WALL INSULATION

Wall Insulation: Preparation and Follow-up
SWS Detail: 4.1101.1 Exterior Wall Dense Packing, 4.1101.2 !Exterior Wall Insulating Sheathing, 4.1101.3 Exterior Wall Spray !Polyurethane Foam (SPF)-Masking and Surface Preparation, r4.1101.4 Exterior Wall Spray Polyurethane Foam (SPF)

Install wall-cavity insulation with a uniform coverage and den-sity. Wall cavities encourage airflow like chimneys. Convection currents or air leakage can significantly reduce wall insulation's thermal performance if channels remain for air t migration or convection.

Important: Provide the client with an insulation receipt or certificate, with insulation type and number of bags installed, installed thickness, coverage area, and insulation R-value.

Blown Wall-Insulation Types

Cellulose, fiberglass, and open-cell polyurethane foam are the leading insulation products for retrofit-installation into walls.

Insulation Material	Density	R-Value/in.
Fiberglass (virgin fiber)	2.2 pcf	4.1
Cellulose	3.5 pcf	3.4
Open-cell urethane foam	0.5 pcf	3.8
pcf = pounds per cubic foot		

Inspect and repair walls thoroughly to avoid damaging the walls, blowing insulation into unwanted areas, or causing a dust hazard.

Preparing for Wall Insulation

Before starting to blow insulation into walls, take the following preparatory steps.

- Calculate how many bags of insulation are needed to achieve the R-value specified on the bag's label.
- Inspect walls for evidence of moisture damage. If an inspection of the siding, sheathing, or interior wall finish shows a moisture problem, don't install sidewall insulation until the moisture problem is identified and solved.
- Inspect indoor surfaces of exterior walls to assure that they are strong enough to withstand the force of insulation blowing. Reinforce interior sheeting as necessary.
- Inspect for interior openings or cavities through which insulation may escape. Examples include balloon-framing openings in the attic or crawl space, pocket doors, unbacked cabinets, interior soffits, and openings around pipes under sinks and closets. Seal these openings to pre-vent insulation from escaping the wall cavity.
- If exterior wall cavities are being used as return or supply ducts, run new ducts somewhere else before insulating the cavity. If metal ducts are run in exterior walls, either avoid insulating these cavities or run a new duct somewhere else before installing insulation. Address existing building durability issues due to moisture in these cavities as they relate to the ducts before insulating.
- Don't insulate cavities containing knob-and-tube wiring.

Patching and Finish after Insulating
The insulators, the home owner, and others should agree about the patching method and the final appearance of the wall finish. The insulators are usually responsible for patching holes and returning the interior or exterior finish to its previous condition or some pre-agreed level of finish.

- Patch the exterior wall sheathing with wood plugs, plastic plugs, or spray foam insulation.
- Use caulk or putty and primer to dress exposed exterior plugs.
- Seal gaps in external window trim and other areas that may admit rain water into the wall.
- Patch interior finish with standard plastering or similar "paint ready" methods.
- Install drywall with joint compound to open cavities to comply with MRC fire codes.

Wall Insulation Quality Control
Insulation will be verified to prevent visible air movement using any of the following:

- Viewing the wall through an infrared camera during depressurization testing of at least -10 Pa, when tempera-ture difference between indoors and outdoors is adequate to achieve good images.
- Looking through an electrical outlet or other access hole for insulation in multiple representative sample locations.
- Calculating installed weight of insulation compared to wall-cavity volume and required density.
- Using chemical smoke at 50 pascals of pressure difference.

Drilling Exterior Sheathing: Insulation Retrofit
Avoid drilling through siding. Where possible, carefully remove siding and drill through sheathing. This procedure avoids the potential lead-paint hazard of drilling the siding. Drilling through only the sheathing also makes it easier to insert flexible fill tubes since the holes pass through only one layer of material.
If you can't remove the siding, consider drilling the walls from inside the home. Obtain the owner's permission before drilling indoors, and practice lead-safe weatherization procedures. Consider these possible methods of removing siding:

- Cut completely through the paint on wood-siding joints with a sharp utility knife before carefully prying the siding off.
- Remove asbestos shingles by pulling the nails holding the shingles to the sheathing, or else cut off the nail heads. Dampen the asbestos tiles to reduce dust. Wear a respirator and coveralls when working with asbestos siding.
- Use a zip tool to remove metal or vinyl siding.
- Insulate homes with brick veneer or blind-nailed asbestos siding from the indoors.

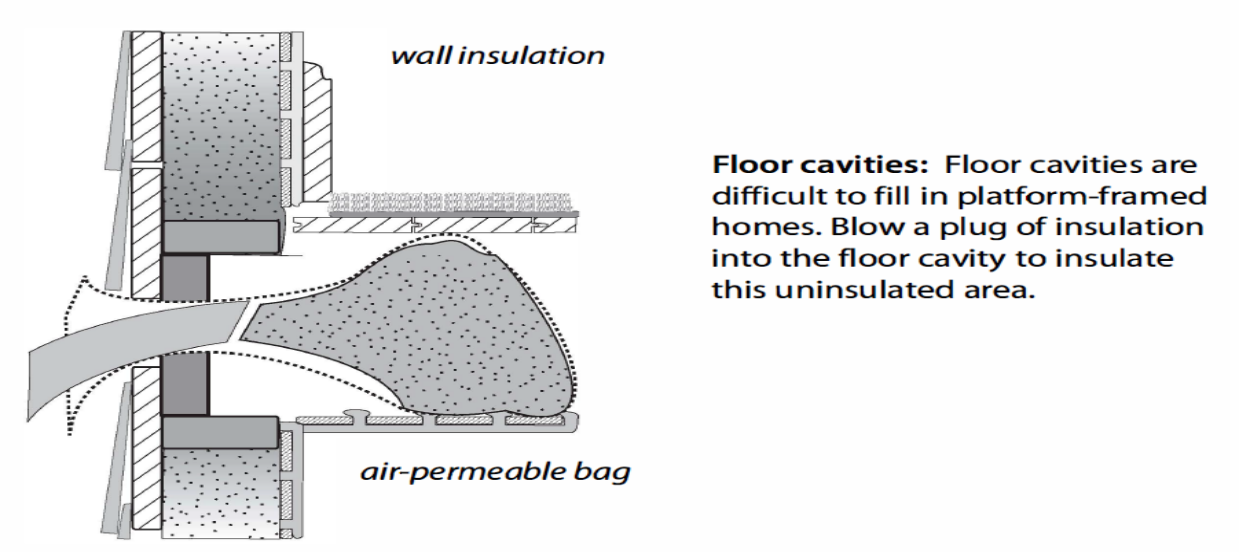
Restore holes drilled for insulation to an appearance as close to original as possible, or in a manner that is satisfactory to the client.
Blowing Walls with a Fill-Tube
Install dense-pack wall insulation using a blower equipped with separate controls for air and material feed. Mark the fill tube in one-foot intervals to help you verify when the tube reaches the top of the wall cavity. To prevent settling, cellulose insulation must be blown to at least 3.5 pounds per cubic foot (pcf)

density. Fiberglass dense-pack must be 2.2 pcf or to manufacturer's specifications and the fiber-glass material must be designed for dense-pack installation. Insulate walls using this procedure.

1. Drill 2-to-3-inch diameter holes to access the stud cavity
2. Probe all wall cavities through holes, before you fill them with the fill tube, to identify fire blocking, diago-nal bracing, and other obstacles.
3. Start with several full-height, unobstructed wall cavities so you can measure the insulation density and calibrate the blower. An 8-foot cavity (2-by-4 on 16-inch centers) should consume a minimum of 10 pounds of cellulose or 6 pounds of fiberglass. An experienced installer should fill be able to fill an 8 foot cavity (2-by-4 on 16 inch centers) in 2- 4 minutes. Monitoring time is important for production, but it can also be an indicator that the machine is set up properly. More critically, you determine if the insulation that you're installing hasn't blown out the cavity that you're filling.
4. Insert the hose all the way to the top of the cavity. Start the machine, and back the hose out slowly as the cavity fills.
5. Then fill the bottom of the cavity in the same way.
6. After probing and filling, drill whatever additional holes are necessary for complete coverage. For example: above windows, missed areas with fire blocking.
7. Use the blower's remote control to achieve a dense pack near the hole while limiting spillage.
8. Seal and plug the holes, repair the weather barrier, and replace the siding.

Insulating the Wall-Floor Junction of Two-Story Walls

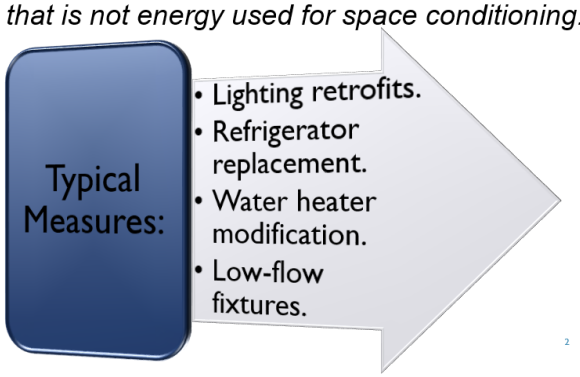
When insulating the perimeter of walls between the first and second floors, blow an insulation plug into the perimeter floor cavities for both thermal resistance and airflow resistance. This method is particularly effective for platform-framed walls because the wall insulation is discontinuous at the floor cavity unless you drill and blow through the rim joist there. This insulation plug prevents the floor cavity from being a ther-mal bridge and an air-leakage conduit. Using a fill tube, blow the insulation into a air-permeable bag that expands inside the cav-ity. The bag limits the amount of insulation necessary to insulate the floor perimeter.

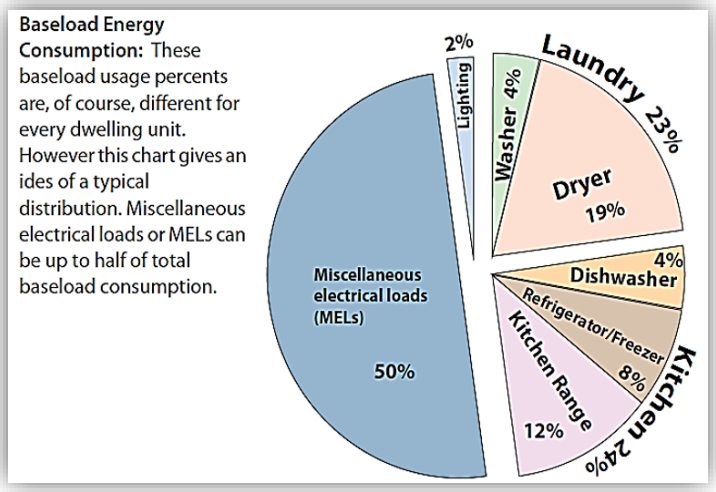


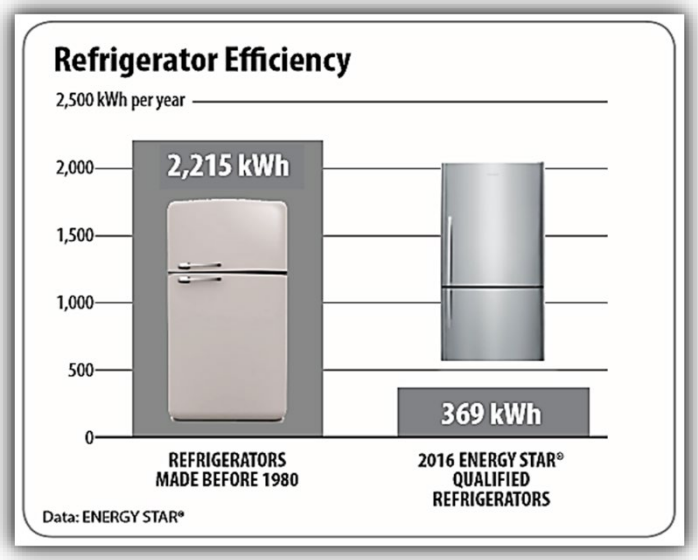
Baseloads

Base Load:

The energy used by electric or gas appliances in a home that is not energy used for space conditioning.







CLEAN REFRIGERATOR COIL

Even if replacement is not an option, some savings are possible.

	Average	High
Energy Savings	36 kWh/yr	200 kWh/yr
$ Savings*	$3.96/yr	$22.00/yr
Frequency of coil cleaning	Once/year, 3% savings	Never been cleaned

** Savings based on $0.11/kWh*

WAP Refrigerator Replacement

- Will be cost cost-effective, Based on metering or recognized database
- Will be 40% more efficient than the minimum federal standards or be labeled ENERGY STAR.
- Refrigerators that are replaced go to a facility that is licensed to reclaim refrigerant and recycle the unit.
- No refrigerator, taken out of service, may be returned to service by sale, barter, or for free.

Notes:_____

CLOTHES DRYERS SERVICE AND VENTING

- CLOGGED CLOTHES-DRYER VENTS ARE A LEADING CAUSE OF HOUSE FIRES.
- DRYING TIME OF A LOAD OF LAUNDRY DEPENDS FIRST ON THE DRYER INSTALLATION.
- THE ORIGINAL INSTALLATION CAN ALSO CAUSE EXCESSIVE DRYING TIME WHEN FLEXIBLE VENTS ARE EXCESSIVELY LONG, KINKED, OR RESTRICTED.
- THE AMOUNT OF LINT IN THE DRYER, VENT PIPING, AND VENT TERMINATION ALSO AFFECTS DRYER SAFETY AND EFFICIENCY.
- LINT BUILDS UP OVER TIME AND SLOWS DRYING TIME AND INCREASES THE FIRE HAZARD.

Venting requirements for clothes dryers

- *Clean lint from the dryer and vent system when making modifications or improvements*
- *Dryer vents should be piped in 4-inch-diameter rigid aluminum or galvanized pipe*
- *Don't use screws or rivets to join rigid pipe sections*
- *Exhaust venting duct must be supported at maximum 4-foot intervals.*
- *Use short, stretched pieces of flexible metal dryer vent, labeled UL 2158A, to connect the dryer to allow dryer to be moved in and out.*
- *Make connections in the direction of exhaust flow*
- *Seal duct connection with foil tape labeled UL 181*
- *Insulate all dryer vents that run through unconditioned spaces to a minimum R-8.*
- *When calculating duct length, add 5 feet for each 90º bend and 2.5 feet for each 45º bend.*
- *Provide make-up air if you measure excessive depressurization or if the dryer moves 200 CFM or more*
- *Dryer terminations will not have a pest screen or other obstruction which could catch lint and hinder air flow.*

Notes:

WATER-HEATING ENERGY SAVINGS

The most important tasks in evaluating hot water energy savings are determining the water heater's insulation level, measuring the shower's flow rate, and measuring the water temperature.

Some manufacturers set water heater thermostats at 140ºF, most households usually only require them to be set at 120ºF, which also slows mineral buildup and corrosion in your water heater and pipes. Water heated at 140ºF also poses a safety hazard—scalding.

insulating hot water heaters is an easy and inexpensive way to improve energy efficiency

- reduces standby heat losses by 25%–45%
- saves about 7%–16% in water heating costs

Number of Residents	Annual kWh	Annual Therms	Gallons Per Day
1	2700	180	25
2	3500	230	40
3	4900	320	50
4	5400	350	65
5	6300	410	75
6	7000	750	85

Notes:_____

Water Conservation Devices

Our clients use water in their homes at several outputs.

- Showers
- Kitchen sink
- Bathroom faucets
- Toilets

Each of these points of water use has opportunities for water conservation.

Showers

Low flow shower heads reduce water consumption from as much as 4.0 GPM to as little as 1.5 GPM. The Evolve Shower head is not only low flow, it has a hot water shut off mechanism where a homeowner can leave the hot water running in a shower and once the water becomes hot, the shower head will automatically close shut until the valve is released ready for use.

Kitchen sink and Bathroom faucets

Low flow aerators reduce kitchen sink water consumption from 2.0 - 3.0 GPM to 1.5 GPM.
Low flow aerators can be installed in bathroom faucets to reduce flow to as low as 1.0 GPM.

Toilets

Dual flush toilets reduce the amount of water per use from 3.0 gallons per flush to 1.0 gallons per flush. Although weatherization generally does not replace toilets, there are other options that go along with client education.

Notes:_____

Guidance for Spot-Type DC Smoke Detectors

SWS

☐	2.0301.1b Smoke alarm (battery operated)	When installing battery operated smoke alarms, it will be installed in accordance with manufacturer specifications	Ensure proper installation

NFPA 72

17.7.3.2* Spot-Type Smoke Detectors.

17.7.3.2.1* Spot-type smoke detectors shall be located on the ceiling or, if on a sidewall, between the ceiling and 12 in. (300 mm) down from the ceiling to the top of the detector.

17.7.3.2.3.2 In all cases, the manufacturer's published instructions shall be followed.

GENERIC SMOKE ALARM USERS GUIDE

(In existing one and two-family dwelling units, approved smoke alarms powered by batteries are permitted)

- When mounting the alarm on the wall, use an inside wall with the top edge of the alarm at a minimum of 4" (10 cm) and a maximum of 12" (30.5 cm) below the ceiling.
- Put smoke alarms at both ends of a bedroom hallway or large room if the hallway or room is more than 30 feet (9.1 m) long.
- Install Smoke Alarms on sloped, peaked or cathedral ceilings at or within 3ft (0.9m) of the highest point (measured horizontally).

MOBILE HOME INSTALLATION

Modern mobile homes have been designed and built to be energy efficient. Install smoke alarms as recommended above. In older mobile homes that are not well insulated compared to present standards, extreme heat or cold can be transferred from the outside to the inside through poorly insulated walls and roof. This may create a thermal barrier which can prevent the smoke from reaching an alarm mounted on the ceiling. In such units, install the smoke alarm on an inside wall with the top edge of the alarm a minimum of 4" (10 cm) and a maximum of 12" (30.5 cm) below the ceiling.

If you are not sure about the insulation in your mobile home, or if you notice that the outer walls and ceiling are either hot or cold compared to the room air temperature, install the alarm on an inside wall. NFPA 72 (National Fire Protection Association) requires smoke alarms be installed in each sleeping area.

RECOMMENDED LOCATIONS FOR ALARMS

- Locate the smoke alarms in all sleeping areas. Try to monitor the exit path as the bedrooms are usually farthest from the exit. If more than one sleeping area exists, locate additional alarms in each sleeping area.
- Locate additional alarms to monitor any stairway as stairways act like chimneys for smoke and heat.
- Locate at least one alarm on every floor level.
- Locate an alarm in every bedroom.
- Locate an alarm in every room where electrical appliances are operated (i.e. portable heaters or humidifiers).
- Locate an alarm in every room where someone sleeps with the door closed. The closed door may prevent an alarm not located in that room from waking the sleeper.
- Smoke, heat, and combustion products rise to the ceiling and spread horizontally. Mounting the smoke alarm on the ceiling in the center of the room places it closest to all points in the room. Ceiling mounting is preferred in ordinary residential construction.

LOCATIONS TO AVOID

- In the garage. Products of combustion are present when you start your automobile.
- Normal cooking may cause nuisance alarms. If a kitchen alarm is desired, it should have an alarm silence feature or be a photoelectric type.
- Do not install within 6 ft. of heating or cooking appliances.
- Less than 4" (10cm) from the peak of an "A" frame type ceiling.
- In an area where the temperature may fall below 40°F or rise above 100°F, such as garages and unfinished attics.
- In dusty areas. Dust particles may cause nuisance alarm or failure to alarm.
- In very humid areas. Moisture or steam can cause nuisance alarms.
- In insect-infested areas.
- Smoke alarms should not be installed within 3 ft (.9m) of the door to a bathroom containing a tub or shower, forced air supply ducts used for heating or cooling, ceiling or whole house ventilating fans, or other high air flow areas.
- Near fluorescent lights. Electronic "noise" may cause nuisance alarms.
- Do not install near vents, flues, chimneys or any forced/unforced air ventilation openings
- Do not install near fans, doors, windows or areas directly exposed to the weather.

CAZ Door

Open

Closed

FORCED AIR BLOWER

Off

Negative number ①

Causes:
- Exhaust appliances

Repairs:
- Eliminate/reduce CFM of exhaust
- Isolate appliances/CAZ from exhaust
- Replace the combustion appliances
- Provide make-up air (not realistic)

More negative from #1 ②

Causes:
- Exhaust appliances in the CAZ or affecting the CAZ

Repairs:
- Eliminate/reduce CFM of exhaust
- Isolate appliances/CAZ from exhaust – interior and exterior connections
- Replace appliances – sealed combustion furnaces, electric or power vented water heaters, etc.
- Pressure relieve CAZ to the house
- Provide make-up air (not realistic)

On

More negative from #1 ③

Causes:
- Supply duct leakage to the exterior of the structure
- Interior door closure

Repairs:
- Seal supply ducts
- Pressure relieve interior rooms

More positive

Causes:
- Return duct leakage to the exterior of the structure
- Interior door closure

Repairs:
- Seal return ducts
- Pressure relieve interior rooms

More negative from #3 ④

Causes:
- Return duct leakage in the CAZ

Repairs:
- Seal return ducts in the CAZ

More positive

Causes:
- Supply duct leakage in the CAZ

Repairs:
- Seal supply ducts in the CAZ

Baseline (Stack Effect) is present in each quadrant – neg or pos

CAZ (Combustion Appliance Zone) Pressure Test Procedure

Step 1

☐ Make sure combustion appliances are unable to operate during set-up
☐ Remove forced air furnace filter (replace cover)
☐ Close all windows, doors, and other openings to the exterior of the structure
☐ Close fireplace and woodstove dampers
☐ Set up a gauge to read CAZ pressure with reference to (WRT) the outside

Record the baseline CAZ pressure: ☐ Pa (can be done CAZ door both open and closed)

☐ Turn on clothes dryer and all exhaust fans
☐ Use a blower door to simulate fireplace flow as needed (300 cfm or appropriate)
☐ Open supply registers in the house – close the registers in the CAZ
☐ Close all interior doors off the main body except to rooms that contain an exhaust fan

Obtain two CAZ pressure measurements with the forced air blower OFF: One with the CAZ door open and one with the door closed (long term averaging makes this process quicker).

	CAZ Door	
	① **Open**	**Closed** ②
Fan **OFF**	☐ Pa	☐ Pa

Note: There will be from 1 to 4 pressure measurements taken depending upon whether a blower or CAZ door exists.

Step 2

☐ Operate the forced air system blower (on the highest speed it can be expected to operate)
☐ Close the doors to rooms with exhaust fans and smoke/pressure test the rooms to determine the appropriate door position (testing is done with the CAZ at your back)
☐ Also, smoke/pressure test the doors to bedrooms that contain return ducts
☐ Reposition the doors as necessary (positive pressure in rooms – door closed, negative pressure in rooms – door open)

Obtain two CAZ pressure measurements with the forced air blower ON: One with the CAZ door open and one with the door closed.

	CAZ Door	
	③ **Open**	**Closed** ④
Fan **ON**	☐ Pa	☐ Pa

Note: For diagnostics, subtract the baseline pressure to get the actual level of depressurization due to exhaust fans, ducts, or doors.

The greatest negative pressure measured in any of the four quadrants would be considered “worst case” depressurization conditions for operational testing of combustion appliances.

- Diagnostics can now be performed using the four quadrant measurements to determine potential causes and appropriate repairs.

IMPORTANT:

- Any time you encounter a door you are unsure about positioning (ex: a bathroom in a bedroom or a CAZ with a door in a basement with a door at the top of the stairs), smoke/pressure test the door to determine its position. Complete twice – once with the fan on and once with the fan off.
- This procedure will cover most houses most of the time. Understand the concepts and apply them as needed in more complicated houses.

Key BPI 1200 Standards

70 ppm or greater	36 ppm-69 ppm	9 ppm- 35 ppm
• Terminate the inspection. • Notify the homeowner -occupant of the need for all building occupants to evacuate the building. • Leave the building and the appropriate emergency services shall be notified from outside the home.	• Advise the homeowner -occupant that elevated levels of ambient CO have been detected. • Open windows and doors. Recommend that all possible sources of CO be turned off immediately. • Where it appears that the source of CO is a permanently installed appliance, recommend that the appliance be turned off and advise homeowner – occupant to contact a qualified professional.	• Advise the homeowner - occupant that CO has been detected. • Recommend that all possible sources of CO be checked and windows and doors opened. • Where it appears that the source of CO is a permanently installed appliance, advise the homeowner - occupant to contact a qualified professional.

Spillage assessment and CO measurement results shall be based on the following criteria:

- **CO measured at 5 minutes of main burner operation**
- **Spillage assessed at 2 minutes of main burner operation for warm vent**

TABLE D.1.A ACTION LEVELS FOR SPILLAGE IN COMBUSTION APPLIANCES **The following actions shall be taken when spillage occurs under the specific circumstances detailed below.**	
TEST RESULT	ACTION REQUIRED
Greatest CAZ depressurization occurs with the air handler on*	Conduct further analysis of the distribution system to determine if leaky ducts or other HVAC-induced imbalances are the cause of the spillage. If so, recommend distribution system repairs that will reduce or eliminate the CAZ depressurization.
Greatest CAZ depressurization occurs with door to CAZ closed, but is alleviated when door to CAZ is open*	Recommend measures to improve air transfer between the CAZ and the core of the house
The cause of spillage has been traced to excessive exhaust** independent of CAZ door position, air handler, or a problem with the flue†	Verify that sufficient combustion air is available per *ANSI Z223.1/NFPA 54* for gas-fired appliances and *NFPA 31* for oil-fired appliances or recommend verification by a qualified professional and/or Recommend further evaluation/service by a qualified professional to address the venting/combustion air issues

Appliance	Threshold Limit
Central Furnace (all categories)	400 ppm air free[4]
Water Heater	200 ppm air free
Oven/Broiler	225 ppm as measured

TABLE D.1 B. ACTION LEVELS FOR CO IN COMBUSTION APPLIANCES	
TEST RESULT	ACTION REQUIRED
Unacceptable CO level	Advise the homeowner/occupant that the appliance should be serviced immediately by a qualified professional Note: If ambient CO levels do not exceed 70 ppm, testing of other appliances and other audit procedures may continue at the discretion of the auditor
Acceptable CO level	No action required

Blower Door and Diagnostic Basics Key Points

Michigan Training & Education Center

BLOWER DOOR TESTING

- Blower door testing is used to locate air leakage by using a fan to generally depressurize a house.
- Air leakage measured by the blower door is related to the size of the holes in the homes pressure boundary
- Blower door testing is done before and after air sealing to determine the effectiveness of our work.
- Blower door testing gives us an idea of potential for energy savings through air sealing.

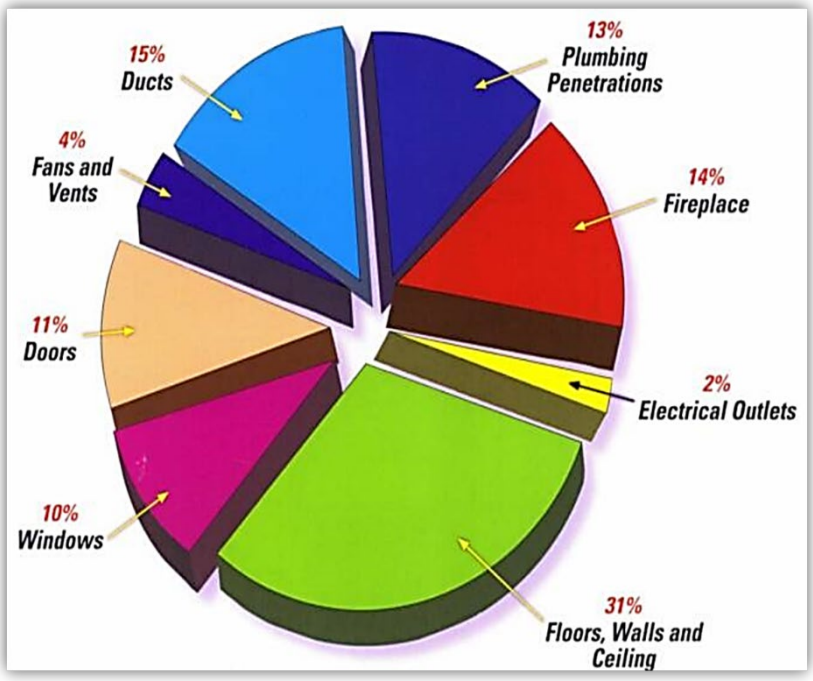
UNITS FOR MEASURING AIRFLOW

Cubic feet per minute (CFM)

- Rate of airflow
- Based on the size of a house and the number of occupants, a house should have a certain amount of fresh air when in winter mode.

CFM_{50} (standard for blower door)

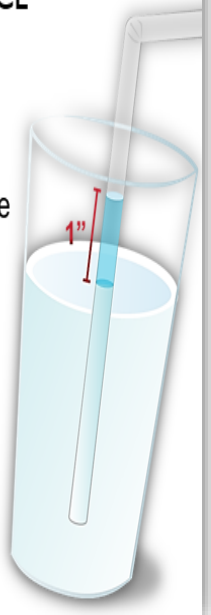
- Blower door measures the rate of airflow in CFM when the pressure difference between the inside of the house with reference to outside is -50 Pascals.



MEASURING PRESSURE DIFFERENCE

Pascal (metric standard)

- 1 Pascal = weight of one Post-It note
- 249 Pascals = 1 in. water column (American standard)
- 1 in. water column = pressure required to suck ½ in. of water up a straw



BLOWER DOOR SETUP

- Set up blower door in an exterior door.
- Put house in winter mode
- Turn off heating/cooling system and gas water heaters.
- Close fireplace dampers.
- Make sure no wood stoves are in use!
- Remove ashes or cover with wet newspaper.

Blower door setup

Blower Door Depressurization Test

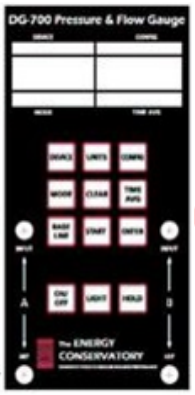
1) Mode to PR/FL @50PA

2)Device to BD 3 (default setting)

3) Configure to ring setting as needed

4) Baseline

(hit Baseline then start wait 10 seconds hit enter)



Right INPUT to fan

Left REF outside

- With fan cover on, press baseline button, press start button (let baseline settle 10 sec minimum), press enter button (ADJ will appear on channel A under the pressure measurement)

- Once you are comfortable with the reading (nothing within the pressure boundary has changed since setup) Record the reading or save to list if using WIFI adaptor

NOTES:_____
_____
_____
_____
_____

Using a Pressure Pan To Diagnose Duct Leakage

- A pressure pan is a duct leakage diagnostic tool used along with a Blower Door to identify exterior air leaks in forced air duct systems.
- Pressure pans do not directly measure leakage rates, they measure the pressure difference between the house and a duct run during a Blower Door test.
- This pressure reading can be used to estimate the degree to which a duct run is connected to the outside.
- Pressure pan testing involves placing a gasketed pan over each register one at a time, with the air handler fan off.
- The pattern of pressure pan readings allows for quick identification of major leakage sites.
- Pressure pan readings can also be used as a quality control tool to tell technicians if they have done a good job of air sealing the duct system.

Pressure pan

1) Mode to PR/PR on a second DG700

2) With blower door @50PA

3) Pan can be used over registers, can lights, outlets,

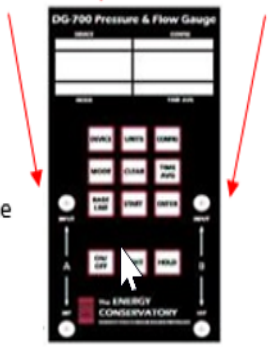
anything that way be communicating with outside

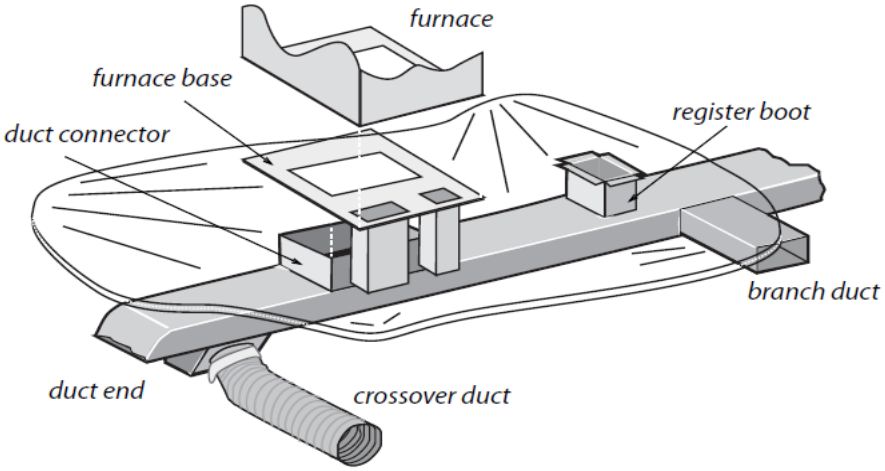
4) Zonal pressure testing is same without pan and to isolated areas of home

with hose to that's room/area

0 - 10 Pa Inside
11 - 39 Pa Confused
40 - 50 Pa Outside

Hose to input on either side





Mobile home ducts: Mobile home ducts leak at their ends and joints — especially at the joints beneath the furnace. The furnace base attaches the furnace to the duct connector. Leaks occur where the duct connector meets the main duct and where it meets the furnace. Branch ducts are rare, but easy to find, because their supply register isn't in line with the others. Crossover ducts are found only in double-wide and triple-wide homes.

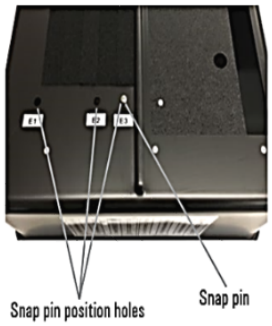
Exhaust Fan Flow Meter™

- The Energy Conservatory's Exhaust Fan Flow Meter is designed to make accurate measurements of air flow through exhaust fans.
- The air flow measurement range for the Exhaust Fan Flow Meter is 10 to 124 CFM with an accuracy of the exhaust fan flow measurement is +/- 10%.
- During the measurement procedure, the Exhaust Fan Flow Meter is placed tightly over the exhaust fan
- The pressure reading is converted to air flow in CFM using a flow table attached to the side of the Metering Box.
- The manometer can also be set up to display air flow readings directly in CFM.
- The Exhaust Fan Flow Meter has 3 calibrated openings to provide an accurate measurement of most exhaust fans.

Set the door position on the metering box

The metering box comes with an adjustable opening which provides three ranges of fan flow measurement.

The door position is determined by the position of the snap pin located on the top of the metering box. The door position can be adjusted by pushing down on the snap pin and sliding the door until the snap pin is in a new position hole.



Door Position	Flow Range in CFM
E1	44 - 124
E2	21 - 59
E3	10 - 28

Door Position	CONFIG Icon on DG-700
E1	A1
E2	B2
E3	C3

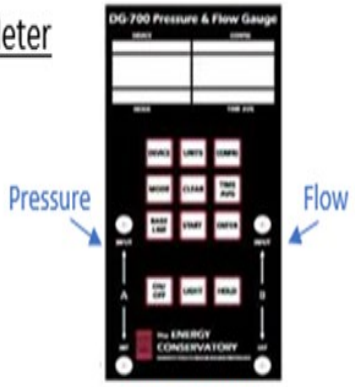
Flow Meter

1) Mode to PR/FL

2) Device to EXH

3) Configure to match slide gate setting

4) Put meter up to fan read measurement in CFM
Cross-reference pressure to chart on flow meter



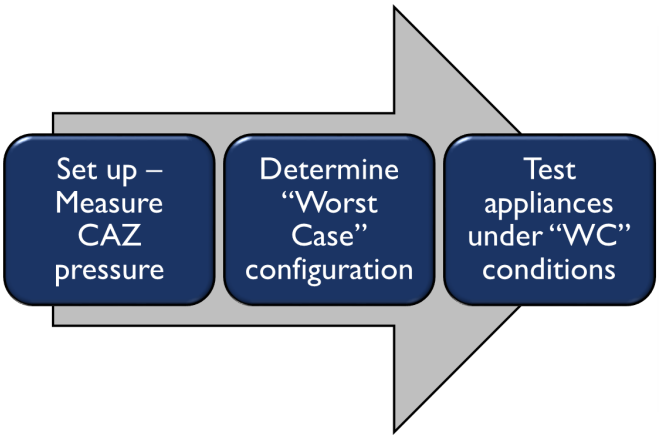
USE SPLITER

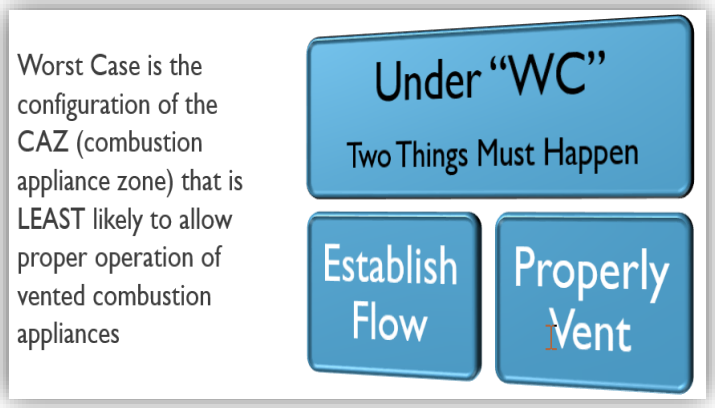
Notes:

Michigan Training & Education Center

CAZ = Combustion Appliance Zone

- Open combustion heating equipment has the potential to allow Carbon Monoxide and other poisonous combustion by-products into your indoor environment
- A combustion appliance zone test is a method of determining whether this could happen under certain "worst case" or natural conditions,
- A combustion appliance zone test should always be performed when air sealing is done on a home
- We perform CAZ testing in our everyday building performance operations to ensure safety.





CAZ Testing

Set up home for CAZ Testing

- ✓ Make sure combustion appliances cannot operate during set-up
- ✓ Remove forced air furnace filter (replace cover)
- ✓ Close all windows, doors and other openings to the exterior of the structure
- ✓ Close fireplace and woodstove dampers

Set up manometer tubing

- Setup gauge to PR/PR
- On channel A
- Input port open to CAZ
- Reference port hose to outside

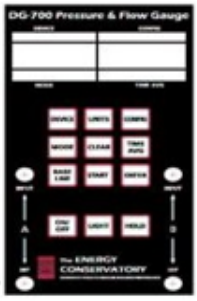
CAZ Depressurization test

CAZ WRT Outside

Set to PR/PR

INPUT port open to CAZ

REF tube to outside



NOTES:_____

_____

_____

_____

There are many variables in testing

When done correctly, these 4 pressure measurements taken from the CAZ WRT outside considers all possible cause scenarios

CAZ Door

Open **Closed**

- **Fan Off:** _____ Pa _____ Pa
- **Fan On:** _____ Pa _____ Pa

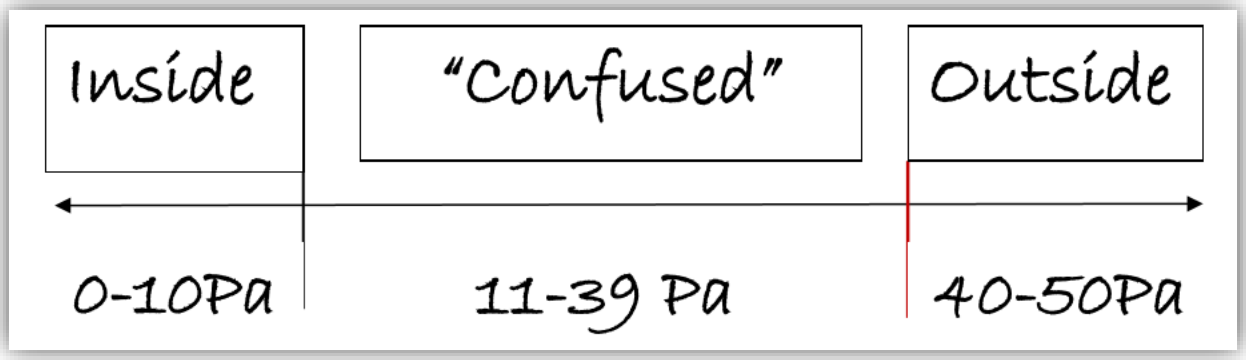
What do the numbers mean?

Air Handler	CAZ Door **Open**	CAZ Door **Closed**
Off	• Exhaust fans	• Exhaust fan either in the CAZ or affecting the CAZ
On	*Negative number*: • Supply duct leakage to the outside • Interior door closure *Positive number*: • Return duct leakage to the outside • Interior door closure	*Negative number*: • Return duct leak in the CAZ *Positive number*: • Supply duct leak in the CAZ

Baseline is present in each quadrant – neg or pos

ZONE PRESSURE DIAGNOSTICS (ZPD)

Zone Pressure Diagnostics are tests that show us where the actual air barriers of the home are located. Up to this point, we generally assume that the sheetrock on the inside of the exterior walls, the ceiling and the floor make up the surfaces that separate the inside conditioned air from the outside. Zonal tests will demonstrate where the air barriers are located in reality. You cannot visually see air barriers, but your manometer can. When determining air barriers, there is a scale that tells you what is inside the pressure boundary and what is outside that boundary, and what is neither in nor out, but 'confused'.



PRESSURE DIAGNOSTIC PROCEDURE

Connect a hose to the input tap of your manometer with the reference tap exposed. Connect the other end of the hose to a probe or pressure pan. Operate the blower door to create a 50 Pascal pressure difference with reference the outside. You can begin testing any areas you suspect may have faulty pressure boundaries as well as verifying areas where the pressure boundary should in fact be.

Appropriate areas to test may be:

1. Drop soffits
2. Chases
3. Interior walls
4. Archways
5. Built-in cabinets
6. Ceilings
7. Floors
8. Interior walls alongside staircases
9. Attached garages

In general, test any area where you are curious about a level of connection to the exterior.

If you have attended quality professional building science training, you will know that the pressure boundary should always be continuous and in direct contact with the thermal boundary. When the pressure and thermal boundaries are not in alignment with each other the effective R value of that assembly can be greatly diminished due to air movement through the assembly.

The thermal boundary must be 100% continuous around the envelope of the building (exterior walls, floor and ceiling) and the pressure boundary must be 100% continuous around the envelope, and most importantly, the pressure boundary and the thermal boundary must be in 100% contact with each other to perform properly. While your eyes can locate the thermal boundaries, only your manometer and blower door can locate the pressure boundaries. So take lots of tests. Find the pressure boundaries everywhere in that home and determine if it is in contact with the thermal boundary.

ROOM PRESSURE TESTING

This test is designed to identify pressure imbalances in the homes with forced air systems when interior doors are closed, and the air-handler is operated.

The procedure for this test is simple:

- Operate the air handler
- Make sure all supply and return openings are fully open
- Connect a hose to the input tap on your manometer
- Place the other end of the hose a few feet into the room
- Close door and record the pressure number and whether it positive or negative

If the difference between the bedroom and central zone is more than 3.0 pascals with the air handler operating, pressure relief is desirable. There will be times, particularly in tighter dwellings, that door closure will cause a pressure imbalance in the main body even if the rooms are 3.0 pascals or less. Because this can cause a variety of problems, consider the following:

- Any time the central area of the home changes pressure with reference to outside due to interior door closure, consider pressure relief regardless of the pressure change. This considers other potential issues such as building durability, comfort and efficiency.
- Measure and record the main body pressure when you perform room pressure measurements.

To estimate the amount of pressure relief needed, slowly open the bedroom door until the pressure difference drops below 1 pascal. Estimate the surface area of that door opening. This is the area of the permanent opening required to provide pressure relief. Pressure relief may include undercutting the door, installing transfer grilles or installing jumper ducts. Another, more expensive, option would be to install a dedicated return duct directly to the problem room.

Infrared Thermography Key Points

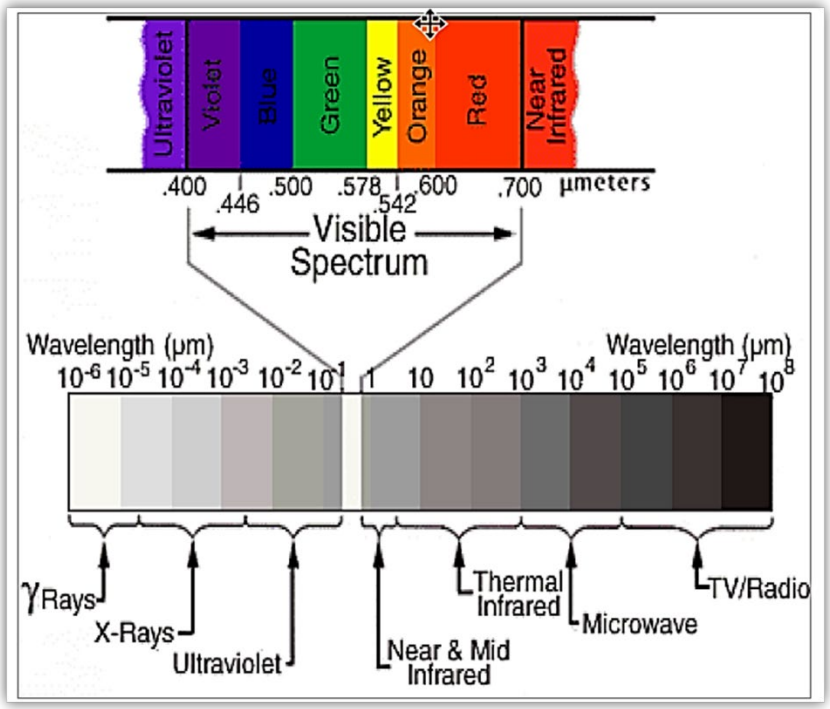
Michigan Training & Education Center

What is an infrared camera?

- IR cameras are non-contact devices that detects infrared energy and then quantify an images, also known as a thermographic camera
- IR cameras uses wavelengths longer than visible light to create images even in total darkness
- IR cameras works by detecting the amount of radiation being emitted from an object based on its temperature.
- Standard IR cameras show image intensity based on the color spectrum

Warmer temperature = Intense/brighter

Cooler temperature = dull/darker



Kirchhoff's Law: E+T+R=1

Emitted Energy + Transmitted Energy + Reflected Energy = 1

(in most cases E+R=1)

Good Emitter = Poor Reflector

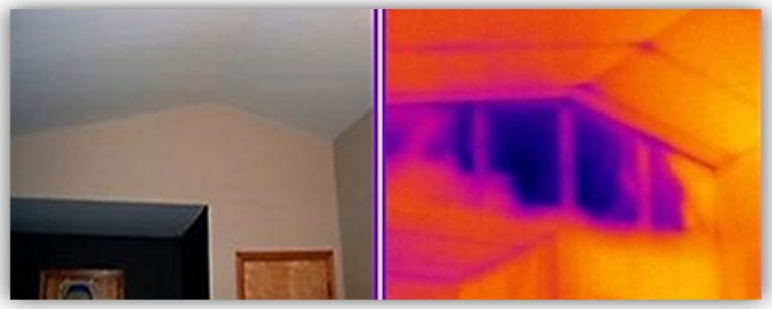
Good Reflector = Poor Emitter

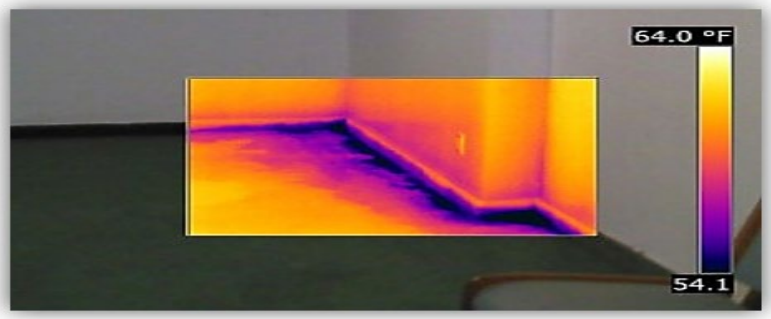
Notes:_____

Infrared Capability

IR cannot see through anything.

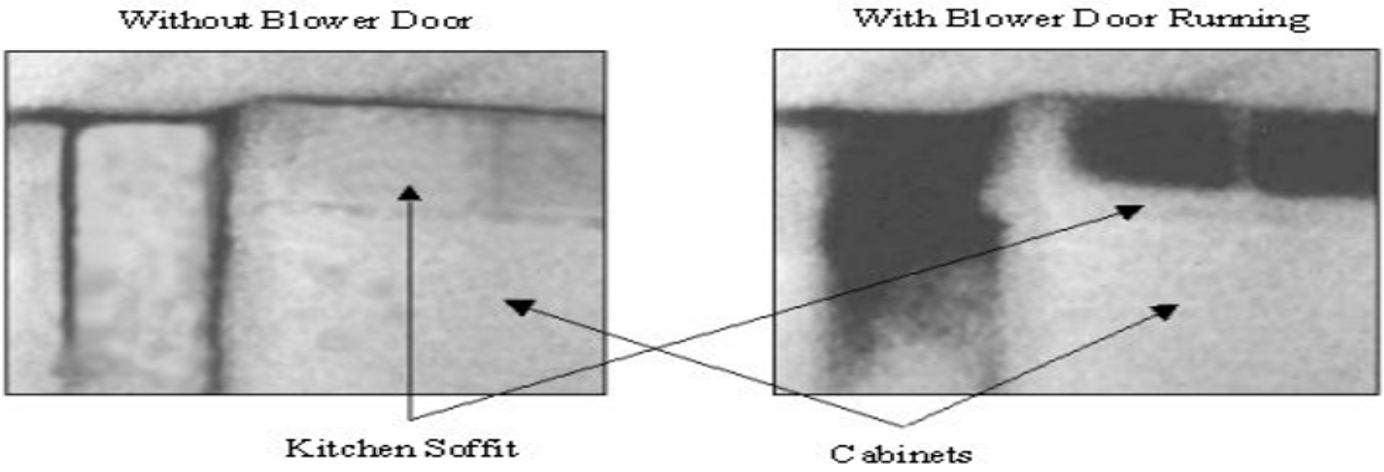
- Sees surface temperatures only
- Cannot see color
- Cannot see air





Air Leakage Path investigation

- Blower Door with an Infrared Camera
- View wall before Blower Door Test
- View wall with Blower Door running



Notes:_____