MONTANA FIELD GUIDE
MOBILE HOME WEATHERIZATION

INTRODUCTION

This field guide highlights the most common and critical details for the weatherization and upgrade of manufactured 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 manufactured homes in the region.

The procedures described in this field guide are generally aligned 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/

Montana Weatherization Training Center
http://www.weatherization.org/

A NOTE ABOUT TERMINOLOGY

Many different terms have been applied to the types of homes discussed in this manual — "mobile", "manufactured", "modular", and "trailers". We include guidance here for all of them, but we use the term "mobile home" throughout to simplify the discussion. Note that the Standard Work Specifications use the term "manufactured housing". Their advice is relevant, as is ours, to improving the performance, durabilty, safety, and comfort all these types of homes.

LEARN MORE AT WXTV

If you want to learn more about weatherizing mobile 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.

http://www.weatherization.org/documents/Quality_Workplan_2016.pdf

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.

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

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!

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

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

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

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.

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), which is unlikely since they cost up to $1000.
- 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, and 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 away get into the home. 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, be sure that the occupant knows how to change the batteries.

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, as well as the DOE Lead-Safe Weatherization practices.
- 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.

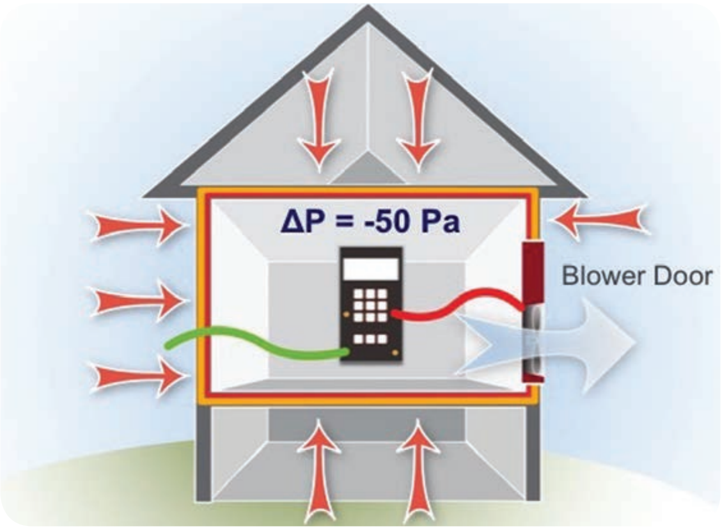
- If you're unsure whether material contains asbestos, have a qualified lab test the material. If suspected ACM is in good condition, don't disturb it.
- The agency must defer the audit when there is the possible presence of friable asbestos. If asbestos levels in the vermiculite have been determined 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 vermiculite attic insulation is present.

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.

Set up the Blower Door

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 work best in mobile homes, but can also give you good information in some site-built homes. They must be performed while the home is set up for a blower door test.

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 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.

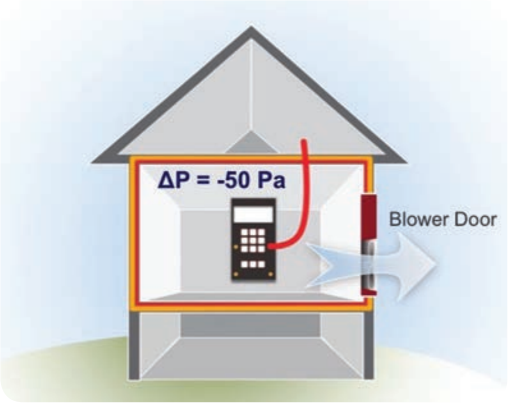
Running a Pressure Pan Test

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/

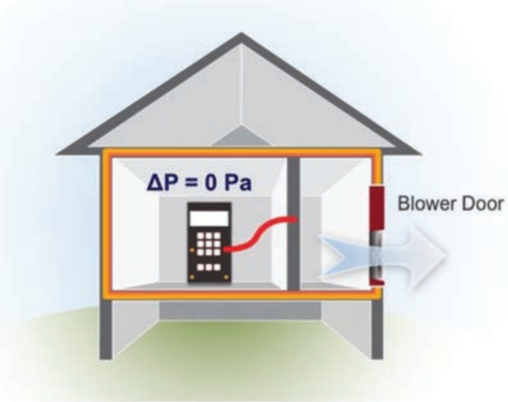
ZONE PRESSURE DIAGNOSTICS (ZPD)

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

You'll want the attic to be separated from the house. This reading of -50 pascals indicates a perfect air barrier at the ceiling.



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.

DUCT BLOWER TESTING

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

A duct blower, also known as a duct blaster, is 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 is also 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

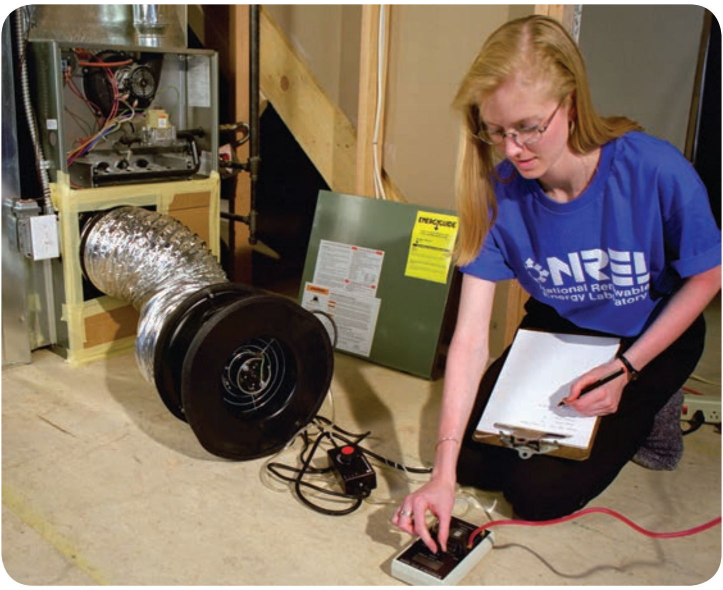
Set up the home for the duct test. We show a simplified set of instructions here — check the manufacturer's instructions for complete instructions since there are plenty of ways to goof up this test.

- 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 pressurize 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.



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.

PRESSURE BALANCING

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

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 not 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 this or any ducts.

Balancing Room Pressures
This auditor has left 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.

COMBUSTION APPLIANCES

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

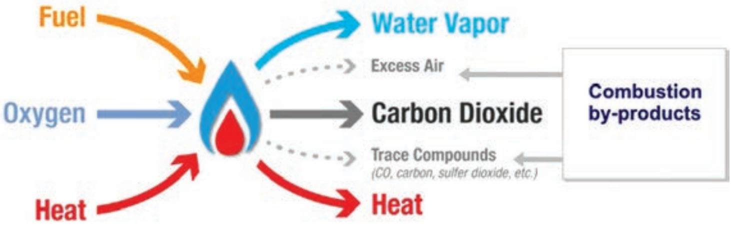
Complete combustion occurs when all the fuel is burned. This creates heat, but also produces carbon dioxide and water vapor. That is the ideal process, but if the combustion process is not complete, poisonous carbon monoxide (CO) or other dangerous combustion by-products can be released.

CO is produced under the following conditions:

- The ratio of fuel-to-oxygen is either too high to permit the complete formation of CO2.
- 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).



SMOKE ALARMS & CARBON MONOXIDE (CO) DETECTORS

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

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

MOBILE HOME FURNACES

Many mobile homes are heated with furnaces designed specifically for mobile homes. They are usually installed in a closet, and though they operate at conventional efficiency (70%), they draw air from outdoors. The blower is located above the burner, and they move air in a counterflow pattern, downward towards the floor. The supply ducts are located in the belly, and return air is drawn through a filter in the front of the cabinet.

Mobile Home Furnace
This typical mobile home furnace has been cleaned and tuned, and is ready for a winter of trouble-free service. These are some of the most reliable heating appliances you'll ever see.

MOBILE HOME WATER HEATERS

SWS 2.0204.1: Isolating Combustion Water Heater Closet
https://sws.nrel.gov/spec/202041

Many mobile home water heaters are installed in closets accessible from the exterior of the home. Even though many of these are connected to the house through holes in the walls of the closet, they should be air-sealed to separate them from the living space.

Oftentimes, the only way to effectively air-seal the closet is by removing the water heater, a measure that is sometimes allowable as Health and Safety work. If you replace a mobile home water heater, it should be approved for mobile homes, and should have the combustion air duct connected through the belly.

When you have finished air-sealing the closet, perform zone pressure diagnostics (ZPD) to assess the integrity of the air barrier. This test should measure Water Heater Closet WRT House, and the pressure differential should be near 50 pascals to ensure that the combustion appliance is completely disconnected from the living space.

INSPECTIONS AND TESTS

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

GAS LEAKS

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.

BACKDRAFT, SPILLAGE, AND CO TESTING

SWS 22.0201.3—Vented Combustion Appliance Safety Testing
https://sws.nrel.gov/spec/202013

This set of procedures will help you confirm that dangerous combustion gases produced by open-combustion appliances are safely carried out of the home. You should do these tests at the end of each workday and at the end of the job.

Some appliance vent systems operate properly only part of the time. Then, when the house is set up differently (when someone starts the dryer or runs an exhaust fan, for example), the vent begins spilling combustion gases into the home. The intent of this procedure is to determine if that dangerous condition could ever exist in your client's home. Follow these steps:

- Determine the location of the Combustion Appliance Zone (CAZ). This is generally the room where the furnace and/or water heater is installed.
- Set up a manometer to measure CAZ with reference to (WRT) outdoors. You'll need a long hose.
- Turn on all exhaust fans in the home.
- Open and close doors in the home to achieve the most negative CAZ pressures.
- Turn on the air handler. If operation makes the CAZ more negative, leave it on.
- Fire each combustion appliance, starting with the lowest BTU unit.
- Apply a smoke pencil to the draft diverter. It should draft, drawing smoke up the chimney within 2 minutes.
- Test the undiluted flue gases in the stack, before the draft diverter. 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 draft test, or has high levels of CO, perform repairs or report to the energy auditor or program director immediately.

Smoke Test at Draft Diverter

The auditor has set up the home in worst case conditions, fired the water heater, and waited 2 minutes for the combustion process to stabilize. Smoke is being drawn into the draft diverter, indicating sufficient draft under these conditions.

COMBUSTION AIR

Open combustion appliances (that draw combustion air from indoors) should have combustion air supplied from outdoors so they draft correctly. Mobile home furnaces usually draw air from the roof through a concentric chimney that expels gases up the center, and draws combustion down around the sides of the assembly. Mobile home water heaters often have a 3" duct that supplies combustion air through the floor.

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. If the appliance is spilling carbon monoxide 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.

FLUE AND VENT SYSTEM INSPECTION

The flue and vent system includes the components commonly known as the chimney, vent connector, and everything in between. This system is responsible for carrying combustion gasses out of the home, and should be visually inspected for these attributes.

- Chimneys for site-built homes should extend at least 3′ above the roof. Chimneys for mobile home furnaces can be shorter than this.
- Vent connectors and draft hoods should be free of excessive rust or corrosion.
- Vent connectors should slope upwards towards the chimney with at least ¼″ per foot rise.
- Vent connectors and metal chimneys should be supported so they do not move around.
- All chimneys should be at least the same diameter as the exhaust port of the combustion appliance.
- Masonry chimneys (brick, stone, or concrete masonry units) should be sound, and with no holes or extra openings into the flue. They should have a sound liner (clay tile or metal) that runs the entire length of the chimney.
- Any chimney inspection hatches should be solidly fastened into place.

INSPECTING HEAT EXCHANGERS

The heat exchanger separates the combustion process from the living space. Since they are subjected to repeated heating, cooling, and possibly condensation, they are prone to rust, corrosion, and cracking. You should inspect the heat exchangers for all open combustion (70% AFUE) furnaces. There is no inspection process for sealed combustion (80% and 95% AFUE) furnaces since there is no easy access to the heat exchanger.

You can inspect heat exchangers using an adjustable mirror and bright light. The process is somewhat different for each type of heat exchanger, depending on the ease and location of access. Look for evidence of excessive rust, corrosion, or cracking. If you identify suspicious areas, bring in an HVAC specialist for further evaluation.

INSULATION

Insulation provides a thermal barrier in the home that improves comfort and reduces energy consumption throughout the year. These benefits are especially true in mobile homes, which are often built with minimal insulation. 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.

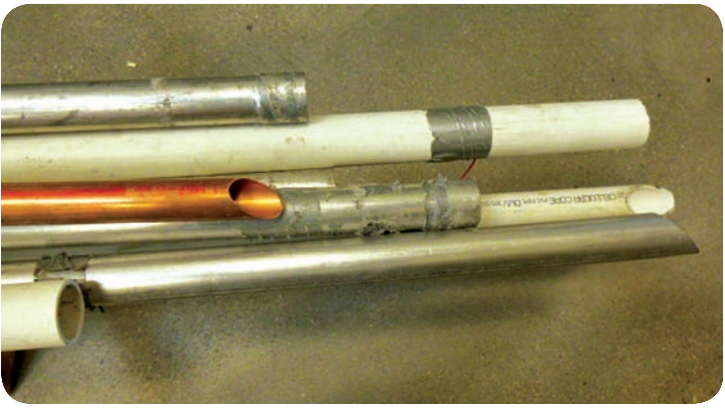
SWS 4.0: Mobile Home Insulation
https://sws.nrel.gov/spec/4

GAINING ACCESS

The methods used to assess, access, and install insulation in mobile homes are different than in stick-built homes. But with a little training and practice, most crews find that insulating and air-sealing mobile homes is not that difficult, and benefits are substantial. There are several ways to access roof, wall, and belly 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.

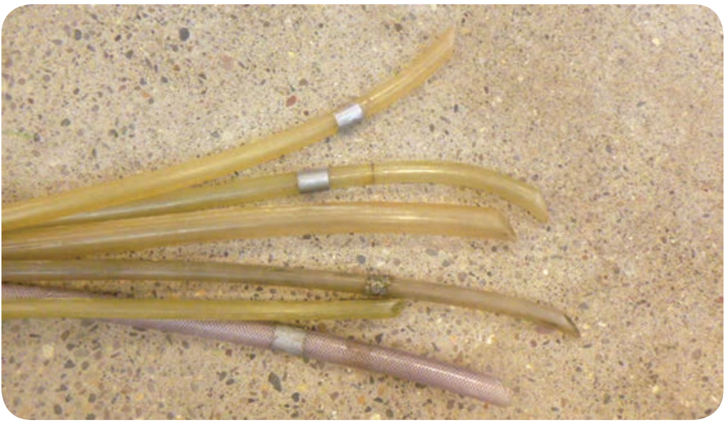
Every Home is Different

You'll need to use several different methods to install insulation in this tidy home. The best access to the roof will be from the ends, since the porches will limit the use of scaffold and ladders along the sides of the home. Access to the walls will also be limited by these porches, preventing you from un-zipping the base of the wall to gain access. But you may be able to gain access to the base of the walls everywhere else, then drill holes through the siding inside the porches, and cover them with plastic caps. Luckily, there appears to be good, clean access to the crawl space, suggesting that one way to insulate the belly may be by slitting the belly board or paper. You won't be able to drill the rim to tube the belly at the porches, though you could do so away from the porches. But, if the home has longitudinal or lengthwise joists (peek through the belly paper to find out), you may be able to tube the entire belly from each end of the home. It takes some long tubes—and room to work—to do so, but sometimes an end-blow is the easiest option of all.



A Variety of Rigid Fill-Tubes

You'll use rigid fill tubes for blowing roofs from the edge, and bellies through the rim or from the end. Steel muffler pipe, metallic electrical conduit, or aluminum pipe all work well as fill tubes. You want the fattest pipes you can handle so you can move the insulation quickly—most crews carry 1 ½" and 2' rigid tubes. ABS plastic drain pipe is good if you can find it in your region. If you use PVC plastic, the moving insulation will create enough static electricity to give the installer a solid but non-lethal shock. The solution is to install a copper ground wire along the side of the pipe, wrapping the bare-metal end around a self-tapping screw fastened where the pipe attaches to the flex insulation hose from the machine. Wrap tape around the wire and pipe to prevent the screw from tearing out.



A Variety of Flexible Fill-Tubes

You'll use flex tubes to fill most walls. They're sometimes useful, too, when obstruction get in the way of using rigid tubes in roofs and bellies. 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.

INSULATING ROOFS

Access to the roof can be gained opening the top, lifting the edge, or drilling from indoors. Working outdoors has the benefit of keeping a mess out of the house. Working indoors can be a good option when the weather is bad. Going through the roof works well when the structure and roofing surface are solid enough to walk upon. Lifting the edge can be a good option when the roof is too soft to support a crew, or when the crew simply prefers working closer to the ground.

INSULATING THE ROOF FROM THE TOP

SWS 4.1003.9: Installing Blown Attic Insulation, from top
https://sws.nrel.gov/spec/410039

This method involves drilling 2 ½" or 3" holes into the roof cavities, blowing insulation through a fill tube, and patching the holes with waterproof materials. In some conditions, this is the fastest way to get the job done.

Typical Roof Framing

Choose a drilling pattern that works around the roof framing. The procedure shown shown in this sequence includes a single set of holes down the middle of the home. But note that some homes have a ridge board as shown here, requiring crews to drill a set of homes down each side.

Drilling the Holes

Drill holes close to the center of the rafter bays. You can find the bays by pressing on the roof in spots along the length of the home: the ridges you feel are the rafters. Soft spots between the rafters are your locations for drilling and should be located on a consistent measurement schedule. Choose a bit size based upon the size of the plug you'll use when you're done — the most common plug is plastic and 2-½" across. In some homes, you'll need to drill one hole for each rafter bay. In others, with open framing, you may be able to access two or three bays from each hole. Take a look inside the cavity after the first hole your drill to determine your subsequent steps. You may need to push some material aside or use a borescope.

Filling the Cavities

Choose a fill tube that is as large as possible, but feeds easily — the type of tube will vary depending on the outdoor temperature and the size of hole you've drilled. Kneel on a board to spread your weight across several rafters (plywood works well). Have someone monitor the inside of the home while blowing to check for insulation leaks or breaks in the finish surface. Refasten or repair these areas as needed.

Capping the Holes

Cap the holes with plastic caps from an insulation supply house. Confirm before you begin that your drill bit matches the caps. Bed them in sealant (Note: a product labeled as a "sealant" works better than one labeled as a "caulk"), and set them flush with the surface.

Installing a Self-Adhesive Cap Sheet

Clean the surface with solvent. For surfaces where cleaning does not reveal bare metal, use a 4-½" grinder with a wire-brush attachment to clean the surface first. Be careful not to damage the home and always wear proper PPE. Cut an 8"x8" piece of peel-and-seal or equivalent, and place it over the plug. Press and or roll it into place so it's good and stuck. Use a J-roller to roll the patch flat, especially around the edges of the plug.

Sealing the Cap Sheet

Heat the patch with a torch or "weed burner." Be careful not to over-heat the surface. Use a rag or hunk of fiberglass to press and smooth the patch into place. Let it cool slightly, and check an edge to confirm that's it's solidly stuck. If you still can lift an edge, add more heat and go again.

COATING THE ROOF

When using methods that involve opening the roof, many crews will take the additional step of coating the entire roof with a white elastomeric roof coating. It comes in 5-gallon buckets, and you apply it to a clean surface with a roller and/or brush. You could get by with coating only the areas that were patched, but it's not that much more work to do the entire surface. These coatings are also quite reflective, so coating the entire roof will improve summer comfort and reduce cooling costs. Follow manufacturer's instructions when applying these coatings and take time to prep the surface as instructed.

INSULATING BY LIFTING THE LID

SWS 4.1003.8: Installing Blown Attic Insulation, side lift
https://sws.nrel.gov/spec/410038

Removing the J-Rail

Remove the J-rail (mini gutter) if present. Start by remove the screws, cutting and removing caulking as you go. If there is a chance that the wind will come up, remove one section at a time, insulate, and re-fasten it before unzipping more roof edge. You may want to replace the screws and/or J-rail if they are too gunked up with layers of roof sealant, replacing with new materials is much faster, easier, and often more economical than trying to use the original pieces.

Prepping the Cavity

Lift the edge, and prop it up the edge with small wooden blocks. Clean up any remaining caulking at the edges with a scraper and/or powered wire brush. Prep the cavity for insulation by building sheet metal dams around heat-producing devices, inspecting and repairing wiring, and repairing weak spots in the ceiling.

Filling the Cavity

Choose the largest tube that you can feed across the entire width of the attic. Block the open edge with a batt of fiberglass to minimize blowback. Start the machine and fill the cavity. Pack tightly enough to get good coverage, but use care to avoid over-pressurizing the cavity and damaging the ceiling. Often, the edges of the building can take a bit higher density than the middle of the structure, but you will need to leave room to refasten the edges. This is something that must be learned in a hands-on environment. Monitor the ceiling from indoors while blowing.

Sealing and Fastening the Edge

Fill the cavity, but don't mound the insulation at the edges where you'll need to lower and re-fasten the roofing. Do a test to confirm that you can lower the lid into place and your screws are the proper size. Then apply a generous bead of pure silicone caulk to the edge. Lower the roofing and fasten the screws. Refasten the J-rail, making sure the flashing laps properly so water from above can move without traveling underneath a lower piece of siding or flashing.

INSULATING THE ROOF FROM INSIDE

SWS 4.1003.10: Installing Blown Insulation Through the Ceiling
https://sws.nrel.gov/spec/4100310

Sometimes the best way to access the attic of a mobile home is by working indoors and going through the ceiling. If you choose this option, be sure to warn the occupant about the mess you'll make. Then be prepared to move and cover furniture, work around personal belongings, and spend time on clean-up afterwards. But in some homes, working from the inside is still the fastest way to get the job done.

Drilling the Ceiling

These crew members have popped a string line down the middle of the home to help drill in a straight line. They're using a 2″ hole saw to drill holes that fit a 2″ plastic cap. You can really reduce the mess by using a shop vac to collect dust.

Filling the Cavity

The installer uses an 1¼″ vinyl tube to blow fiberglass. He'll run the 8′ tube all the way to the edge before begin to blow. Once that half of the cavity is full, he'll re-insert and fill the other side.

Capping the Holes

These plastic caps come in 2″, 2½″, and 3″ sizes, and are sold by insulation supply houses (see the Appendices). Bed them in a thin bead of caulking. It sometimes works well to install a strip of trim to cover the holes, or to temporarily remove an existing piece of trim, if it's in the correct location, and drill underneath it.

INSULATING THE BELLY

SWS 4.1303: Manufactured Housing Floor Cavity Insulation
£https://sws.nrel.gov/spec/41303

Insulating and air-sealing the belly of a mobile home can have great benefits in both comfort and energy efficiency, providing a better savings-to-investment ratio than perhaps any other weatherization measure.

PREPPING THE BELLY

Since mobile home ducts are located in the belly, you should inspect, do a pressure pan test, and repair ducts as needed before insulating. Floor boots, and nearby minor disconnects, are best repaired by removing the registers and working from above, this procedure is covered in Chapter 7 air-sealing. If you find major disconnects, the best way to access and repair them is often to cut a hole in the belly paper or board, do the work, then repair the belly.

Water lines and sewer lines are located in the belly and/or in the crawl space. Inspect these systems and repair any leaks before insulating. In cold climates, you should also be aware of freezing issues before installing insulation — add insulation to water lines if needed, and avoid installing insulation above water lines where it would have the effect of isolating them from heat emanating from the floor.

The belly of mobile homes is usually covered with either rigid fiberboard, or flexible belly paper. You'll need to repair any holes larger than 1-2" before insulating.

Patching Belly Board or Paper

You can patch small holes in the belly paper using self-adhesive repair sheets. Larger holes are best repaired with housewrap, such as Tyvek. If you're doing the repair work with fiberboard, cut the board with a skilsaw, and fasten it with screws and washers. In some cases, you may find so much damage that it's easiest to just replace an entire section.

Fastening the Patch

Repair patches should be stuck into place with urethane caulk or spray glue, and fastened with an outward-clinching stitch-stapler. In some causes you can use wood battens or strips to fasten the paper directly to the floor joists. See the suppliers in the Appendices for sources of repair paper, adhesives, and stitch staplers.

Accessing the Belly: Side versus Bottom Blow

Mobile home bellies can be blown from either the side or the bottom. You'll make the choice based upon the type of construction, conditions around and under the home, and the experience of the crew.

Blowing from the side has the advantage that crews don't have to work in the crawl space, though they'll may still need to work there to repair the belly, ductwork, or ground-moisture barrier. The disadvantages of side-blow include the need to loosen and re-fasten the siding without causing damage. Sometimes it's just easier to go through the belly where no one is apt to complain about the appearance of your work.

BLOWING THE BELLY FROM THE SIDE

To insulate the belly from the side, you'll need to either remove a strip of siding (if horizontal), or loosen the lower edge (for vertical siding). Experiment in one area, removing or loosening siding and blowing a cavity, before you commit to opening the entire side of the home. In general, avoid bending the siding too much, and do not remove more screws than necessary. In some cases, you can save time and get a better looking job by replacing the screws with new hex-head neoprene washer screws. If the holes are prone to stripping, you can buy the next size larger.

You'll need long fill-tubes for this job: 16′ for crosswise joists, and as long as you can handle for longitudinal joists that require you to blow from the end.

Drilling the Rim

This crew member uses a ½″ right-angle drill to drill 2 ½″ holes in the rim. Use care in this process to avoid injury: wear gloves and keep your hands free of pinch points since these big drills can throw you for a loop when they hit a nail. Using a drill with a clutch is recommended for both safety and comfortable ergonomics. On this job, the crew removed the strip of aluminum starter strip to gain access to the rim.

Tubing the Belly

The insulator began by inserting the tube to the far side of the building. Use care when passing the pipe around wires, ducts, and pipes. Begin filling until the flow of insulation slows and the machine bogs down. Withdraw the tube slowly until each section is lightly packed. Watch the belly for sagging as you go — you can't get a true dense-pack in belly cavities. Keep track of how many bags of insulation you are using. If your numbers exceed your initial calculations, you may have a tear in the belly and are filling the crawlspace with loose insulation.

BLOWING THE BELLY FROM UNDERNEATH

For this method, you'll blow the belly by removing skirting, working under the home, and cutting slits in the belly-board or paper to insert the insulation hose. Sometimes, this is the only appropriate method for filling a belly. There are some tricks to performing this task in the easiest way possible that must be learned in a hands-on setting with experienced installers or instructors.

Blowing through the Paper

This crew member uses a 3" flex tube to fill each joist cavity. You'll need to experiment to determine the correct size and flexibility of tube. Insert the tube to the far end of the cavity, and fill while slowly withdrawing the tube. If you get a lot of blowback in your face, wrap a scrap of fiberglass around the opening. Patch the holes as outlined in the repair section.

INSTALLING GROUND MOISTURE BARRIERS

SWS 2.0403.4: Ground Moisture Barriers
https://sws.nrel.gov/spec/204034

Properly installed ground moisture barriers protect the home by slowing the flow of moisture out of the ground and into the home. A good ground moisture barrier should have these attributes:

- 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.
- Fastened to the ground as needed around entry points or where wind could lift it.

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.

INSULATING THE WALLS

SWS 4.1104: Manufactured Housing Wall Insulation
https://sws.nrel.gov/spec/41104

The walls of older mobile homes are often insulated with only 1″ or 2″ batts. It's easy to fill these cavities with additional insulation to improve their performance. The best way is to loosen the siding at the bottom, or to remove the 6-8″ starter strip that sometimes runs along the bottom.

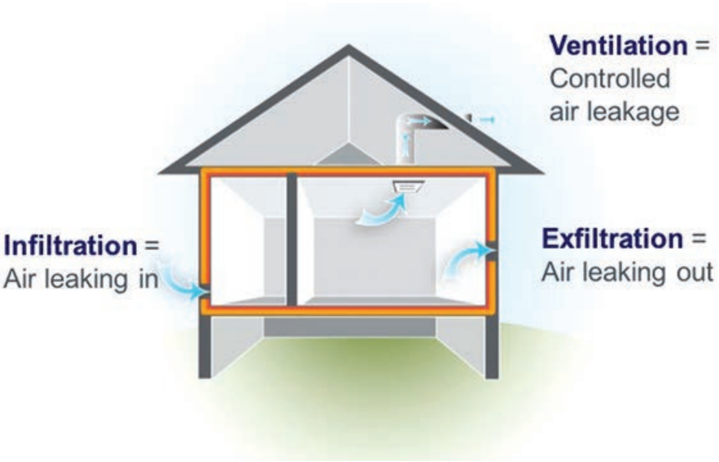
Loosening the Siding
Each mobile home is constructed a differently. Experiment to determine which how much siding and how many screws you'll need to remove. Replace the screws if the old ones are gunked-up or stripped out.

Tubing the Wall
This insulator is using an 1½″ vinyl tube to fill the wall cavity. He'll insert the tube all the way to the top of the wall, begin filling, then slowly pull the tube back as he hears and feels the insulation pack tightly. It takes some experience to walk the line between getting sufficient density and plugging the hose. On this job, the transition to 3″ pipe is made with a tapered fitting that was made by a muffler shop. You'll save a lot of time — and avoid plugging the tube — if you use tapered fittings at the transitions to keep the material flowing smoothly.

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 3.1101: Sealing Manufactured Housing Walls
Link: https://sws.nrel.gov/spec/31101

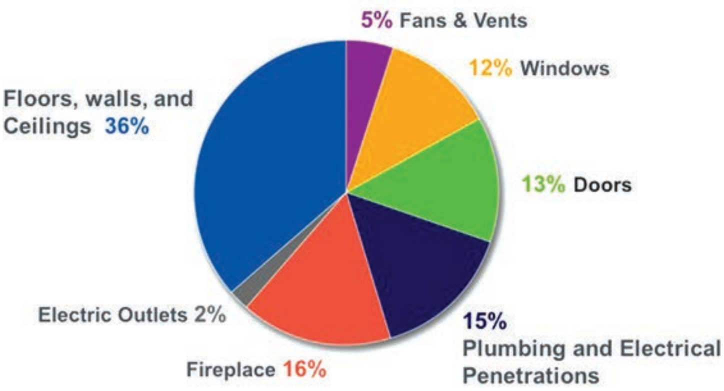


Air Leakage Pathways

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.



Data courtesy of the California Energy Commission

Where to Focus Air-Sealing Work

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.

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

The water heater cabinets in some mobile homes present a large challenge since they sometimes contain large holes that leak into the wall and cabinets of adjacent bathrooms. Seal what you can by reaching around the tank, but sometimes the best solution is to remove the tank, seal the walls, and reinstall the tank. These cabinets should be sealed away from the house so they are connected to the outdoors. A zone pressure diagnosis (ZPD) should show that this space is nearly outdoors, at or around 45-50 pascals House WRT (with reference to) the water heater cabinet.

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.

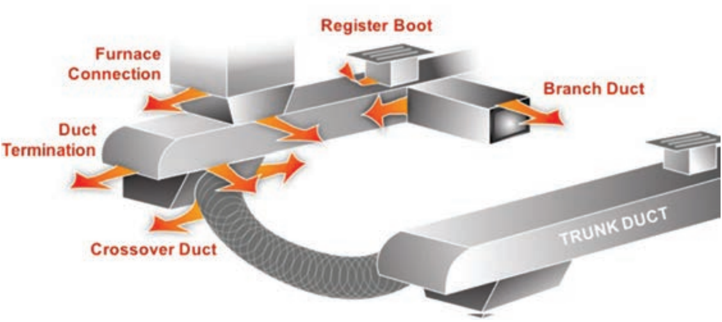
Repairing Interior Surfaces

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.

MOBILE HOME DUCTS

This 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.

The best materials for sealing any ducts are duct mastic and fiber tape. It's messy, but it's fast and it always sticks. Do not ever use gray fabric "duct tape" — it doesn't really stick to anything for long.



Sources of Mobile Home Duct Leakage

Some of these leaks can be reached from below the home: trunk ducts, duct terminations, branch ducts, and crossovers (on double-wides). The register boots can be sealed from indoors by lifting the register and sealing the boot to the floor. The furnace connection can only be improved when removing the furnace.

The Best Duct Sealing Materials

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..

DUCT BOOTS

The area around the penetration for the furnace registers is often poorly connected to the floor. These sheet metal boots are often hastily stapled to the subfloor when manufactured. Gaps in this area leak heated air from the furnace directly into the crawl space, so they must be repaired. Performing a pressure pan test will identify leaky boots, but simply removing the registers and taking a look will show where leaks are apt to occur. Here's the process.

- Start by reattaching the boot to the subfloor. Use screws or ring shank nails to secure the metal boot around the entire perimeter. You may need to predrill holes through the sheet metal.
- Clean the entire area so the tape and mastic will stick. Vacuum down into the duct to pick up any debris.
- Install blue painters tape or duct mask around the outside of the register to keep the duct mastic off the visible portions of the floor.
- Install fiber mesh tape between the floor and the boot, covering the gap between the floor and the metal completely. Stay inside the tape that's protecting the floor. Use staples to secure the mesh tape if needed. Apply mesh to any open seams between boot and duct. You don't need to apply mastic to small, tight seams — it can bridge minor gaps.
- Apply duct mastic over the fiber tape and any minor cracks. It's messy, so be careful not to get the mastic on any components that will show once the register is reinstalled.
- Leave the register off as long as possible so the mastic can dry. Don't let carpet come in contact with the wet mastic!

Sealing the Boots

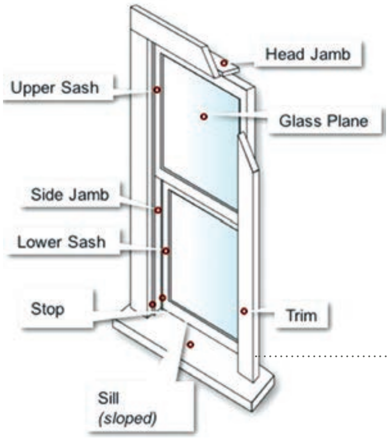
Allow a lot of heated air to escape into the crawl space when the furnace is running, and allow cold air to leak into the house when it's not. Sealing this boot, and as many seams as you can reach inside the duct, will result in large performance improvements.

DOORS & WINDOWS

The doors and windows in any home are a high maintenance item. Most of them work well when new, but they always take a beating, and eventually most doors and window need maintenance and repair work. And even though many clients believe window and door replacement will solve their energy problem, it's not usually the case. It's just a matter of simple science: replacing doors and windows may save a little energy, but the cost is often too high to produce a good savings-to-investment-ratio (SIR).

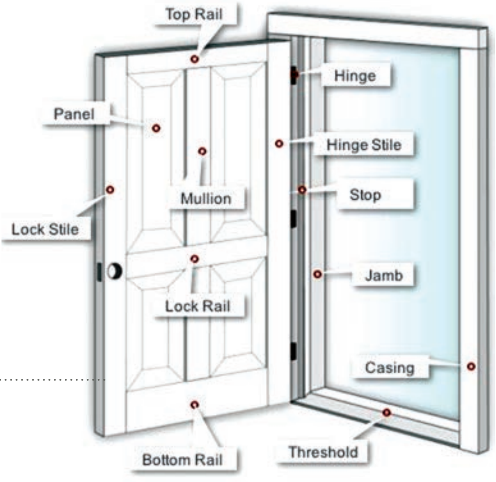
It is almost always worth the time to REPAIR doors and windows. Adjusting latches, replacing weatherstrip, or replacing broken glass is always a good idea on a weatherization job. But, if a door or window is so badly deteriorated that it cannot be repaired, then you can sometimes justify the expense of doing a full replacement.

SWS 3.1203.3: Replacement of Manufactured Housing Windows & Doors
https://sws.nrel.gov/spec/312033



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

REPLACING DOORS AND WINDOWS

It's far easier to replace doors and window in a mobile home than in a site-built home. That's mostly because they are held in place with screws that are easy to access, and because the units come in standard sizes.

You'll need a basic kit of tools for this job. Your materials should include putty tape, available from a mobile home supplier, and some non-hardening caulk such as urethane. Many crews like to replace the screws, too, if the old ones are corroded or have too much gunk stuck to them. Be sure to order windows with an Energy Star rating to assure that you get the best performance possible.

If the home was built before 1978, use lead-safe work practices to protect the occupants from contamination.

The installation process is almost identical 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 exterior screws fastening the unit, and pull it from the opening. You may need a flat bar and knife to cut the sealant away.
- Re-fasten any siding or paneling that has come loose.
- Inspect the area under the threshold (doors) or sill (windows) for damage. Perform repairs if needed.
- Clean up the surface where the the flanges rest on the siding. A heat gun and putty knife work well for this. You may want to clean further with a wire brush and/or solvent.
- 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.
- While holding the unit in the center of the opening, trace a line around the edge of the flanges. Remove the unit.
- Install putty tape around the perimeter of the exterior opening. Follow your traced line as best you can so the tape doesn't extend too far onto the siding.
- Install the unit in the opening and against the putty tape. 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. Install the rest of the screws.
- Reinstall any trim or jambs you removed. You're done!

A Quick Job: Replacing Doors and Windows

These louvered, or jalousie, windows are certain to cause discomfort in a climate like Montana. Replacing these will usually provide a good SIR. Door replacement becomes a reasonable investment, too, when the unit is so deteriorated that it doesn't operate properly or when it is full of holes. You'll find lots of good replacement doors and windows at the specialized mobile home suppliers shown in the Appendices.

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.

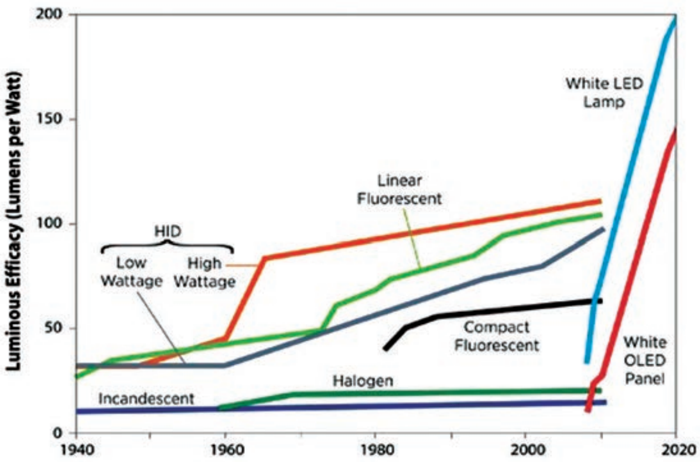
Not all baseload uses are addressed by the Montana program. The most common allowable measures are described here.

LIGHTING UPGRADES

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

Good lighting helps create a healthy, safe, and pleasant home. Lighting upgrades give you the chance improve upon these basic human needs will 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, lighting emitting diodes (LEDs) can provide one more boost in efficiency. Even when a home has CFLs, you can see a good SIR by replacing these with LEDs. 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.
- 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.

WATER HEATER MEASURES

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

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

- Check the temperature of the hot water. Using a cup and a thermometer, run hot water from a kitchen or bathroom sink and test it. The ideal temperature is 120 degrees F. If the water is too hot or too cold, reset both the upper and lower thermostats on the water heater and mark the temperature 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, and are all too often found behind the unit in a tight, mobile home water heater closet. These leaks are nearly impossible to fix without first removing the water heater, often making a full replacement more practical than repair.
- Examine the water heater closet and door. On a mobile home, these closets may be located outside, and insulation and air-sealing measures in the closet can greatly enhance the efficiency of the home. If you plan to replace the water heater, you also have the opportunity to do a good job of air-sealing the closet, a task that's impossible with the tank in place.
- Wrapping mobile home water heaters, once a common measure, is now usually impractical since the tight space in mobile homes limits a proper installation. Plus, 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.

Typical Mobile Home 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 an 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. What you cannot see is the 3" supply-air duct that goes through the floor.

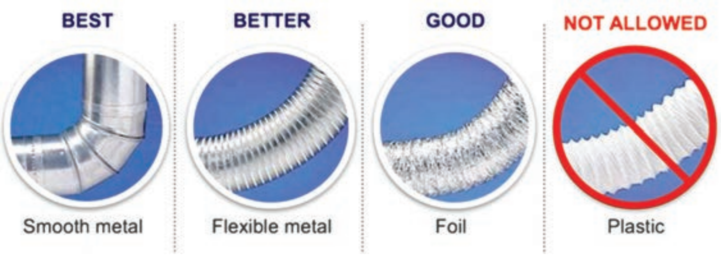
DRYER MAINTENANCE

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 duct tape — this is the one place where gray fabric duct tape is the right material. 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 condensation 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 allow 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.

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: 3.0/inch

Fiberglass, batts: 3.0/inch

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: 3.0/inch

Rock Wool, loose fill: 2.2/inch

Extruded Polystyrene: 5.0/inch

Expanded Polystyrene: 4.5/inch

Urethane Spray Foam: 6.5/inch

Vermiculite: 2.2/inch

Sawdust or Shredded Wood: 1.3/inch

Straw Bales: 2.5/inch

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.

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/TEC_Blower_Door_Guides_all.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 procedures double 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

SUPPLIERS

Mobile Home Depot

One of the biggest suppliers of equipment and supplies for the renovation and repair of mobile homes.

www.mobilehomedepotmi.com
Phone: 248-887-3187

Mobile Home Parts Store

A good source for many of the hard-to-find items you need to repair mobile homes.

www.mobilehomepartsstore.com
Phone: 888-277-7220

J&R Products, Inc.

This supplier stocks most of the tools and specialized materials used by the pros to insulate and air-seal both site-built and mobile homes.

www.jrproductsinc.com
Phone: 800-343-4446

Produced by the Montana Weatherization Training Center in Bozeman, Montana. for the Montana Department of Health & Human Services.

MONTANA STATE UNIVERSITY EXTENSION

MONTANA DPHHS
Healthy People. Healthy Communities.
Department of Public Health & Human Services