MONTANA FIELD GUIDE

Weatherization of Site-Built Homes

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INTRODUCTION

This field guide highlights the most common and critical details for the weatherization and upgrade of site-built homes in Montana. This document was produced for the Montana Weatherization Assistance Program (WAP) as administered by the Montana Department of Health and Human Services (MDHHS), but it provides relevant guidance for the improvement of any homes in the region.

The procedures described in this field guide are generally aligned with the Standard Work Specifications (SWS) that are published by the National Renewable Energy Laboratory (NREL). In the interest of brevity, we do not include all details from the SWS here, but instead we offer what we believe is sufficient detail for most field technicians to complete their work competently and according to the Montana program standards.

This document was produced by the Montana Weatherization Training Center in Bozeman, Montana — where you can get hands-on training on all aspects of the weatherization, home performance, and renewable energy industries.

MT Dept of Public Health & Human Services
http://dphhs.mt.gov/

The Standard Work Specifications (SWS)
https://sws.nrel.gov/

Learn More at WxTV

If you want to learn more about weatherizing all types of homes, and doing all other types of weatherization work, visit WxTV and check out the video tutorials.

WxTV: The Learning Resource
http://wxtvonline.org/

RESOURCES

To learn more about the implementation of the weatherization program in Montana, see the **State of Montana Weatherization Manual**.

http://www.weatherization.org/documents/MT_WAP_Manual.pdf

The Quality Work Plan, updated each year, includes operational guidance for the Montana weatherization program. Review this document to learn about standards for communication, inspection and monitoring, training, and program variances.

Available upon request from the Weatherization Training Center.

HEALTH & SAFETY

Like all trades people, weatherization workers can be exposed to hazards in the workplace. Weatherization clients can also be exposed to home hazards that existed before the crew arrived, or to hazards created when performing weatherization work. This chapter shows you how to reduce hazards in all these situations, and for both worker and occupants.

SWS 2.0100—Safe Work Practices
https://sws.nrel.gov/spec/20100

PERSONAL PROTECTIVE EQUIPMENT

You are required to use personal protective equipment (PPE) to work safely as a home energy professional. It's also just a good idea. OSHA regulations also require that supervisors provide PPE, and the training to show you how to properly use it. Every job site should also have Safety Data Sheets (SDS) available that describe all caulks, sealants, foams, and other potentially hazardous materials on the jobsite.

Proper personal protective equipment (PPE) should be supplied to all workers to reduce injuries and avoid exposures to lead, mold, asbestos, pests, and other hazardous items. At a minimum, each worker should have access to the following equipment, and receive training in how to use it correctly.

Hard Hats. Wear a hard hat if you're apt to bump your head or be struck by falling objects.

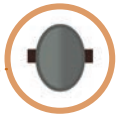
Gloves. Wear durable gloves that protect your wrists and can withstand the work y ou're doing. When working with mastic or foam, wear nitrile gloves. Save your hands!

Personal CO Monitor. Wear a personal CO monitor to warn you if carbon monoxide is present. This stuff can sicken or kill you!

Closed Toed Shoes or Boots. Wear closed-toed shoes or boots to save your feet. The pros wear boots with steel shanks and steel toes.

Glasses, Goggles & Masks. Wear proper eye gear for the job you're performing. It only takes one second to become blinded for life.

Respiratory Protection. Wear proper respiratory protection if you can't reduce the risk of airborne contaminants. Learn about proper respirator types below.



Knee Pads. Use your knee pads so you can work more quickly, be more comfortable, and avoid tearing up your knees.

Respiratory Protection

The best way to avoid exposure to airborne contaminants is to avoid creating them in the first place. If you can't avoid disturbing contaminants, proper respiratory protection must be worn.

- All forms of respirators (including filtering facepieces or "paper masks") require fit testing and a cleanly-shaven face. The only exception is if you're using a powered air purifying respirator (PAPR).
- For most jobsite dust, the appropriate protection is a filtering facepiece rated for N-95 or equivalent.
- When working with lead or in dusty/dirty environments, a half-face mask with a P-100 filter is more appropriate than a filtering facepiece.
- When applying any two-component spray polyurethane foam, the appropriate protection is a supplied-air, full-face respirator (SAR). In some situations, when using low-pressure two-component spray polyurethane in an environment with ample ventilation, using a full-face, air-purifying mask with an organic vapor cartridge AND P-100 particulate filter may be acceptable .
- When applying high-pressure spray-foam insulation, you should always use a supplied-air, full-face respirator (SAR) that brings in fresh air from another location.

Types of Respirators

The N-95 respirator is good enough for occasional nuisance dust. The P-100 is required when you're exposed to dust that may include lead paint, or anytime when you are working in a extremely dusty environment. The supplied air respirator (SAR) provides the best protection when applying spray foam and other toxic compounds.

Eye Protection

Your eyes are at risk when performing many common weatherization tasks. You should always have access to proper eye protection, and take time to find it and wear anytime you're exposed to airborne debris. For most jobs, a pair of safety glasses with the stamped Z87 marker will be sufficient. For tasks with a lot of flying debris, or if you're working directly overhead, a full face protector is a good idea.

Check the Safety Data Sheets (SDS) for the materials you're using to learn about the glasses you should wear.

ELECTRICAL SAFETY

Electrical hazards are present on almost all jobsites, and account for nearly 10% of on-the-job deaths for construction workers. Follow these precautions to avoid electrocution.

- Be sure that your electric tools are protected by ground-fault circuit interrupters or are double insulated.
- Always use three-wire type extension cords with portable electric tools. Don't use cords with the ground plug cut off!
- GFCI "pigtails" are required when using a non-permanent outlet at a jobsite (e.g. use of an extension cord).
- Don't use worn or frayed electrical cords. If an electrical device is damaged, replace it.
- Keep water away from electrical sources and tools.
- Avoid using aluminum ladders.
- Take special precautions when working around knob-and-tube wiring.
- Keep aluminum foil products such as foil-faced insulation away from live wires.
- If you're using a generator or gas-powered compressor, don't let its exhaust gases get into the home or your work trailer. Additionally, be mindful of proper grounding if your generator is not already equipped.

CARBON MONOXIDE

Carbon monoxide (CO) is a colorless and odorless gas that can kill or sicken both workers and occupants. CO in the home is usually produced by improperly operating furnaces, boilers, or water heaters.

- Monitor the ambient CO inside the home while doing combustion testing. The use of a personal CO monitor during combustion testing is required for all weatherization workers. Stop testing if the ambient CO inside the home exceeds 35 parts per million (ppm).
- Be sure that every home has an operable carbon monoxide alarm. If it's battery operated, show the occupant how to change the batteries. Remind occupant that all CO alarms have a lifespan of about 5 years, and should be replaced periodically.

CHEMICAL SAFETY

The most common hazardous materials on weatherization jobs are volatile organic compounds (VOCs), sealants, insulation, contaminated drywall, dust, foams, asbestos, lead, mercury, and fibers.

- Read the manufacturer's specifications or Safety Data Sheets (SDS) for materials on your job.
- Get training on how to use PPE.
- Use your PPE on the job.

CONFINED SPACE SAFETY

Simply put, a "confined space" is defined by OSHA as an area that is not designed for continuous occupancy AND has limited entrance/egress. These work spaces are potentially dangerous because workers can be caught in a harmful environment with limited means to escape. Most attics and crawl spaces are considered confined spaces.

A second category of confined space is called a "permit-required confined space." Permit-required confined spaces are defined by OSHA as a confined space that has one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere;
- Contains a material that has the potential for engulfing an entrant;
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
- Contains any other recognized serious safety or health hazard.

Permit-required confined spaces require special training and the use of a confined-space form prior to entering. In most cases, unless a worker brings a hazard into the confined space (e.g. Spray Foam) an attic and crawlspace would NOT be considered a permit-required confined space.

Helpful tips for all confined spaces:

- Locate all the access points of any confined space before entering.
- Look for and avoid frayed electrical wires or open junction boxes.
- Provide adequate ventilation by opening the space or setting up a fan.
- Avoid or reduce the use of toxic materials in the space.
- Don't enter a confined space without telling someone where you're going.

ERGONOMIC SAFETY

The purpose of ergonomic safety is to prevent injuries from awkward postures, repetitive motions, and improper lifting.

- Use PPE such as knee pads, bump caps, or additional padding on rough ground.
- Lift with your legs. Save your back and get help for moving heavy things.

SLIPS TRIPS AND FALLS

Use care setting up your job site, especially when working around ladders, power cords, hoses, tarps, and plastic sheeting. Approximately 38% of all construction deaths are attributed to falls.

- Take your time when working with ladders or scaffold.
- Ladders must be placed on firm ground and set at a slope of 1:4.
- Ladders must extend 3' above the landing deck when moving from one surface to another.
- Fall protection of some form is required when a worker is 6' or more above a surface (see OSHA standards for specifics).
- Scaffolding above 10' requires additional fall protection.
- Use walk boards if practical in attics.
- Wear strong foot gear and long, but not loose, clothing.

HEAT AND THERMAL STRESS

Pay attention to the risks of heatstroke and heat exhaustion during extremely hot weather, and hypothermia in winter.

- Set up appropriate ventilation equipment as needed.
- Drink water.
- Take rest breaks.
- Rotate duties on the jobsite.

FIRE SAFETY

Take time to identify flammable materials and ignition sources on the job.

- Keep flammable materials away from combustion appliances
- Turn off pilot lights when working with flammable solvents.
- Avoid the use of flammable materials when possible.

LEAD PAINT ASSESSMENT

In homes built before 1978, you should assume they contain lead based paint unless testing confirms otherwise. Testing, using chemical swabs, is encouraged as it saves program funds which can be used to help additional clients.

- Follow the EPA Renovation, Repair, and Painting (RRP) Program Rule in pre-1978 homes."
- Document all testing, containment, and clean-up practices with forms and photos. Do not keep test swabs as they are not necessary to document testing and often change color over time.

ASBESTOS-CONTAINING MATERIALS

Take time to assess potential asbestos containing material (ACM) on the job.

- If you're unsure whether material contains asbestos, have a qualified lab test the material. If suspected ACM is in good condition, don't disturb it.
- The agency must defer the audit when there is the possible presence of friable asbestos. If asbestos levels in the vermiculite have been determined to be present, or if the agency is assuming the presence of asbestos without testing, the weatherization of the dwelling must be deferred until the vermiculite has been removed by a certified asbestos abatement contractor and an air clearance exam test has been performed on the dwelling to ensure that there is no asbestos present in the ambient air that would be a health and safety risk.
- When working around ACM, do not a) dust, sweep, or vacuum, b) saw, sand, scrape, or drill holes in the material, or 3) use abrasive pads or brushes to strip materials. Only trained professionals may abate, repair, or remove ACM.
- Asbestos abatement or repair work should be completed prior to blower door testing.
- Do not perform blower door tests around friable asbestos or when asbestos-bearing vermiculite insulation is present.

HANTAVIRUS

Hantavirus is a dangerous virus that can sometimes lead to Hantavirus Pulmonary Syndrome (HPS), a severe, sometimes fatal, respiratory disease in humans.

In Montana, hantavirus is most often carried by the deer mouse. Deer mice shed the virus in their urine, droppings, and saliva. The virus is transmitted to people when they breathe in air contaminated with the virus. Workers come into contact with deer mouse droppings in crawl spaces, attics, and any areas of the home where mice can move around freely.

People who have contracted hantavirus exhibit these symptoms:

- Fatigue
- Fever
- Muscle aches (especially in the large muscle groups)
- Diarrhea
- Dizziness
- Nausea
- Vomiting
- Abdominal pain

Personal Protection

You should wear proper respiratory protection when you work in areas where hantavirus is suspected.

- An N95 filtering facepiece is acceptable.
- A half-face or full-face respirator with P100 filters is preferred.

MOLD AND MILDEW

The weatherization program is not a mold and mildew remediation program. But it's important to recognize mold and mildew issues in a home, especially if the measures we install could potentially make the problem worse.

If mold and mildew exist in a home, you'll need to make a judgement call about whether it is too severe to proceed with weatherization services. Typically, this is decision made during the initial audit, but it's possible to miss mold problems during the audit and discover them when work begins. Either way, make the best decision for the safety of the homeowner and the workers.

Types of Mold in a Home

There are 1000s of types of mold spores floating around inside every home. Although we hear a great deal about "black mold" (Stachybotrys), not all mold that is black in color is harmful. The only way to determine the type of mold growing in a home is to take a sample and have it sent to a lab for analysis. This is not usually practical on weatherization jobs.

Causes of Mold and Mildew

Mold and mildew in the home is caused by excess moisture. If you have a home with mold and mildew, you should identify the source of the moisture so you can respond appropriately.

Controlling Bulk Moisture. If water is entering the home through leaks in the roof, leaks in the siding, plumbing leaks, or excess ground moisture, no reasonable amount of ventilation is going to solve the problem. You must first deal with the moisture problem itself. Many of the measures available in the weatherization program, such as installing ground moisture barriers, deal directly with controlling bulk moisture. Some measures, such as fixing the grade surrounding a home or installing rain gutters, may be possible within the program with proper approval in advance of the work.

Ventilation for Airborne Moisture. Not only does air exchange supply the home with clean, healthy air, ventilation also moves trapped moisture out of a home and replaces it with dry outside air. Montana is an extremely forgiving environment for moisture, but a tight home can trap unwanted moisture, leading to mold and mildew. Follow the ASHRAE 62-2-2016 standards and using calculators like RED Calc to reduce the chances of mold and mildew problems in a home.

Symptoms of Mold Exposure

Unfortunately, symptoms of mold exposure vary so greatly that it is nearly impossible to produce a useful list. Many people have no symptoms from exposure to mold and others can become extremely ill.

Personal Protection

You should wear proper respiratory protection when you work in areas where mold or mildew is suspected.

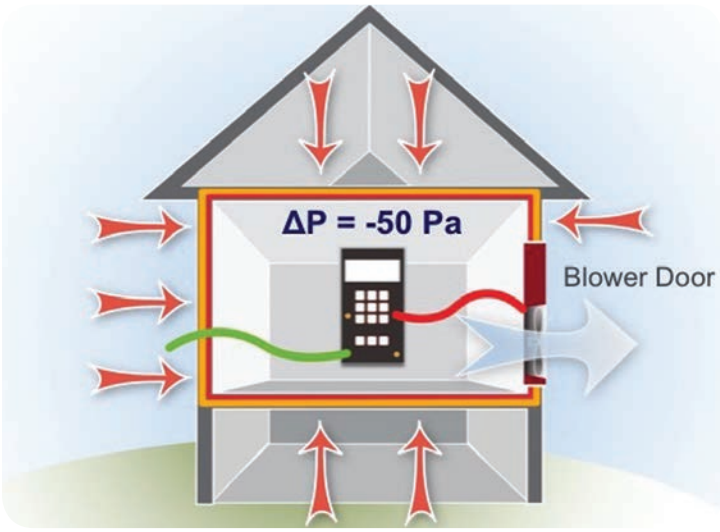
- A half-face or full-face respirators with P100 filter is recommended.
- A Tyvek suit is recommended.
- Nitrile gloves are recommended.

Learn more about Health & Safety at WxTV Online.
http://wxtvonline.org/category/healthsafetyseries/

PRESSURE DIAGNOSTICS

Pressure diagnostic tests help you understand the air barriers within a building —walls, floors, ceilings, and ducts. These barriers affect how heat, moisture, and contaminants travel through the building. Good air barriers help control the building's efficiency, safety, comfort, and longevity.

The most basic tools for measuring air flow in a building are the blower door, pressure pan, and duct tester. Procedures for using these tools are shown here, as are the procedures for doing zone pressure diagnostics and balancing room pressures.



Airflow During a Blower Door Test

The blower door creates an exagerated pressure on the house that magnifies air leakage. If you tour around the home with the fan running, you can find the source of leaks using a smoke pencil or wet hand. By using zone pressure diagnostics, you can use a second manometer to compare leaky zones such as bedrooms, attics, soffits, or hidden building cavities.

BLOWER DOOR TESTING

You should conduct a blower door test on every home before, during, and after you do work. You'll need to set up the home correctly to get accurate results from your test.

Set up the home:

- Set up the house in "winter conditions" by closing and latching all exterior doors, hatches, and windows.
- Open all interior doors so air can travel freely among the rooms.
- Inspect the attic and walls for vermiculite insulation. Look for asbestos pipe or duct insulation. If you suspect that the home has these types of friable asbestos, do not proceed with the test.
- Inspect the crawl space for sewage leaks or other pollutants. If you find these, do a positive-pressure test, rather than depressurization, to avoid pulling pollutants into the home.

- Check for a wood- or coal-burning stove or fireplace. Do NOT do a blower door test if these are burning. If these appliances are out and cool, you're good to go, but do cover the ashes with wet newspaper so soot doesn't get sucked into the home during the test. Close any chimney dampers.
- Set any combustion appliances to OFF or PILOT so they cannot light during the test.

You're now ready to perform the test. You'll usually depressurize to -50 pascals with-reference-to (WRT) outdoors.

Set up the blower door with these steps.

- Set the fan in an exterior door. If the door leads to a porch, open the porch door.
- Run the exterior reference hose well away from the door and fan.
- Set the fan up in the door. Read and follow the manual for hooking up the manometer.
- Take a baseline measurement to determine how much natural depressurization is taking place in the house. Record the measurement and adjust the manometer for that measurement. Remember, baseline measurements are NOT used to account for wind.
- Slowly bring the pressure up to -50 pascals. Tip: bring the house slowly up to about 25 pascals or so, then walk the house looking for any problems such as ashes coming out of the wood stove or insulation sucked in from the attic. Correct these as needed, then bring the house up to -50 pascals.
- Calculate the air leakage in cubic feet per minute at 50 pascals (CFM50), or let your manometer do it for you. Record the results in your job file.

When you've completed the blower door test, return the home to the condition in which you found it, including turning any combustion appliances back to ON.

Learn more at WxTV Online
http://wxtvonline.org/category/blowerdoorbasics/

PRESSURE PAN TESTING

Pressure pan tests give you an easy way to test the air-tightness of ducts. Leaky ducts waste energy by allowing expensive heated or cooled air to escape to outdoors. Leaky ducts can also reduce comfort, and can interfere with the safe operation of combustion appliances.

Pressure pan tests should be conducted in all site-built homes with ductwork installed outside the pressure boundary (usually attics or crawl spaces). They should be performed in all mobile homes.

Set up the test like this.

- Make a simple sketch of the home's floor plan duct system, showing all the grilles or registers.
- Connect a manometer to the pressure pan.
- Set up a blower door test and run the fan at -50 pascals.
- Keep the fan running and place the pan over each register, sealing tightly around the edges. If the register is too large to seal with the pressure pan, use grille mask or paper and tape to seal it, then insert the probe through the paper or tape.
- If there is no duct leakage, you'll see a reading of close to 0. Ideally, each register should have a pressure pan reading of 1 pascal or less, with a total of 6 pascals if you add up all the readings.
- If you have numbers higher than this, the duct system is leaky and should be sealed. The location of the leaks will be close to the registers with the highest readings.

Find and seal any duct leaks using duct mastic and fiber tape. Do not use gray fabric "duct tape". See the Air Sealing section for more info on duct sealing.

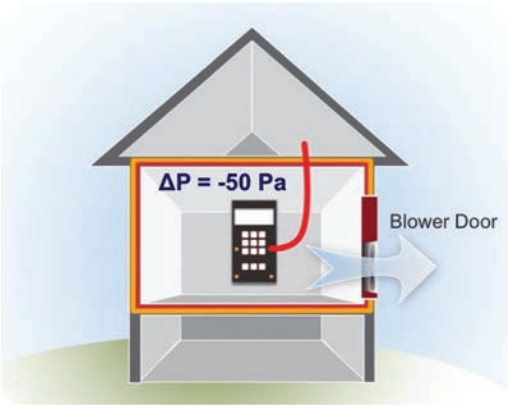
Running a Pressure Pan Test

The pressure pan should cover the entire grille or register. If you don't have a pan that's large enough, you can make one by attaching a hose fitting onto a plastic wash basin or box.

Learn more at WxTV Online
http://wxtvonline.org/2010/06/ductsealing/

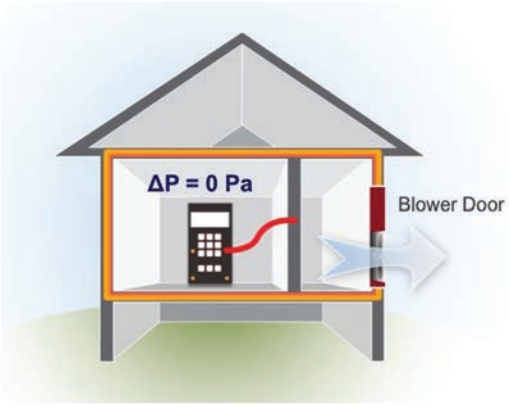
ZONE PRESSURE DIAGNOSTICS (ZPD)

Zone pressure diagnostics are used to determine the location and severity of air leaks in the building shell. These tests are performed in conjunction with a whole-house blower door test. This test is performed with the blower door running. You can test zone pressures to the attic, crawl space, garage, wall cavities, soffits, or any intermediary building cavity.



Using ZPD to Determine Attic Connection

This reading of -50 pascals indicates a perfect air barrier at the ceiling. If the reading is less than 45 pascals, you're required to perform additional air sealing between the house and attic.



Performing ZPD to Determine Wall Connection

The wall cavities should be connected to the house. This reading of 0 pascals shows that the wall and living space are well connected.

In the first illustration, the blower door is depressurizing the home to -50 pascals, and a hose has been inserted through the attic hatch (with the hatch kept as closed as possible), or through a hole drilled in the ceiling. The measurement, taken House WRT Attic, should be between -45 and -50 pascals. Larger numbers indicate that the pressure boundary between house and attic is more airtight. Lower numbers indicate that more air-sealing is needed at the ceiling, recessed light fixtures, open tops of interior walls, or anywhere that house air can leak into the attic.

In the second illustration, the measurement is taken in an interior wall. The reading here, for a zone that is within the thermal boundary, should be close to zero.

SWS: 3.1602 Air Sealing Duct Systems
https://sws.nrel.gov/spec/316021

DUCT BLOWER TESTING

AA duct blower, also known as a duct blaster, can be used to test the air-tightness of duct systems. This test is more complicated to set up than a pressure pan test, but it provides more accurate information. A duct test may be required in some programs.

Duct tests come in two forms: Total Duct Leakage and Duct Leakage to Outdoors. The Total Leakage test measures the air leakage in the entire duct system, including leaks to both the outdoors and into conditioned areas such as a heated basement. The Leakage to Outdoors test measures only that portion of duct air leakage that gets to outdoors. We show the simpler Total Duct Leakage test here.

Duct tests are usually performed at +25 or -25 pascals WRT the house, pressures that are similar to the typical operating pressures created by the air handler.

Total Duct Leakage—Pressurization

Set up the home for the duct test. We show a simplified set of instructions here — check the manufacturer's instructions for complete instructions since there are plenty of ways to goof up this test.

- Remove any duct air filter(s).
- Install duct blower either at the door of the air-handler, or at a large return air grille.
- Seal all supply and return registers and grilles with self-adhesive duct mask or paper and tape. Be sure to seal hard-to-find grilles such as those under kitchen and bath cabinets, behind big furniture, or under rugs.
- Set up the manometer to measure Duct WRT House on channel A. Insert the input hose through the grille mask on a nearby register to get duct pressure, or through a ¼" hole drilled into a supply plenum that is at least a few feet away from the duct tester. Set up channel B to measure Fan WRT Room (where the fan is installed).
- Open a door, window, or hatch into any rooms, attics, or crawl spaces that contain ducts. The intent is to assure that you are measuring only the air barrier created by the ducts and not by structural elements such as floors, walls, foundations, garages, or roof decks.

You're now ready to perform the duct test. You'll be pressurizing the ducts to +25 pascals.

- Set the manometer to correct settings for device, configuration, and rings.
- Turn on the fan and slowly bring the pressure up to 25 pascals. Check for and refasten any grille mask that has come loose.
- Calculate the air leakage in cubic feet per minute at 25 pascals (CFM25), or let your manometer do it for you. If the reading is excessively high, check that you have found and sealed all registers and grilles. Record the reading.
- Use this opportunity to check for duct leaks by working your way out from the air handler and feeling for leaks. Use a smoke bottle or wet hand to help you perceive airflow. Record the locations of air leaks.

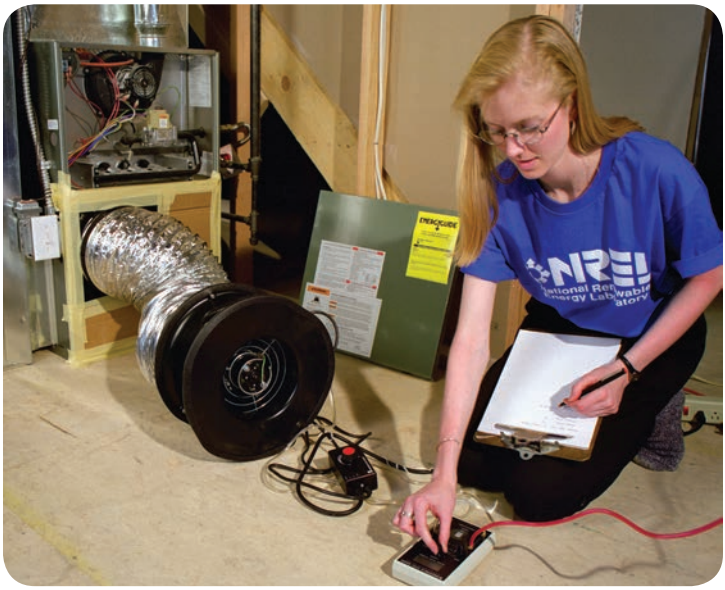
When you've completed the duct blower test, return the home to the condition in which you found it, including turning any combustion appliances back to ON.

Total Duct Leakage—Depressurization

You may sometimes want to depressurize the ducts. The procedure is almost the same, with these differences. Follow this procedure with the TEC equipment.

- Install the foam flow conditioner and at least one flow ring into the round transition piece on the inlet side of the fan. With the TEC equipment, you cannot do a depressurization test with an open fan.
- Install the fan with the flow conditioner and ring on the side of the fan against the duct system or flexible extension duct.
- Install a hose connecting the manometer Channel B reference port with the plastic tap on the round transition piece.
- Run the test as for the pressurization test.

With the Retrotec DucTester, the procedure for depressurization is easier. You simply turn the fan around.



Setting up the Duct Blower. You'll sometimes have to get creative with cardboard and tape to set up the duct blower. In this case, the auditor has removed the door to the air handler to get access to the duct system.

SWS 6.6201.2: Primary Ventilation Air Flow between Rooms
https://sws.nrel.gov/spec/662012

PRESSURE BALANCING

Room pressure testing is required whenever a forced air heating system is present. Pressure balancing accomplishes several things.

- Prevents the air handler from interfering with the safe operation of combustion appliances.
- Avoids moisture problems that can result when air and moisture are forced into building cavities.
- Assures that the forced air heating or cooling systems deliver the right amount of air to all the rooms.

Perform these steps to determine if pressure balancing is needed.

- Run the air handler.
- Close interior doors one at a time.
- Use a manometer to check each room pressure.
- Room pressures should not exceed +/- 3 Pascals with reference to the main living area.
- If room pressures exceed these limits, and it causes combustion safety issues such as depressurization in the CAZ, take steps to balance the room pressures.
- If no combustion safety issues are identified, balancing is not required but is still allowable and encouraged.

If pressure balancing is needed, perform one of these procedures. Some occupants may find these procedures intrusive, so be sure to show them what you'll be doing, explain the benefits of better comfort and lower cost, and get their permission to proceed.

- Undercut the door to the unbalanced room. Remove the door, and cut no more that 1" off the bottom. Use good workmanship: cut a straight line and don't mar the door.
- Install a bypass grille in a door or wall that leads to the room. Install a non-closable grille on each side of the wall or door. Finish the installation so there are no unsightly holes or air bypasses.
- Install a jump-duct through the ceiling and attic and into the room. Use grilles at both finished surfaces. Use flex duct in the attic, and fasten the joints with screws and mastic. Do not use fabric "duct tape" for sealing these or any ducts.
- You can leave the furnace fan running by setting the thermostat to Fan Only. It's OK to use the Heat setting, too, though the house will sometimes get a little warm if you have the burner firing.

MECHANICAL SYSTEMS

Mechanical systems provide heating, cooling, and ventilation in most homes. We address the most common equipment here.

Combustion appliances—burning natural gas, propane, or fuel oil— provide safe, reliable, economical heat to many homes. But ongoing testing, maintenance, and repair are needed to assure their proper operation. You should inspect and test all combustion appliances and their exhaust systems prior to performing work on every home. If you find any combustion-related issues, they should be resolved before you install air-sealing measures.

Personal CO Monitor.
Whenever you're inspecting or testing combustion appliances, be sure to protect yourself by wearing a personal CO monitor. You should stop work if it reaches 35 ppm or higher, and correct the problem before resuming work.

SWS 2.0201—Combustion Safety General
https://sws.nrel.gov/spec/20201

ABOUT THE COMBUSTION PROCESS

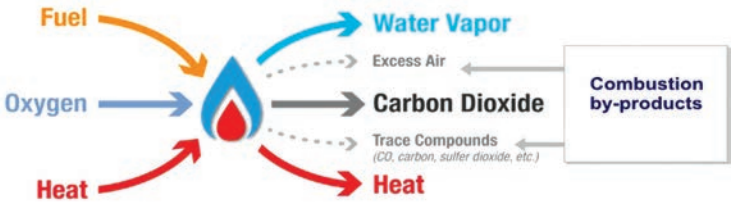
Complete combustion occurs when all the fuel is burned. This creates heat, but also produces carbon dioxide and water vapor. That is the ideal process, but if the combustion process is not complete, poisonous carbon monoxide (CO) or other dangerous combustion by-products can be released.

CO is produced under the following conditions:

- The ratio of fuel-to-oxygen is either too high to permit the complete formation of CO_2.
- Or the temperature of the combustion chamber is too low for complete burning to occur.

Here are the common causes of these conditions:

- Too much fuel for the amount of oxygen (over-fired).
- Not enough oxygen for the amount of fuel (insufficient combustion air).
- Not enough heat (flame impingement).



SWS 2.0301—Smoke Alarms & Carbon Monoxide Detectors
https://sws.nrel.gov/spec/20301

SMOKE ALARMS & CO DETECTORS

At least one smoke alarm and one CO detector should be installed in every home to protect occupants. These can be either hardwired or battery operated.

Smoke alarms should be installed in the following locations:

- In each sleeping room
- Outside each separate sleeping area in the immediate vicinity of the bedrooms
- On each additional story of the dwelling, including basements and habitable attics

CO detectors should be installed in these locations:

- Outside of each separate sleeping area

FURNACES

Forced air furnaces are used to heat the majority of homes in Montana. Most utilize combustion to produce heat, with fuel sources that include natural gas, propane, and fuel oil. A few forced air systems use electric resistance coils to produce heat. All use electricity to operate fans and control systems.

Combustion appliances can provide years of reliable and economical service. But they do require periodic service to keep them operating at peak efficiency and safety.

WATER HEATERS

Water heaters can utilize both combustion fuels or electricity to produce heat. Electric water heaters are remarkably trouble-free, requiring little more maintenance than replacing an occasional burned-out heating element. Combustion water heaters require more assessment and maintenance, and are the primary target of the procedures outlined here.

INSPECTIONS AND TESTS

You should know how to perform all the following inspections and tests. These are all described on the Furnace Worksheet.

Testing for Gas Leaks

Leaking gas wastes energy, smells bad, and is dangerous. You should inspect all gas lines for leaks before beginning work. Use an electronic leak detector, moving along the lines, checking each joint at the rate of one inch per second. Confirm any leaks with liquid leak detector (soapy solution). Mark any leaks, and repair them before performing additional work.

If leaks are found, immediate action will be taken to notify occupant to help ensure leaks are repaired.

Emergency problems (such as ambient gas levels greater than 10% Lower Explosion Limit, or ambient CO levels that exceed 70 ppm) will be communicated clearly and immediately to the occupant, the home shall be evacuated, and appropriate personnel shall be contacted; Significant problems (such as gas leak less than 10% LEL, ambient CO levels that exceed 35 ppm but less than 70 ppm) will be communicated clearly and immediately to the customer and appropriate solutions will be suggested.

SWS 2.0201.3—Vented Combustion Appliance Safety Testing
https://sws.nrel.gov/spec/202013

Inspecting Chimneys and Combustion Air inlets

Chimneys for both furnaces and water heaters must be properly installed and in good condition to effectivley carry combustion gassses out of the home.

Perform these safety inspections.

- Inspect chimney connectors—the single wall flue that connects the appliance to the chimney—to confirm that they are intact, well-fastened at any joints, and sloped upwards towards the chimney. Refasten or repair as needed.
- Inspect the burner compartment, draft diverter (if present), and vent connector for sign of spillage of combustion gasses. Correct the cause if spillage is found.
- Inspect roof terminations from outdoors to confirm that a roof cap is installed and the chimney is unobstructed. Repair as needed.

Rollout and Burner Related Abnormalities

Burner rollout sometimes occurs when the burner is firing. Evidence of rollout is usually seen as scorching or soot accumulation around the combustion chamber. The causes of rollout include poor draft, an obstructed chimney, or negative slope at the vent connector.

Rollout that continues for more than a moment at the beginning of the firing cycle is never acceptable, and should be further evaluated and the causes corrected.

Evidence of Rollout. This water heater has plenty of evidence of poor draft: scorching from rollout, and corrosion caused by the condensation of escaping flue gases. This is surely a fire hazard, and could be a health hazard if the appliance is spilling combustion gases. Do not take these signs lightly—people die ever year because of poorly maintained combustion appliances just like this.

WORST CASE DEPRESSURIZATION TESTING

Worst case depressurization (WCD) testing is a basic assessment of the safety of any combustion appliance. The intent of this test is to evaluate the ability of the equipment to move flue gasses safely out of the home when the CAZ (combustion appliance zone) is subject to depressurization.

Though this "worst case" rarely exists in a normally-operating home, such conditions—when they happen—can result in serious sickness or death of the home's occupants. That's why good technicians take this test very seriously.

Perform the worst case depressurization test by following these steps.

- Deactivate all combustion appliances by setting them to Pilot or OFF.
- Close all exterior doors and windows.
- Remove or replace the furnace filter.
- Open interior doors to spaces containing exhaust fans or the dryer. Close all other interior doors.
- Set up a manometer to measure CAZ with-reference-to outdoors. Your manometer will be in the room with the combustion appliance. Your INPUT port will be open. Your REFERENCE port will run through a long hose to outdoors. Record the reading. Leave this manometer set up.

You have now measured a baseline pressure in the CAZ with-reference-to outdoors. Now you'll run the fans, dryers and/or the air handler to see what the effect is on the CAZ pressure. Perform these steps next.

- Turn on all exhaust devices: bathroom fans, kitchen fans, and dryer.
- Record the pressure difference in the CAZ with-reference-to outdoors. If your manometer has a BASELINE feature, use that to capture the baseline.
- Open and close interior doors, monitoring the change in CAZ pressure as you go. Leave the doors in the position that creates the most NEGATIVE pressure in the CAZ.
- Turn on furnace blower (air handler). Use the FAN ONLY setting if present at the thermostat; if you have no FAN ONLY switch, fire the appliance and wait until the air handler starts. Determine if the CAZ pressure is worse (more negative) when the air handler is running. If so, leave it on for worst case.
- Record this worst case reading—which is **the most negative pressure you can create in the CAZ.**

You are now ready to combustion safety tests for combustion appliances in the CAZ. For open-combustion appliances with a draft hood (usually 70% AFUE), the tests you'll perform are **spillage** at the draft hood, and **carbon monoxide (CO)** in undiluted flue gases. For fan-assisted or induced draft appliances (80% or 90%+), you only test for **carbon monoxide** in undiluted flue gasses.

- Set up your tools for this procedure: a stopwatch, and a smoke generator.
- Establish a location to sample CO. This should always be undiluted flue gasses. When a draft diverter is present, you can insert the probe down into the breach of the appliance to sample gasses before dilution air is mixed in. With 80% or 90%+ appliances, you can sample at the chimney termination. Do not drill PVC or B-vent to take this sample.

You are now ready to fire the appliance(s). Leave the home set up in worst case conditions.

- Fire the burner of the appliance with the lowest BTU input rating. Start a timer when the burner fires.
- Measure spillage at the draft diverter, using smoke to confirm that flue gasses go up the chimney within 2 minutes. Record the results.
- Finally, measure the CO in undiluted flue gasses once the burner comes to steady state. Compare this to the BPI action guidelines. You may wait up to five minutes to take this reading.
- If you have multiple appliances, leave the smallest running (burner firing), and repeat the tests for all other vented appliances. Record the results.
- When you're done with the tests, return the doors, exhaust fans, and combustion appliances to normal settings.

Action Guidelines.

If an appliance **fails a worst case spillage test,** repeat spillage test under natural conditions.

- If equipment **passes spillage test** under natural conditions, provide client education (minimize exhaust fan use etc.), have client sign below and initiate a Work Order to remedy equipment draft issues.
- If equipment **fails spillage test** under natural conditions, the CO producing appliances must be disabled until repairs can be made. Alternative emergency lodging of the occupants may be required.

Solving Problems with the CAZ

If your testing shows that that CAZ is excessively depressurized, or the combustion appliances don't draft under worst case depressurization, these are the repairs you should consider performing.

- Provide a combustion air inlet to CAZ.
- Seal leaks in the return ducts of the CAZ.
- Balance supply and return air by adding new returns.
- Balance supply and return air by adding passive return air openings to the main body of the house.
- Repair chimney obstructions, disconnections, or leaks.
- Increase the size of the vent connector or chimney.
- Install a metal chimney liner and/or a wind-rated chimney cap.
- Reduce the capacity of large exhaust fans.
- Provide make-up air for dryers and exhaust fans.

End of Day Proceedure

You must do this test at the end of each workday during which changes were made to the envelope, and at the end of the job.

- Zero your CO meter in fresh air.
- Set up worst case conditions and test spillage.
- Test the undiluted flue gases in the stack. CO levels should not exceed 400 ppm (air-free) in furnaces, and 200 ppm (air-free) in water heaters, unless the manufacturer's spec calls for another number.
- If the appliance fails either the spillage test, or has high levels of CO, perform repairs or report to the energy auditor or program director immediately.

MECHANICAL VENTILATION SYSTEMS

Mechanical ventilation systems use electric fans to move measured amounts air through the home. They protect the home by removing excess moisture that could result in mold, mildew, and rot. They protect the occupants by reducing the accumulation of pollutants.

Ventilation fans can be designed to provide exhaust ventilation (removing air from the home), supply ventilation (moving fresh air into the home, or balanced ventilation (with both supply and exhaust air streams). This field guide addresses only exhaust ventilation, the most common type used in the weatherization program.

Bath fans remove moisture, odors, and pollutants at the source. These fans can be controlled by a simple ON/OFF switch, or by a timer that controls run-time. When installed in conjunction with advanced controls, high-quality bath fans can meet the ventilation requirements of the the most recent ASHRAE 62.2 standards.

Kitchen fans and range hoods should be installed as close to the cooking surface as possible and ducted to the outdoors--recirculating or so-called ductless range hoods are ineffective at removing anything from the air besides a few odors. With proper controls, these can also meet ASHRAE standards.

Guidelines for Installation of Fans

- Install the quietest and highest-quality fan you can afford. These hard-working appliances are subject to long run-times and environmental abuse. Cheap fans don't last long. Occupants won't use noisy fans.
- Duct all fans to outdoors. Use solid aluminum or steel ducting, and run it by the shortest route to the outdoors. Use a minimum number of elbows.
- Do not neck down the size of the ductwork. Use the same size duct as the fitting on the fan.
- Fasten duct sections with screws. Seal all joints as you would other HVAC ductwork: with self-adhesive metallic tape or fiber-tape and mastic. Do not use gray fabric "duct tape" for anything besides repairing sporting goods.
- Insulate the top of the fan and all ductwork to avoid condensation.

INSULATION

Insulation provides a thermal barrier in the home that improves comfort and reduces energy consumption throughout the year. The effectiveness of insulation is largely determined by the type of material, the thickness of the material, and the quality of air barrier adjacent to the insulation. This chapter covers the assessment and installation of insulation — air-sealing is covered in Chapter 5.

SWS 4.0: Insulation
https://sws.nrel.gov/spec/4

GAINING ACCESS

The methods used to assess, access, and install insulation will vary widely among different styles of construction. But with a little training and practice, most crews find that insulating and air-sealing is not that difficult, and benefits are substantial. There are several ways to access roof, wall, and floor cavities to install insulation—your choice of which to use will depend on the type and condition of the home, access around the home, weather, and the tools you use. We show the most common methods on the next pages.

INSULATING ATTICS

Preparing Attics

Perform these steps before installing attic insulation.

- Seal air leaks and bypasses as shown in the Air Sealing chapter.
- Repair roof leaks and other attic-related moisture problems.
- Vent all kitchen and bath fans outdoors through roof or soffit. Use PVC or rigid metal piping whenever possible, and do not use flexible plastic ducting. Insulate the duct to R-8 to prevent condensation.
- Install chutes or dams at soffits to prevent blown insulation from blocking pathways.
- Confirm that electrical wiring is safe and properly installed. All wire splices should be enclosed in junction boxes with covers. If you must install insulation over junction boxes, mark them with a flag.
- Install insulation blocking or sheet metal to achieve 3" clearance (or manufacturer's specs) around chimneys, B-vents, exhaust fans, recessed light fixtures, and other heat-producing devices.
- Install attic rulers at the rate of one per 300 square feet to help you gauge the depth of the insulation.

Improving Attic Hatches

- Install an attic access hatch if none is present. It's best to install it near the highest point in the attic, and preferably at the exterior of the home.
- Build an insulation dam around the attic hatch. Use rigid materials like plywood or OSB so that it will support the weight of a person entering or leaving the attic. Insulate the hatch to match the R-value of the attic insulation.

Protect heat producing devices such as recessed lights, fans, and chimneys so the insulation does not create a fire hazard.

Improving Ventilation

- Attics are ventilated to remove excess moisture that can accumulate in winter. Improvements to ventilation should be undertaken only when there is evidence of a problem caused by lack of ventilation.
- If moisture problems are present in the attic, evaluate the existing ventilation to confirm that it provides at least one square foot of ventilation for each 150 square feet of floor area (1:150 ratio).
- Install additional ventilation if needed. Split the location of vents if possible so approximately half the vents are located high near the peak, and half low near the soffit.
- Install chutes or blocking if needed to prevent insulation for blocking roof vents.

Setting Up the Attic

- Set up a solid ladder to gain access to the attic. If indoors, lay a tarp to help contain the mess.
- Set up plenty of bright lights in the attic.
- Evaluate the strength of the any framing you need to walk on. Install walk boards if needed.

Setting Up the Machine

- Set the machine as close to the attic as possible. Use the shortest hose possible to speed up the job.
- Stack the insulation as close to the machine as possible.
- Look down into the machine and identify the chopper and paddles. Do not stick your hands down there when the machine is running.

A safe and efficient workspace. Take time to set up a work station with all your tools and materials within easy reach. Be sure you can work safely before you start the machine.

Guts of the machine. Inspect the choppers and augers before you load the hopper. If anything goes wrong down there, STOP the machine before reaching in.

Running the Machine

- Wear gloves, safety glasses, and a respirator.
- Adjust the feed gate and air shutter to move as much insulation down the house as possible. If you add too much air, the insulation will have insufficient density and the job will go slower. If you add too little air, the hose will clog.
- Keep the hopper full to speed the job.

Working the Attic

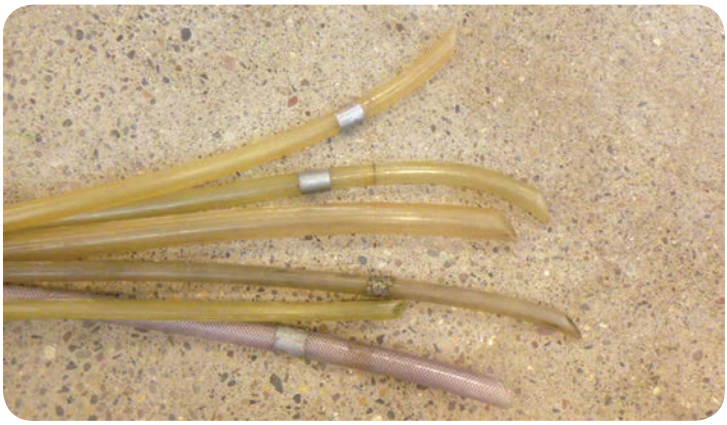
- Wear gloves, safety glasses, and a respirator.
- Start in the far end of the attic. Your hose should reach within 10" of the farthest point.
- Measure out a fraction of the attic, perhaps 1/4 or 1/3, so you can check the coverage. Start the machine, and install insulation to what you believe is the correct depth. Stop the machine, confer with the person on the machine, and calculate the number of bags you have used per square foot. Compare this to your estimate to confirm that you're installing insulation at the proper depth and density.
- Adjust your coverage as needed, and continue insulating. Back up until you are out of the hatch.
- Clean up your mess.

Good working conditions. Take time to set up the attic with good lights and boards to walk or kneel on. You should be able to get within 10' of the farthest corners of the attic.

INSULATING WALLS

Wall insulation is one of the best weatherization measures available for homes that have insufficient insulation. It improves the R-value of wall assemblies, slowing the flow of heat into and out of the home, reducing utility costs, and improving comfort. When installed at a sufficient density, it also reduces air leakage.

The best way to insulate existing wall cavities is by drilling a 2-3" hole in each cavity and using a flexible fill tube to dense-pack the cavity. It's possible to fill cavities with a nozzle inserted into 2 or 3 small holes per cavity, but using the fill tube is always better since it assures that insulation reaches the entire cavity. You can use either fiberglass or cellulose to fill wall cavities, but cellulose is preferred because it creates a better air seal.



You'll use flex tubes to fill the walls in most site-built homes. To keep the job moving quickly, you want the fattest flex tubes that fit into the space you're insulating. Most crews carry 1" and 1¼" flex tubes. You should also carry different tubes for winter and summer—softer hoses will feed more easily in cold weather, but they will often kink when the weather is warm.

Prepping for Wall Insulation

You'll need to prepare the home to have a successful insulation job. Follow these steps.

- Inspect the exterior walls inside and out to assure that they are strong enough to hold the insulation. Repair any weak areas as needed.
- Look for evidence of moisture damage. If you have an existing moisture problem, don't install insulation until the moisture problem has been fixed.
- Look for openings where insulation can escape: utility chases, holes in the walls, openings in the attic or crawl space, dropped soffits, pocket doors, or cabinets without backs. Repair these places as needed.
- Look for exterior wall cavities that are used for forced air system ducts. Do not insulate these cavities.
- Confirm that electrical wiring is safe before you bury it in insulation. If in doubt, have an electrician inspect it, and either certify that it's safe or upgrade it.

Accessing the Walls from Outside

Installing wall insulation from the outside has the advantage that you're not making an indoor mess. There are several ways to gain access to the cavities.

- It's always best to avoid drilling holes in the siding, unless you have a good method for repairing all those holes. Plus, if you drill painted wood siding, you may have to use lead-safe work practices. Where possible, try removing the siding so you can drill through the sheathing instead.
- If the home has metal or vinyl siding, remove it with a zip tool that you can get from a siding supplier. Remove one strip at a comfortable working height across all the cavities you'll insulate. Number the pieces you remove, to keep track of their locations, and set them aside where they won't be damaged.
- Once you have access to the wall sheathing, drill a 2½" or 3" hole in each cavity. Be sure to find and drill hidden cavities above doors, below windows, and at the end of wall runs where there may be off-width cavities.
- Do not remove asbestos shingles. But it is OK to insulate these homes by drilling from the inside. If you do insulate from the inside, run a blower at low speed to pressurize the home while insulating to reduce the entry of dust and other pollutants into the home.

Removing lapped siding. You'll need a different set of tricks for removing each type of siding. Once you have the siding off, it's easy to drill through the sheathing.

Accessing Walls from Inside

Sometimes you cannot drill from the outside, perhaps because you have stucco, brick veneer, or asbestos shingles. In these cases, you can drill the walls from inside. Since you'll usually be drilling through paint, you must be prepared to use lead-safe work practices.

- Take time to protect the home from the mess you'll be making. Move furniture away from the walls, working one part of the room at a time if necessary. Cover everything with drop cloths.
- Make a plan to repair the holes before you start. You may be able to use plastic caps, available from an insulation supplier, if the client approves of the appearance. You may also be able to cover a straight line of holes with a 3" or 4" strip of wood (chair rail) at waist height. Paint the strip to fit the decor.
- Drill a straight line of holes, finding and drilling all the cavities around doors, windows, and corners. Use a probe to reach into the cavities and identify framing members such as fire blocking that limit the travel of insulation.

Dense-Packing the Walls

To do decent job of dense-packing insulation, you'll need a high-quality machine with a powerful motor. The light machines available at lumber yards will not do the job. Your machine should be equipped with separate controls for the blower and auger.

A big powerful machine. Your work will go faster and you've less problems if you use a professional insulation blower like this one.

To achieve good air sealing, cellulose insulation should be blown at a density of 3.5-4.0 pounds per cubic foot. This equals about **1.2 pounds per square foot in a 2"x4" wall cavity** on 16-inch centers, and **1.8 pounds per square foot in a 2"x6" wall cavity** on 16-inch centers. You cannot get this density without using a fill tube.

Insulate the wall with this procedure.

- Mark the tube at one-foot intervals to help you see when the tube has reached the top of the wall cavity.
- Start with two or three full-height wall cavities so you can measure the insulation density and calibrate the blower. An 8-foot cavity, framed with 2"x4"s on 16-inch centers, should take at least 10 pounds of cellulose.
- 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. Work the hose back and forth in the cavity to pack the insulation tighter. Shut off the flow of material when about 6" from the end.
- Seal and plug the holes.

INSULATING FLOORS & FOUNDATION WALLS

It's a good idea to insulate either the floor or foundation walls in a place as cold as Montana. The choice of where to insulate depends upon whether the space is heated, the ease of access, and the possibility of moisture issues.

You should always perform air-sealing at the floor or foundation walls before installing insulation.

It's often best to insulate and air-seal the foundation walls, rather than the floor, so you protect the furnace, heat ducts, and water lines. Floor insulation is better where you have moisture problems, or where the foundation is made of stone, and insulating it would be difficult.

Insulating at the Floor Joists

The best way to insulate a floor cavity is to completely fill the joist cavity with unfaced fiberglass batt insulation. Partially filling the cavity with a fiberglass batt is less satisfactory because air movement above the batts reduces their effectiveness.

- Air-seal the floor before before installing insulation to prevent air from traveling through the insulation.
- If the walls are balloon-framed, air-seal the bottoms of the stud cavities prior to installing floor insulation to contain the wall insulation.
- Install the thickest insulation practical between floor joists. This is probably R-19 but in some cases it's R-30.
- Install the insulation without voids, edge gaps, or end gaps. Fit insulation closely around cross bracing and other obstructions.
- Securely fasten the batts with insulation hangers, plastic mesh, or other supporting material.
- Insulate any water lines that run outside the insulation.
- Seal and insulate any ducts that are below the insulation.
- Install a ground moisture barrier that runs up the foundation walls in crawl spaces. Secure the ground moisture barrier to the foundation wall with urethane sealant and/or mechanical fasteners.

Sealing air leaks. You should find and seal all the major leaks in the floor before installing insulation in the floor cavities.

Insulating Rim Joists

Rim joists create a large cold spot in the thermal boundary. Insulating and air sealing this area is an important weatherization measure in cold climates.

- Rigid foam board insulation is the best method. Be sure to seal the edges with caulk or foam.
- Do NOT use fiberglass batts for rim joists. Air will circulate around the fiberglass, carrying moisture, creating condensation, and encouraging mold and rot on the cold rim joist.

Insulating Foundation Walls

If you have access to the foundation walls, this is the best way to insulate a basement or crawl space.

- Extruded or expanded polystyrene insulations are the most appropriate insulation products for flat concrete or concrete-block walls, because they are good air barriers with excellent moisture resistance.
- Attach insulation firmly to the entire inside wall surface with appropriate fasteners and/or adhesive. Install insulation with no significant voids or edge gaps.
- If you install foamboard in a finished space such as a conditioned basement, you may need to cover it with a material that has an approved flame-spread rating. This is usually drywall or a spray-on intumescent coating.
- FSK fiberglass insulation should be clamped to the sill plate by a wooden strip, which is nailed, stapled, or screwed into the sill. The bottom of this batt insulation should be air-sealed to the wall with a strip of wood nailed into the foundation or by sealing the FSK facing to the wall with caulk, or by any other effective method.

SWS 2.0403.1: Ground Moisture Barriers
https://sws.nrel.gov/spec/204031

GROUND MOISTURE BARRIERS

Properly installed ground moisture barriers protect the home by slowing the flow of dust, moisture, radon, and soil gasses out of the ground and into the home.

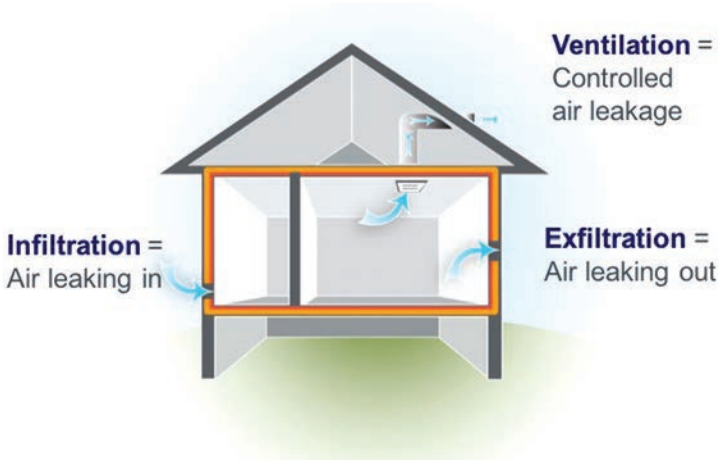
- Impermeable enough to resist the flow of water vapor. Clear polyethylene is the most common material with the required spec of <0.1 perm.
- Tough enough to resist damage from wind, animals, and service people. 6-mil polyethylene is sufficient where no traffic is expected; 8, 10, or 20-mil is even better.

The auditor should determine if a ground moisture barrier should be installed. Do not install a barrier if there's evidence that high groundwater could puddle on top of the sheet.

AIR SEALING

Good air sealing will vastly improve the comfort and energy efficiency of any home. It has a critical role in helping insulation work well, and it's the best way to slow the migration of moisture into building cavities. An insulation job that does not include air-sealing may result in a home that is still cold, drafty, and wet after the work is done. That's why air-sealing almost always has a good savings-to-investment ratio (SIR) in weatherization jobs, and why it's one of the best energy-saving measures around.

SWS 3.0 Air Sealing
Link: https://sws.nrel.gov/spec/3

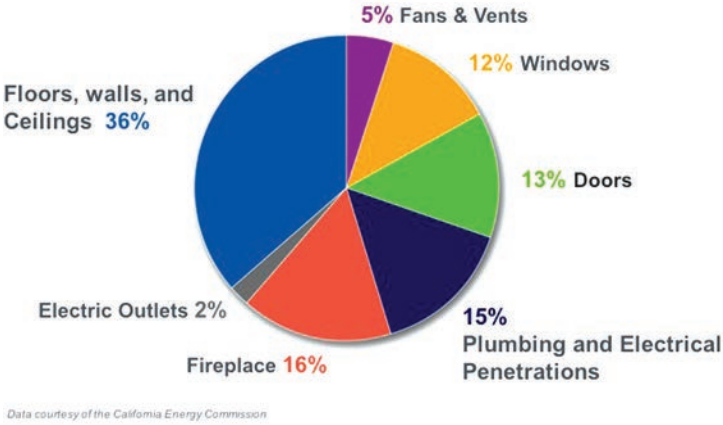


The air that leaks into the home through infiltration often comes from crawl spaces, attics, and building cavities. This air can carry mold, mildew, dust, radon, moisture, and other pollutants into the home. Air-sealing slows the flow of this unhealthy air. We often install ventilation systems in the bath and/or kitchen after doing air-sealing work so that stale air is removed from the home, and fresh air is supplied where and when we need it.

HIT THE BIG TARGETS

The best way to measure the airtightness of any home is by doing a blower door test. The higher the number, the more air-sealing that's needed. You can also use the blower door to help judge the effectiveness of your air-sealing work by stopping work occasionally and taking another blower door reading to check your work. By following this method -- blower door guided air sealing -- you'll soon learn that the best way to improve the performance of the house is to find and seal the BIG openings such as open walls, dropped soffits, and plumbing and wiring chases. There is little benefit in caulking up small small cracks and holes.

You should focus your air-sealing efforts on the top of the building (attic floor or room ceiling) where pressures are the greatest. You may also find bypasses in crawl spaces or basements— leading sometimes all the way to the attic—that should be sealed if possible.



This chart shows you where to focus your air-sealing work. Caulking the little stuff doesn't usually add up to much. Check the chart: if you seal just the building shell (floors, walls, and ceilings) and utility penetrations (plumbing and wiring), you'll get over 50% of the leakage!

AIR SEALING MATERIALS

You need the right materials to do a good job of air-sealing. Smaller cracks (up to ¼") can be sealed with simple caulking. Moderate-size cracks holes (up to 3") should be sealed with one-part foam from a can. Big holes (utility chases, open wall cavities, soffits, etc.) can be sealed with drywall, foam board, or sheet metal that is sealed at the edges with one-part foam or caulk. Cracks against heat-producing appliances such as fans, flues, or chimneys should be sealed with red hi-temp RTV caulking and non-combustible materials such as sheet metal.

What to Use for Air-Sealing. Caulking, liquid foam, and sheet goods that include foamboard, drywall, and plywood. These are the most common materials for air-sealing, and you'll be most productive if you have plenty of them on the truck at all times.

PLUMBING AND ELECTRICAL CHASES

Some of the biggest openings in site-built homes are found where pipes and wires enter the home. You'll find these big gaps in furnace closets, under sinks and tubs, and at electrical panels.

SWS 3.1001 Penetrations and Chases
Link: https://sws.nrel.gov/spec/31001

ATTICS AND CRAWL SPACES

In many homes, you'll find the biggest air leaks in attics and crawl spaces. You'll often get the biggest reduction in whole-house air leakage by focusing your air-sealing efforts on these areas.

Take time to inspect these areas with a bright light. Look for the big openings and concentrate there. Follow these guidelines.

- Use plywood, drywall, or foam board for any openings larger that 1". Fasten these materials solidly with fasteners, and seal the edges with caulk or one-part liquid foam.
- Use one-part or two-part liquid foam for cracks between 1/4 " and 1".
- Use caulk only for sealing very small cracks.

Bath fans and recessed lights. Caulk joints in the housing with high-temp red caulking, build an airtight box, or install an airtight trim kit.
Soffits over kitchen or bathroom cabinets. Seal the top of the soffit, in the attic, with foam board, plywood, or drywall. Fasten it down and seal the edges.
Tops and bottoms of balloon-framed walls. These sometimes open into attics and crawl spaces. Seal the stud bays with a fiberglass insulation plug and spray over it with foam. Or cut a piece of foam to fit each bay, and seal the edges.
Soil stacks and plumbing vents. Seal around pipes and ducts with foam or caulk. Or stuff fiberglass insulation into a bag, push it into the opening, and spray foam over the top to seal it.
Masonry chimneys. Seal these with sheet metal and fasten it to nearby framing. Caulk the edges with high-temp red caulking.
Bathtubs and shower stalls. Seal holes from underneath with rigid foam board and/or expanding foam. Seal the edges with foam or caulk. Don't spray over faucet and drain fittings that plumbers may need to get to in the future.
Wire and pipe penetrations. Seal them with caulk or foam.

INTERIOR SURFACES

Holes in interior paneling and drywall can allow a lot of air into the home. In weatherization work, you generally don't want to get involved in doing cosmetic work. But sometimes you'll have to repair these damaged surfaces when they allow a lot of infiltration, or when they prevent you from installing insulation. Leave the surface in a paint-ready condition.

Repairing Interior Surfaces. If the holes are big enough, you can get big improvements from wall and ceiling repair. But you should avoid doing a big interior makeover: just plug the big holes and move on.

SWS 3.16 Furnace Ducts
Link: https://sws.nrel.gov/spec/316

FURNACE DUCTS

The duct system will often contain the biggest air leaks in the home. Gaps in the ducts are more important than gaps of the same size in the building shell since they leak not just room air, but air that has been heated at some expense. Find and seal all the duct leaks you can.

You can find and seal a lot of duct leaks by simply using your eyes and a good flashlight. Start sealing near the furnace, since that's were the pressure is greatest and air is the hottest. Work your way outwards towards the branch ducts and registers. If you have the equipment and funding, you can improve the effectiveness of your work by testing duct leakage with a duct blower. See the Pressure Diagnostics chapter to learn about that procedure.

The best materials for sealing any ducts are duct mastic and fiber tape. It's messy, but it's fast and it always sticks. You'll get the best results if you clean the ducts with a wet rag before applying mastic.

Do not ever use gray fabric "duct tape". It doesn't really stick to anything for long.

Duct mastic and self-adhesive fiber tape is easy and fast to apply, and is the very best duct-sealing solution. It sticks to everything, which is good -- but because it's so messy, you'll need rubber gloves, rags, and plastic to protect nearby surfaces.

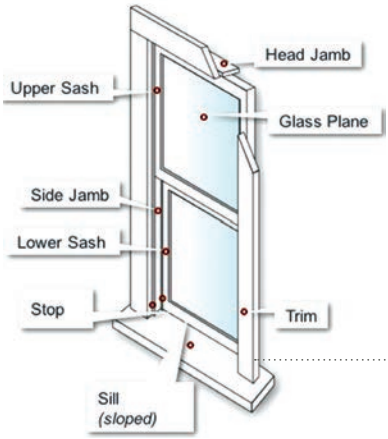
DOORS & WINDOWS

The weatherization program is designed to save energy for your clients. Unfortunately, replacing doors and windows does not usually provide enough energy savings to produce a good savings-to-investment-ratio (SIR). In most homes you'll provide better service to your clients if you spend your time and money on other measures.

DOOR AND WINDOW REPAIR

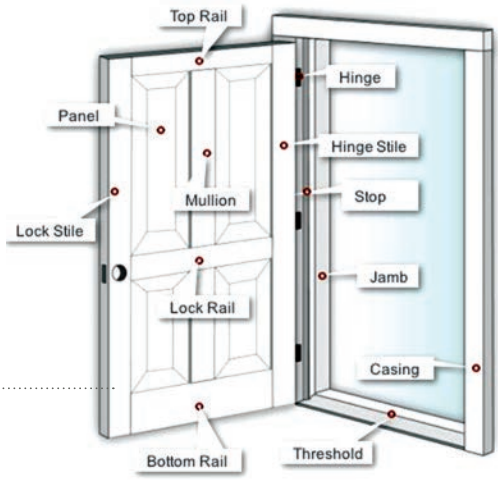
It is almost always worth the time to REPAIR doors and windows. Adjusting latches, replacing weatherstrip, or replacing broken glass is always a good idea on a weatherization job. If the home was built before 1978, use lead-safe work practices to protect the occupants from contamination.

SWS 3.1201 Window Maintenance, Repair, and Sealing
https://sws.nrel.gov/spec/31201



It's a good idea to learn the correct terminology for doors and windows so you can communicate effectively with suppliers, co-workers, and clients. Plus you look a lot more professional when you know what you're talking about!

Window Components



Door Components

DOOR AND WINDOW REPLACEMENT

If a door or window is so badly deteriorated that it cannot be repaired, then you can sometimes justify the expense of doing a full replacement.

You'll need a basic kit of tools for this job. Your materials should include non-hardening caulk such as urethane, one-part foam, and a selection of fasteners.

Be sure to order doors and windows with an Energy Star rating to assure that you get the best performance possible.

SWS 3.1203 Window Replacement
https://sws.nrel.gov/spec/31203

SWS 3.1203.5 Exterior Door Replacement
https://sws.nrel.gov/spec/312035

INSTALLING DOORS AND WINDOWS

The installation process is similar for doors and windows.

- Measure dimensions of the installed unit to confirm that you have the correct replacement.
- Decide whether you need to remove the interior trim or jamb extensions. In many cases you can leave them in place. If you need to remove them, now is the time.
- Remove the fasteners holding the old unit in place. Remove any trim at the inside and exterior, and pull it from the opening. You may need a flat bar and knife to cut the sealant away.
- Inspect the area under the threshold (doors) or sill (windows) for damage. Perform repairs if needed.
- Determine if you will fasten the window or door through the flanges/fins, or through the jambs. Clean up the surfaces where the unit will rest on or be sealed to the wall.
- Do a dry fit of the unit to confirm that it fits in the rough opening. Make any adjustments needed to create a flat and secure surface for the unit to rest upon. Don't open the door or window at this stage -- keeping it closed helps keep it squared-up without racking.
- Install a bead of caulk under the flanges, along the jamb, or wherever the unit will be fastened to the wall.
- Install the unit in the opening. Install just enough screws to hold it in place.
- Now — check the door or window for proper operation and sealing against its weatherstrip. Remove a few screws and re-square the unit if needed, checking carefully that the unit is square (the diagonals should be the same), and in plane (all edges are aligned when viewing across the front of the unit).
- Install the rest of the screws. Add additional sealant as needed to complete the seal.
- From the inside, fill the gaps between the jambs and framing with non-expanding one-part foam.
- Reinstall any trim you removed.

BASELOAD MEASURES

Baseload measures are types of energy consumption that don't change over the course of the year. Water heating, lighting, refrigeration, laundry, plug loads (such as entertainment devices and computers), and other appliances are all examples of baseload uses. Absent from this list are heating and cooling, which are considered seasonal, and so are not a part of a home's baseload consumption.

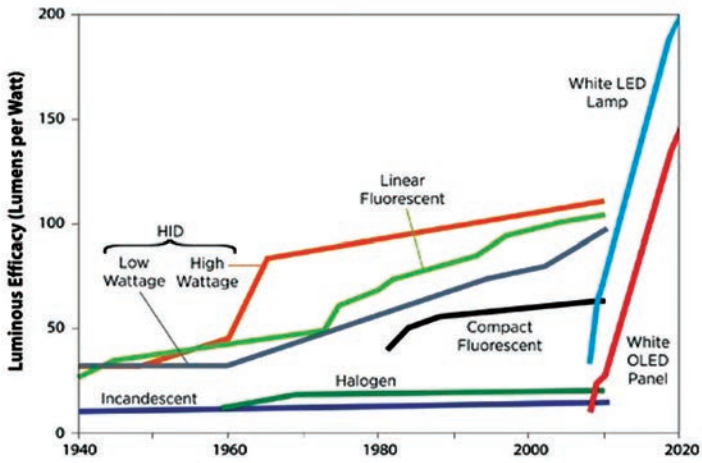
Not all baseload uses are addressed by the Montana program. The most common allowable measures are described here.

SWS 7.8003.1: Lighting Upgrade
https://sws.nrel.gov/spec/780031

LIGHTING UPGRADES

Good lighting helps create a healthy, safe, and pleasant home. Lighting upgrades give you the chance improve upon these basic human needs while still saving substantial energy.

Lighting systems have evolved quickly over the last few decades. Though old-fashioned incandescent "light bulbs" were the go-to lighting system for over 100 years, we have now replaced most of these with far better options. Compact fluorescent lamps (CFLs) were the first replacement technology that we used in the WAP program, and they provided a good SIR in most cases. Now, light emitting diodes (LEDs) can provide one more boost in efficiency. Though LEDs are often built into dedicated fixtures, the easiest replacements utilize simple Edison-type screw-in bases.



Improvements in Lighting Efficacy
The efficiency of lamps is measured as "efficacy". Efficacy is calculated by dividing the output in lumens by the consumption in watts. Modern LED lamps operate with an efficacy of 100 or higher, compared with an efficacy of 10-20 for incandescent lamps, and 50-70 for CFLs.

Efficacy = Lumens (output) ÷ Watts (consumption)

GUIDELINES FOR LAMP REPLACEMENT

Follow these guidelines when replacing lamps.

- Purchase only lamps with the Energy Star seal.
- Install LED lamps whenever possible.
- If you have a fixed number of lamps for each job, install them in the fixtures that are used the most. Do not install new lamps in fixtures that are used less than one hour per day — ask the client which these are.
- Be sure that the lamp fits correctly in the fixture, and that you can still install any shades.
- Choose a lamp that has the same output (in lumens) as the lamp that is already installed. Read the box to determine the output of the lamps you install. You should carry at least three different sizes with you so you can replace every size you're apt to encounter. You'll also need a range of styles, including 3-way, PAR, candelabra, and dimmable.
- Whenever possible, provide lamps with a pleasant "soft-white" output rather than a harsh "daylight" color.
- Confirm with the client that they are happy with the replacement.

BRIGHTNESS / BULB	450 lumens	800 lumens	1100 lumens	1600 lumens
LED	6W	9-10W	13W	16-18W
CFL	8-9W	13-14W	18-19W	23W
Regular Incandescent	40W	60W	75W	100W

Choosing the Correct Lamp. This chart compares the output of incandescents, CFLs, and LEDs. For example, if your client has installed a 100-watt incandescent, you should replace it with a 23-watt CFL or an 18-watt LED.

SWS 7.8102.4: Storage Tank-Type Water Heaters
https://sws.nrel.gov/spec/781024

WATER HEATER MEASURES

Water heating is usually the largest baseload use in the home. The following steps should be taken to assess and improve water heating efficiency.

- Check the temperature of the hot water, using a cup and a thermometer at a kitchen or bathroom sink. The ideal temperature is 120 degrees F. If the water is too hot or too cold, reset the thermostat (upper and lower on electric units) and mark the temperature you've set on the unit itself. Notify the client of any changes. If you have time, wait several hours or overnight to re-measure and assess the effect of your adjustment.
- Examine the water heater unit for leaks, damage, and/or excessive age. Unit replacements are not uncommon in the program as a Health and Safety measure. Leaks can contribute significantly to energy bills.
- Wrapping water heaters, once a common measure, is now usually impractical since many manufacturers are specifically requiring that no additional insulation be applied to their heaters. If you do install water heater blankets, be sure to follow the recommendations of the water heater manufacturer. Note that the Montana program has a variance allowing us to install R-10 blankets.
- Educate the client about hot water use.

Typical Water Heater. This is nice clean installation. There is no evidence of rollout or scorching. Earthquake straps have been installed. Valves are installed on both hot and cold water lines, and all the lines are insulated. The pressure relief valve (PRV or TP valve) has extension to send any discharge to outdoors. The gas supply line is composed of black pipe and approved flex lines, with a drip leg to catch any condensation or debris.

SWS 6.6005.1: Clothes Dryer Maintenance
https://sws.nrel.gov/spec/660051

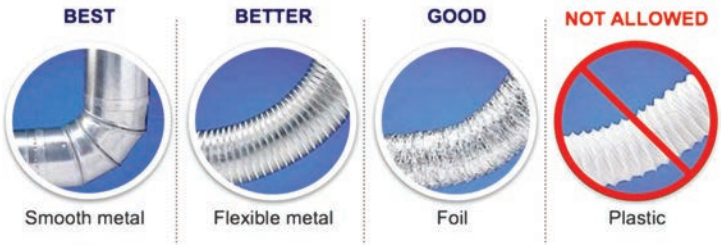
DRYER MAINTENANCE

Dryers can use a lot of energy. One of the best ways to improve their efficiency is to assure that the vent system is clear and air can flow well. Better airflow means reduced dry times, and that saves money.

All dryers should vent to the outdoors. It may be tempting to vent them indoors, in an attempt to save some energy, but releasing all that moisture and lint into the house is a bad idea.

Follow these steps to clean and upgrade dryer vents.

- Unplug the 220-volt power for electric dryers. Turn off the gas to electric dryers, and unplug their 110-volt power cord.
- Pull the dryer away from the wall so you can get to the vent. Use care as you move and stretch the vent and gas lines.
- Inspect the dryer vent pipe to confirm that it's in good condition, made of the proper materials, and runs to the outdoors. Replace it if not with approved materials. Fasten the joints with aluminum duct tape. Do not use screws since they will collect lint and slow airflow. Insulate the duct where if it runs through unconditioned spaces.
- If you did not replace the vent, disconnect the old vent where it leaves the appliance. Use a shop vac and brush to collect as much lint and debris as possible. You may have to remove multiple sections of pipe.
- Go outdoors and find the vent hood. Use the shop vac and a brush to clean this end. Confirm that the back-draft damper is loose and operates properly. Repair or replace it if not.
- Reconnect the ductwork, gas, and/or electric supply. Confirm that the dryer operates correctly.



Correct Materials Make a Difference
Dryer vent material make a big difference. Bumpy and corrugated materials catch lint and slow airflow. Use 4" rigid aluminum material whenever you can.

APPENDICES

GLOSSARY

Air barrier - Any part of the building shell that offers resistance to air leakage. The air barrier is effective if it stops most air leakage. The primary air barrier is the most effective of a series of air barriers.

ACH50 - The number of times that the complete volume of a home is exchanged for outside air each hour, when a blower door depressurizes the home to 50 Pascals.

Backdraft damper - A damper, installed near a fan, that allows air to flow in only one direction.

Backer rod - Polyethylene foam rope used as a backer for caulking.

Band joist - The outermost joist around the perimeter of the floor framing. See Rim joist.

Batt - A narrow blanket of fiberglass insulation, often 14.5 or 22.5 inches wide.

Belly return - A configuration found in some manufactured homes that uses the belly cavity as the return side of the distribution system.

Boot - A duct section that connects between a duct and a register.

BTU - British thermal unit, a unit of energy with the capacity to raise one pound of water one degree Fahrenheit.

Building cavities - The spaces inside walls, floors, and ceilings between the interior and exterior sheeting.

Carbon monoxide (CO) - An odorless and poisonous gas produced by incomplete combustion.

CFM50 - The number of cubic feet per minute of air flowing through the fan housing of a blower door when the house pressure is 50 Pascals (0.2 inches of water). This figure is the most common and accurate way of comparing the airtightness of buildings that are tested using a blower door.

CFMn - The number of cubic feet of air flowing through a house from indoors to outdoors during typical, natural conditions. This figure can be roughly estimated using a blower door.

Combustible - The rating for building materials that will burn under some conditions.

Combustion air - Air that provides oxygen for combustion.

Combustion appliance zone (CAZ) - A zone within the home that contains a combustion appliance for the purpose of space heating or water heating.

Condense - When a gas turns into a liquid as it cools, we say it condenses. Condensation is the opposite of evaporation.

Conditioned space - For energy purposes, space within a building that is provided with heating and/or cooling equipment or systems, or communicates directly with a conditioned space. For mechanical purposes, an area, room or space being heated or cooled by any equipment or appliance.

Conduction - Heat flow from molecule to molecule in a solid substance.

Confined space - A space that is not designed to be a dwelling or living space and that has limited entrance and/or egress (difficult to enter or exit).

Convection - The transfer of heat caused by the movement of a fluid like water or air. When a fluid becomes warmer it becomes lighter and rises.

Cubic foot per minute (cfm) - A measurement of air movement past a certain point or through a certain structure.

Delta-T - difference in temperature. Also expressed as ΔT.

Density - The weight of a material divided by its volume, usually measured in pounds per cubic foot.

Dew point - The warmest temperature at which water would condense on an object.

Direct vent - A combustion appliance that draws combustion air from outdoors and vents combustion products to outdoors.

Distribution system - A system of pipes or ducts used to distribute energy.

Dormer - A vertical window projecting from a roof.

Drainage plane - A space that allows water storage and drainage in a wall cavity, adjacent to or part of the weather-resistant barrier.

Eave - The part of a roof that projects beyond its supporting walls. See also soffit.

Efficiency - The ratio of output divided by input.

Envelope - The building shell. The exterior walls, floor, and roof assembly of a building. Sometimes denotes a building cavity or building assembly.

Fire barrier - A building assembly, designed to contain a fire for a particular time period: typically 1-to-4 hours.

Fire stop or blocking - Framing member designed to stop the spread of fire within a wall cavity.

Firewall - A structural wall between buildings designed to prevent the spread of a fire.

Flashing - Waterproof material used to prevent leakage at intersections between the roof surface at walls or penetrations.

Floor joists - The framing members that support the floor.

Gable - The triangular section of an end wall formed by the pitch of the roof.

Gable roof - A roof shape that has a ridge at the center and slopes in two directions.

Gasket - Elastic strip that seals a joint between two materials.

Glazing - Glass installation. Pertaining to glass assemblies or windows.

Glazing compound - A flexible, putty-like material used to seal glass in its sash or frame.

Ground-moisture barrier - Many crawlspaces require ground-moisture barriers to prevent the ground from being a major cause of moisture problems. The ground under a building is the most potent source of moisture in many buildings, especially those built on crawlspaces.

Heat-recovery ventilator (HRV) - A central ventilator that transfers heat from exhaust to intake air, and provides balanced ventilation.

Heat transmission - Heat flow through the walls, floor, and ceiling of a building. Does not include air leakage.

Heating degree day - Each degree that the average daily temperature is below the base temperature (usually 65°F) constitutes one heating degree day.

Heating load - The maximum heating rate needed by a building during the very coldest weather.

Ignition barrier - A material installed to prevent another material, often plastic foam, from catching fire.

Inches of Water Column (IWC) - The pressure exerted by a column of water of 1 inch in height. 1.0 IWC = 250 Pascals. See also Pascal.

Infiltration - The inflow of outdoor air into the indoors, which is accompanied by an equal outflow of air from indoors to the outdoors.

Jamb - The side or top piece of a window or door frame.

Joist - A horizontal wood framing member that supports a floor or ceiling.

Kilowatt (kW) - A unit of electric power equal to 1000 joules per second or 3412 BTUs per hour.

Kilowatt-hour (kWh) - A unit of electric energy equal to 3600 kilojoules or 3412 BTUs.

Lath - A thin strip of wood or base of metal or gypsum board serving as a support for plaster.

Low-e - Short for low emissivity, which means the characteristic of a metallic glass coating to resist the flow of radiant heat.

Make-up air - Air supplied to a space to replace exhausted air.

Nailing fin - A window fin with holes for fastening to sheathing or a window buck.

Natural ventilation - Ventilation using only natural air movement, without fans.

Net free area - The area of a vent after that area has been adjusted for insect screen, louvers, and weather coverings. The net free area is always less than the actual area.

Noncombustible material - Materials that pass the test procedure for defining non-combustibility of elementary materials set forth in ASTM E 136.

Pascal - A unit of measurement of air pressure. 250 Pascals = 1.0 inches water column (IWC). See also Inches of Water Column.

Perm - A measurement of how much water vapor a material will let pass through it per unit of time.

Plate - A piece of lumber installed horizontally to which the vertical studs in a wall frame are attached.

Plenum - The piece of ductwork that connects the air handler to the main supply duct.

Pressure Relief Valve - A safety component required on a boiler and water heater, designed to relieve excess pressure buildup in the tank.

Purlins - Framing members that sit on top of rafters, perpendicular to them, designed to spread support to roofing materials.

R-value - A measurement of thermal resistance. Used to measure insulation among other things. See U-value.

Rafter - A beam that gives form and support to a roof.

Relative humidity - The percent of moisture absorbed in the air compared to the maximum amount possible. Air that is saturated has 100% relative humidity.

Resistance - The property of a material resisting the flow of electrical energy or heat energy.

Return air - Air circulating back to the furnace from the house, to be heated by the furnace and supplied to the rooms.

Rim joist - The outermost joist around the perimeter of the floor framing.

Sash - A movable or stationary part of a window that frames a piece of glass.

Sill - The bottom of a window or door frame.

Sill pan - A metal or plastic pan installed on a window sill during window installation to trap water and divert it to outdoors.

SIR - Savings to investment ratio.

Sling Psychrometer - A device holding two thermometers that is slung through the air to measure relative humidity.

Soffit - The underside of a roof overhang or a small lowered ceiling, as above cabinets or a bathtub.

Solar heat-gain coefficient (SHGC) - The ratio of solar heat gain through a window to incident solar heat. Includes both transmitted heat and absorbed and re-radiated heat.

Stack effect - The draft established in a building from air infiltrating low and exfiltrating high.

Stop - A thin trim board for windows and doors to close against or slide against.

Strike plate - The metal plate attached to the door jamb that the latch inserts into upon closing.

Subfloor - The sheathing over the floor joists and under the flooring.

Thermal boundary - A line or plane where insulation and air barriers exist in order to resist thermal transmission and air leakage through or within a building shell.

Thermal break - A piece of relatively low conducting material between two high conducting materials.

Thermal bridging - Rapid heat conduction resulting from direct contact between very thermally conductive materials like metal and glass.

Thermal envelope - The basement walls, exterior walls, floor, roof and any other building element that enclose conditioned spaces.

Truss - A lightweight, rigid framework designed to be stronger than a solid beam of the same weight.

U-factor or U-value - A measurement of thermal conductivity. Used to measure the effectiveness of window among other things. The amount of heat that will flow through a square foot of building cross-section experiencing a temperature difference of 1° F. See R-value.

Unconditioned space - An area within the building shell that is not intentionally heated or cooled.

Vapor barrier - A Class I vapor retarder that resists the flow of water vapor to less than 0.1 perm.

Vapor retarder - A material that resists the flow of water vapor to less than 1.0 perm.

Ventilation - The movement of air through an area for the purpose of removing moisture, air pollution, or unwanted heat.

Volt - The energy contained in each unit of charge in joules per coulomb.

Watt - A unit of electrical power equivalent to one joule per second or 3.4 BTUH.

Watt-hour - A unit of electrical energy equivalent to 3600 joules or 3.4 BTUs.

Weep holes - Holes drilled for the purpose of allowing water to drain out of an area in a building where it has collected.

Wet-bulb temperature - The temperature of a dampened thermometer of a sling psychrometer used to determine relative humidity, dew point, and enthalpy.

Worst-case CAZ or **Worst-case depressurization test** - A safety test, performed by specific procedures, designed to assess the probability of chimney backdrafting.

WRT - The acronym for With Reference To, used to specify the zones compared in a differential pressure test.

Zone - A room or portion of a building separated from other rooms by an air barrier.

R-VALUE OF COMMON MATERIALS

Fiberglass, loose fill (per inch): 3.0

Fiberglass, batts: (per inch): 3.0

Fiberglass, batts, 3 ½" standard-density: R-11

Fiberglass, batts, 3 ½" medium-density: R-13

Fiberglass, batts, 3 ½" high-density: R-15

Fiberglass, batts, 5 ½" standard-density: R-19

Fiberglass, batts, 3 ½" high-density: R-21

Cellulose loose fill (per inch): 3.0

Rock wool, loose fill (per inch): 2.2

Extruded Polystyrene (blue or pink rigid)(per inch): 5.0

Expanded Polystyrene (white beadboard)(per inch): 4.5

Urethane Spray Foam (per inch): 6.5

Vermiculite (Zonolite)(per inch): 2.2

Sawdust or shredded wood (Silvawool)(per inch): 1.3

Straw bales (per inch): 2.5

NOTICE OF DANGEROUS CONDITIONS

If a home contains a dangerous condition that prevents weatherization services, note the condition using this document and defer weatherization until the condition is corrected. Some examples of dangerous conditions may include, but are not limited to:

- Asbestos
- Excessive mold
- Sewage leaks
- A lack of structural integrity in part of all of the home

Notice of Dangerous Conditions PDF. Complete this form if you note dangerous conditions.

http://www.weatherization.org/documents/EAP%20023%20Notice%20of%20Dangerous%20Conditions%202005.pdf

CONFINED SPACES

A confined space is an area that is not designed for continuous occupancy AND has limited entrance/egress.

A second category of confined space is called a "permit-required confined space." Permit-required confined spaces are defined by OSHA as a confined space that has one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere;
- Contains a material that has the potential for engulfing an entrant;
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
- Contains any other recognized serious safety or health hazard.

OSHA Guidance. What is a confined space versus a "permit confined" space?

http://www.weatherization.org/documents/Confined_Spaces.pdf

Confined Space Checklist. Complete this form if you will enter a confined space.

http://www.weatherization.org/documents/Confined_Space_Entry_Permit_Checklist.pdf

EQUIPMENT MANUALS

Blower Door Manual, from Retrotec. The big pressure diagnostics manual for anyone who uses the more advanced Retrotec equipment.

http://www.weatherization.org/documents/Retrotec_Blower_Door_Operation_200%201000%202000%203000.pdf

Blower Door Manual, from The Energy Conservatory. There is a lot of good information here — it's good to review it even if you think you're familiar with the equipment.

http://www.weatherization.org/documents/TEC_Blower_Door_Guides_all.pdf

DucTester Manual, from Retrotec. The big manual for duct testing -- a procedure you'll need to understand if you're doing HERS ratings or testing new homes.

http://www.weatherization.org/documents/Manual_DucTester_Operation_Model_US341_0.pdf

Duct Blaster Manual, from The Energy Conservatory. How to set up and run a duct test using TEC equipment.

http://www.weatherization.org/documents/Duct_Blaster_Manual_Series_B_DG700.pdf

WEATHERIZATION PROGRAM DOCUMENTS

Worst Case CAZ Test. Weatherization changes the operation of a home. Before leaving the job site each day, an end-of-day CAZ test is required. This procedure checks the operation and proper drafting of naturally-vented combustion appliances.

http://www.weatherization.org/documents/Worst%20Case%20Combustion%20Appliance%20Zone_End%20of%20Day_D3.pdf

Furnace and Water Heater Worksheet. This worksheet directs the inspection and testing of heating units in program homes. It should be completed during both the initial audit and final inspection.

http://www.weatherization.org/documents/EAP-008%20Heating%20Worksheet%202015_02172016.pdf

Client File Documentation Checklist. Weatherization jobs generate a lot of forms and require more than a few signatures. To keep track of everything required for a job, use this Client File Documentation Checklist and keep it in the file with everything else. It's a quick way to stay in compliance with State and Federal requirements.

http://www.weatherization.org/documents/Weatherization%20Client%20File%20Checklist.pdf

RRP RULES AND GUIDELINES

Lead contamination is the single biggest environmental hazard for children living in the US. Following lead safe procedures has proven to lower the risk of lead contamination in the homes we weatherize. All weatherization workers must be certified under the RRP rule and follow the lead safe regulations set out by EPA and DOE.

http://www.weatherization.org/rrp_registration.html

MATERIALS SUPPLIERS

A + M Conservation Group
www.amconservationgroup.com
888-513-3005

J&R Products, Inc.
www.jrproductsinc.com
Phone: 800-343-4446

Retrotec
www.retrotec.com
855-738-7683

Tamarack Technologies
www.tamtech.com
800-222-5932

The Energy Conservatory
www.energyconservatory.com
612-827-1117

TruTech Tools
www.trutechtools.com
888-224-3437

475 High Performance Building Supply
www.foursevenfive.com
800-995-6329

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MONTANA STATE UNIVERSITY EXTENSION

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