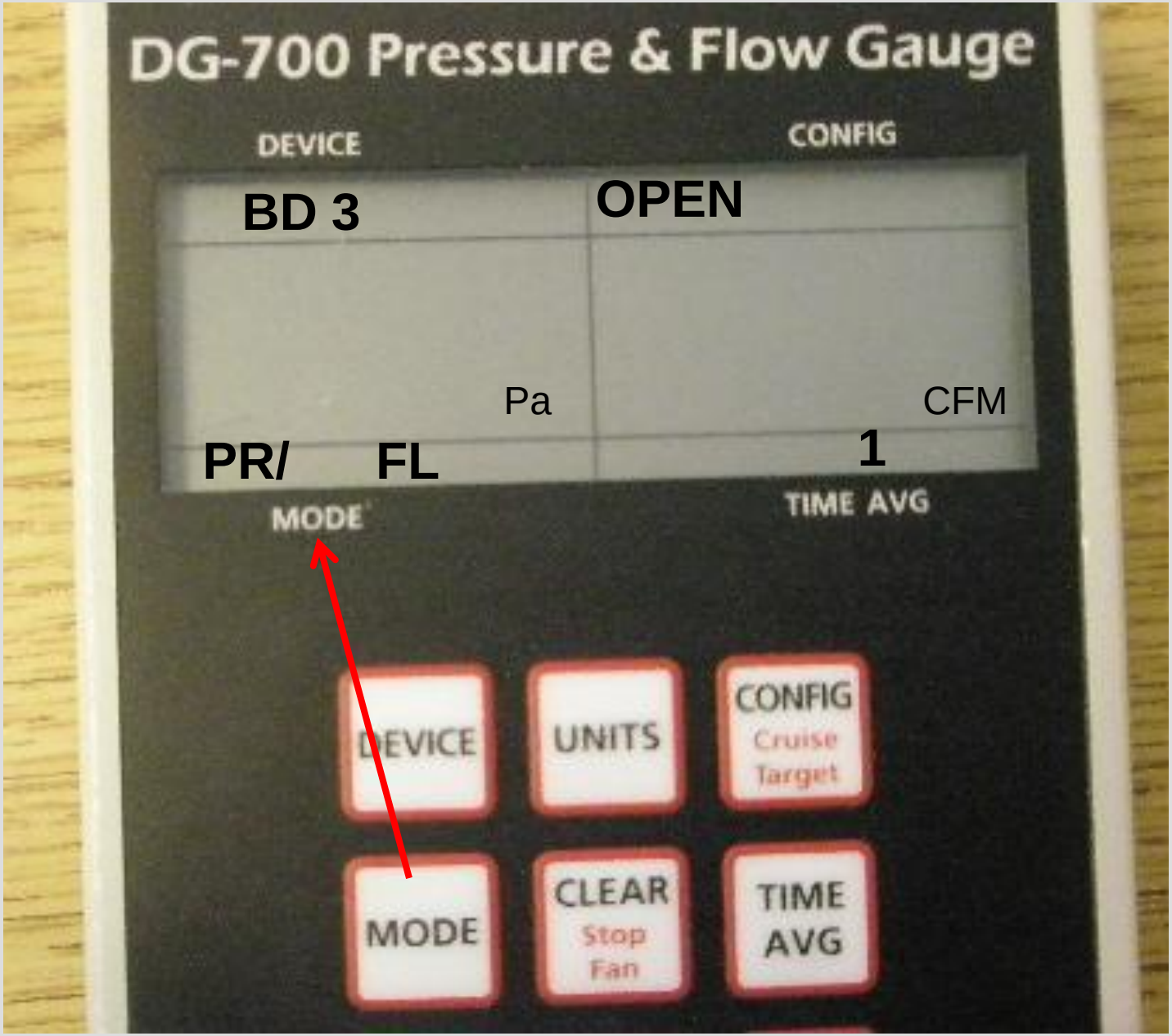
"Input" ports

"REF" ports

BD = Blower Door




DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
BD 3
OPEN
Pa
CFM
PR/
FL
1
MODE
TIME AVG
DEVICE
UNITS
CONFIG
Cruise
Target
MODE
CLEAR
Stop
Fan
TIME
AVG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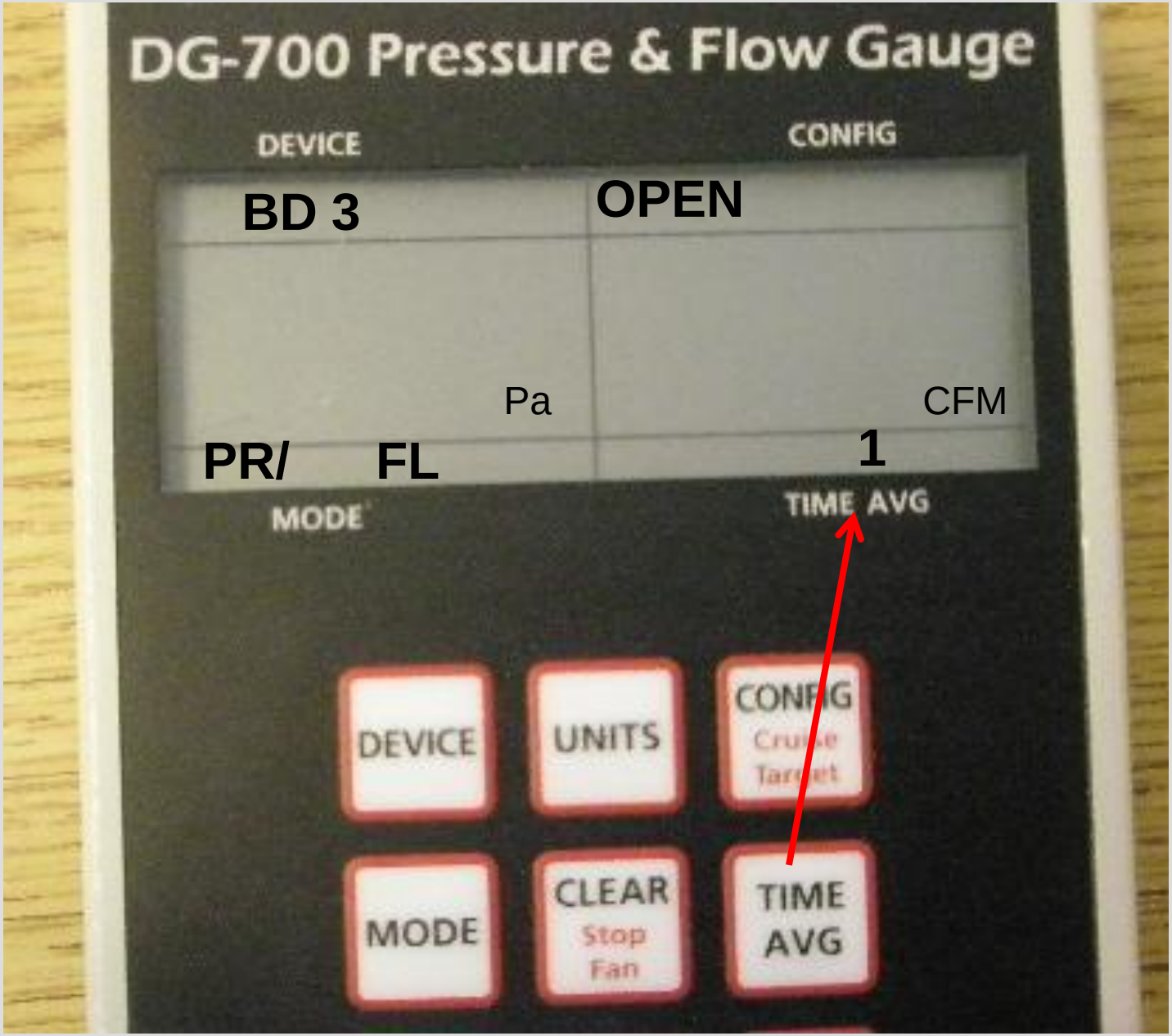
DG-700 Pressure & Flow Gauge
DEVICE
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BD 3
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PR/
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DEVICE
UNITS
CONFIG
MODE
CLEAR
Stop
Fan
TIME
AVG

During Testing

- Exterior windows and doors closed
- Fireplace and stove doors closed
- Close dampers (depressurizing the house sucks gravity dampers closed)
- Plumbing traps must be filled with water or blocked in some other manner.
- Interior doors open

During Testing

- Open access hatches to conditioned attics or crawl spaces
- Exterior ventilation openings closed and sealed
- HVAC ducts and registers not sealed
- HVAC, water heater, OFF

What the numbers mean

Pressure (in Pascals)

Flow rate (CFM)

Calculating SLA

(Specific Leakage Area)

- SLA = (CFM50 X .055) / (CFA X 144)
- SLA = (1790 X .055) / (2240 X 144)
- SLA = 98.45 / 322,560
- SLA = .00030

Duct testing Calculator (New Construction)

At Rough-in (Total Leakage)

	CFA of Home	Standard[1]	Calculated Target	Test[2] CFM_{25}
Air Handler Present		≤ 6 CFM_{25} per 100 sf of CFA		
Air Handler not Present		≤ 4 CFM_{25} per 100 sf of CFA		

Post Construction

	CFA of Home	Standard[1]	Calculated Target	Test[2] CFM_{25}
Air Handler Present (Total Leakage)		≤ 8 CFM_{25} per 100 sf of CFA		
Air Handler Present (Leakage to Exterior)		≤ 6 CFM_{25} per 100 sf of CFA		
Air Handler not Present		≤ 4 CFM_{25} per 100 sf of CFA		

1. Test results must comply with one of the Standards options.
2. Test CFM_{25} must be equal to or less than the calculated target.

Air Leakage testing Calculator (Blower Door Test)

Standard	CFA of Home	Tested CFM_{50}	Test Result
0.00030 SLA ($(CFM_{50} X 0.055) / (CFA X 144)$)			

Glossary

Rough-In: After installation of the complete air distribution system but before installation of insulation and sheet rock. Allows for access to all duct seams and connections for re-evaluation of seal integrity if standard is not met in intitial test.

Post Construction: At or near final inspection. The home must be complete enough to pressurize the home to 25 pa.

Total Leakage: Aggregation of the entire systems duct leakage in a duct test.

Leakage to Exterior: Aggregation of all duct system leaks to the exterior of the CFA in a duct test.

CFA: Conditioned floor area

CFM_{25}: Cubic feet per minute of air leakage at 25 pascals of pressure

CFM_{50}: Cubic feet per minute of air leakage at 50 pascals of pressure

Pascal (pa): Unit of pressure

SLA: Specific leakage area