Pre-Retrofit Assessment of Crawlspaces and Basements

Insulating and air sealing an unheated basement or vented crawlspace might be undertaken for many reasons – for example to convert the basement to livable space, to make the floors over a vented crawlspace warmer, to provide conditioned space for HVAC equipment to reduce energy costs, or to address foundation moisture issues. The Existing Homes Tool provides links to several guides on **air sealing** [1], **insulating** [2], and **controlling moisture** [3] in crawlspaces and basements. The first step in developing a plan for upgrading crawlspaces and basements is to perform a thorough visual evaluation of both the exterior and interior conditions of these assemblies. This inspection must be based on federal, state, and local regulations and carried out by a licensed or certified contractor. For crawlspaces, some elements of the inspection vary depending on whether the crawlspace is a vented space or a non-vented conditioned space. The first section below, Potential Stop-Work Conditions, provides a summary of the most critical conditions to look for when assessing a crawlspace or basement. The following sections provide greater detail on these conditions. This assessment is adapted from the ***Guide to Closing and Conditioning Ventilated Crawlspaces*** *[4]*, prepared by IBACOS for Building America.

Potential Stop-Work Conditions

Figure 1 summarizes potential stop-work conditions and the remediation actions needed for each of these conditions. If any of these conditions are found during the site assessment, they must be dealt with before proceeding with improvements to the crawlspace or basement. Additional information on these conditions and others follows the figure.

If active knob and tube wiring or exposed wiring that poses a safety threat is observed	Then the house must be rewired before work in the basement or crawlspace may begin.
If the house has a natural-draft combustion appliance (furnace, boiler, water heater) located in the crawlspace or basement	Then replace with a sealed-combustion, direct-vent appliance or have a qualified contractor check for gas leaks, CO spillage, and makeup air, and do worst-case depressurization in the CAZ before and after air sealing and insulating the space.
If ducts are located in a vented crawlspace	Then a mold remediation professional will need to inspect and remediate the affected areas. No work can proceed until the space has been certified clean. See the EPA Protocols (See links in the text below.)
If any mold is observed	Follow the most current version of EPA's Lead-Based Paint Renovation, Repair, and Painting Rule.
If the structural integrity of the framing is not adequate and/or any wood shows signs of rot	Then the rot must be removed, the framing must be made structurally sound, and any sources of moisture must be corrected before work can proceed.
If standing water is observed on the crawlspace or basement floor	Then the standing water must be removed and the source of the water must be determined and eliminated before work can proceed.
If testing and inspection reveal asbestos, pests, or other hazardous materials in the basement or crawlspace	Then remove or remediate before proceeding with other measures. Asbestos and pest removal specialists may be needed.
If measured radon levels exceed the EPA acceptable level	Then a radon mitigation professional must develop an appropriate strategy to be implemented as part of the project.

Figure 1. Potential Stop Work Conditions when Conducting Renovations in a Basement or Crawlspace

Wiring and Electrical Systems

Assessing the current electrical system within the crawlspace is one of the first steps. A qualified electrician might need to be consulted if there is exposed or damaged wiring within the crawlspace. If there is a risk of shock or electrocution from faulty wiring, postpone the inspection of the interior systems until any issues have been resolved and the space is safe.

Combustion Appliances and Carbon Monoxide

If fuel-fired combustion appliances such as furnaces or water heaters are located in the crawlspace or basement, determine their venting and combustion air sources before conducting renovations such as air sealing the crawlspace or finishing the basement. If they are natural- draft or open-combustion (Category 1) appliances that draw their combustion air from the surrounding space,

the best approach is to replace a natural draft-vented furnace or water heater with a sealed-combustion, direct-vent appliance or an electric heat pump or heat pump water heater. Direct-vent gas furnaces draw combustion air directly from outside through piping to the unit. All combustion by-products are vented through sealed piping to the outdoors, minimizing the possibility of any carbon monoxide spillage into the home.

If the Category 1 appliances will remain, test all gas lines and gas appliances for gas leaks; visually inspect the venting system for proper size and horizontal pitch and to verify there is no blockage, restriction, leakage, or corrosion; visually inspect the burners and crossovers for blockage and corrosion; visually inspect the furnace heat exchangers for cracks or excessive corrosion. A worst-case depressurization test and worst-case spillage test of the combustion appliances should done, and carbon monoxide levels around the appliances should be checked with a CO detector before and after renovations are completed.

These life-safety test-in and test-out procedures are typically done by a certified home performance contractor and are a critical first step in the overall renovation effort. See the assessment guide "**Pre-Retrofit Assessment of Combustion Appliances** [5]" for more information.

See the guide **Combustion Appliance Zone Testing** [6] to calculate how much combustion air is needed to safely operate natural draft appliances. An outside air duct may need to be added to provide adequate make-up air.

Verify that a carbon monoxide detector is installed and operational in the crawlspace or basement. If there are any gas line regulators within the crawlspace, they will need to be moved so they vent to the outdoors. Carbon monoxide (CO) is a major health threat that can quickly lead to death. CO poisoning is preventable. If the house has combustion appliances of any kind, carbon monoxide alarms complying with UL 2034 must be installed in close proximity to the combustion appliances and outside each separate sleeping area in the immediate vicinity of the bedrooms.

Ductwork

Ductwork should not be located in vented crawlspaces. If ducts are currently located in a crawlspace or basement, that is one reason for deciding to air seal and insulate the crawlspace or basement. If ducts are located in a vented crawlspace and the crawlspace will not be sealed and insulated, then test the ducts for air tightness and inspect the ducts to ensure that they are adequately insulated and properly installed and supported. For guidance see the section of the existing homes tool related to **duct sealing and insulation** [1].

Mold and Structural Integrity

Humidity levels above 50% will support the growth of mold. Finding some traces of mold or mildew is common in a poorly detailed and ventilated crawlspace. The floor deck and all framing in the crawlspace are vulnerable to some level of fungal attack if moisture levels within the crawlspace go unchecked. Once high levels of moisture are present, moisture will tend to condense on the cooler surfaces of the wood framing and floor deck. Any surface mold or fungal growth will require a certified mold remediation expert to conduct an inspection and determine an appropriate remediation protocol to clean all the components before work can proceed. Structural repairs to framing components will be necessary if there is extensive damage or wood rot. Sources of moisture should be addressed as described below. If indoor relative humidity levels above 70% persist once the space is enclosed, supplemental dehumidification may be required.

Interior Moisture

Moisture in a basement or crawlspace could come from interior or exterior sources. Interior sources include water vapor from ground moisture from an uncovered bare earth floor; a dryer vent that exhausts into the space; plumbing leaks; condensate from an air conditioner, heat pump, or condensing furnace that is discharging into the space rather than outside; or water vapor from an open sump pump crock. Combustion appliances can also give off a considerable amount of moisture; sealed-combustion direct-vent appliances will add less indoor moisture. Crawlspace vents and leaky basements in humid climates can allow in warm humid air that will condense on cooler surfaces, adding moisture to the space (**Lstiburek 2010** [7]). Conduct a thorough investigation and correct any problems. **Sealing, insulating, and conditioning the basement or crawlspace** [8] is one major step that can be taken to create a drier basement or crawlspace. Other measures include installing a 6-mil **plastic vapor barrier** [9] over bare ground and up the walls; making sure **clothes dryers vent correctly** [10]; **covering sump pumps with a gasketed lid** [11]; and installing a **dehumidifier** [12]. Mechanical system condensate is potentially corrosive and must be drained as required by local jurisdictions, typically to a sealed sump crock lid, a floor drain fitting, or a sanitary sewer. An auxiliary drain pan with a separate drain should be installed under compression cooling equipment to prevent condensate from flooding the crawlspace if the primary drain fails.

Exterior Moisture

The presence of water in a basement or crawlspace or evidence of seasonal standing water (damp areas, mildew, discoloration of the foundation walls, etc.) must be investigated and treated before renovations such as air sealing and insulating are undertaken. If interior sources such as plumbing leaks have been ruled out, consider the following potential sources.

Roof Drainage: Inspect **gutters and downspouts** [13] to ensure that water is draining and is not allowed to collect near the foundation but is discharging to a storm sewer system, drywells, retention pond, ground that slopes away from structures, or yard bubblers that are a minimum of 10 feet away from the foundation.

Grading: Ideally, the **ground should slope** [14] a minimum of 5% away from the foundation walls for at least the first 10 feet to direct groundwater away from the structure on all sides. Any **patios, driveways, porch slabs, or sidewalks** [15] should slope away from the house at a grade of 2%. If proper slope away from the foundation cannot be established because of the home's elevation and surrounding grade, a surface drainage system ("grade gutter") should be installed to collect water and divert it away from the foundation. Or install below-grade drainage pipes at the footing. Before beginning any excavation work, make sure to contact any utilities that may have underground utilities on the property.

Sprinklers: Turn on all sprinklers installed near the foundation to observe their flow pattern. The sprinklers must be positioned so they do not subject the foundation or its immediate vicinity to water.

Foundation Waterproofing and Drainage: Implementing **foundation damp-proofing** [16] and a **perimeter drain** [17] strategy on the exterior walls will be required on exceptionally problematic sites. Such sites typically have high groundwater or water flow against the foundation that cannot be remediated in any other way. If the bottom of the crawlspace is below grade, the exterior of the foundation wall should be **damp-proofed** [18].

Crawlspace Vents: Crawlspace vents can allow bulk entry of water if they are located at or below grade. If the dirt and ground cover cannot be removed to slope the ground away from the house, install French drains or another drainage system to direct water away from the house or fill in and seal the vent. If one or more vents are sealed off, additional vents may need to be added to compensate for the lack of ventilation.

Access Door: If the crawlspace has an exterior access door, inspect to see that the grade outside the door directs rain and snow away from the door. If the door is located too low and there is not enough clearance to adjust the entry height, remove the door, seal the opening, and install a new entry at a different location on the exterior that will accommodate the clearance. If no suitable exterior location meets these criteria, it may be necessary to cut an access way through the floor system within the house.

Sump Pump [19]: In areas with poor site drainage, non Group 1 soils, or a high water table, a sump pump can be installed to pump water from the foundation drainage system into an approved sewer system or other appropriate location. Grade the crawlspace floor with at least a 3% slope toward a low-spot collector to direct water to the sump. Install a battery backup for the pump, especially in areas with a high water table. Make sure the sump has a tight-fitting, **gasketed lid** [20]. The 2009 IRC states the following in Section R405.2.3, Drainage System:

> In other than Group I soils, a sump shall be provided to drain the porous layer and footings. The sump shall be at least 24 inches (610 mm) in diameter or 20 inches square (0.01129 m2), shall extend at least 24 inches (610 mm) below the bottom of the basement floor, and shall be capable of positive gravity or mechanical drainage to remove any accumulated water. The drainage system should discharge into an approved sewer system or to daylight.

Drain Pipes: To prevent any water backups through drain pipes, Advanced Energy recommends (**Advanced Energy 2012** [21]) using a backflow valve in crawlspace drains and a check valve in sump pump out-flow pipes to prevent reverse flow of outside water into the crawlspace and to reduce the chance of vermin entry. Floor drains with p-traps that connect to the whole house plumbing waste drain or to a municipal sewer system may allow entry of sewer gases if (when) the trap dries out and may pose a risk of sewage backup.

See the **Ensure Moisture Protection** [3] section of the Existing Home Checklist for more information on moisture management.

Asbestos

Exposure to asbestos increases a person's risk of developing lung disease. Old crawlspaces and basements might have asbestos-based insulation wraps on ductwork and plumbing pipes. If discovered, a certified asbestos abatement firm should be contracted to inspect and determine the best treatment strategy for the particular situation. Unintentional contact with asbestos-based products can stir the fibers, which may then become airborne within the confined space, posing a health risk to workers. See the assessment guide **Pre-Retrofit Assessment of Hazardous Materials** [22] and the U.S. Environmental Protection Agency's *Healthy Indoor Environment Protocols for Home Energy Upgrades* for more information.

Hazardous Materials

Hazardous materials (like creosote-treated lumber or pesticides) and flammable materials (like gasoline and solvents) should not be stored in a crawlspace or basement. Remove and properly dispose of all hazardous materials. See the assessment guide **Pre-Retrofit Assessment of Hazardous Materials** [22] and the EPA Protocols for more information.

Radon and Other Soil Gases

In areas where radon is a risk or where the local residential code requires control of radon or other soil gases, houses with closed crawlspace foundations must be tested and monitored. If necessary, an approved mitigation system must be installed. The U.S. Environmental Protection Agency (EPA) and the Surgeon General recommend testing all homes for radon. The EPA's Healthy Indoor Environment Protocols include guidance for radon assessment and remediation.

Installing a passive radon mitigation system before undertaking air sealing work could be necessary in radon-prone areas. After the crawlspace is closed and sealed, final testing for radon should take place. Converting the passive system to an active system by adding a fan to the vent stack is easily accomplished if readings exceed the EPA's acceptable levels. See the guides on **passive** [23] and **active radon** [24] systems for more information.

See the Ensure Fresh Air section of the Existing Home Checklist and the Pre-Retrofit Site Assessment of Ventilation Equipment for more information on indoor air quality and ventilation.

Pests

Feces, Carcasses, and Other Animal Waste: Existing crawlspaces, if left unattended, can contain animal droppings or carcasses of animals that have found a way into the crawlspace and died. Be prepared for this possibility and have the means to conduct a thorough cleanup before proceeding.

Animal Infestation: In some cases, crawlspaces that have been left unattended or neglected can harbor wild animals. Missing screens on crawlspace vents, gaps around access doors, missing siding underneath porches, evidence of animal activity, and reports from homeowners can prepare the inspector for the likelihood of encountering wild animals. Depending on the severity, the local animal control agency might need to assist in removing any unwanted animals. See the guide **Reduce Pest Intrusion** [25] for steps to reduce future pest entry.

Termites and Carpenter Ants: Termites and carpenter ants are known to thrive in dark, damp places that have a readily available supply of wet wood. The foundation walls and framing should be inspect for signs of these pests before making air sealing and insulation improvements. Any observed signs will then require a more in-depth inspection and treatment by a pest control professional. In some jurisdictions a 3-inch pest control inspection gap is required at the top of insulation installed on the interior of foundation walls. Painting this strip white will help make pests easier to spot.

Insulation and Conditioning

The best practice for crawlspaces and basements is to seal them from outside air and insulate the walls. A good work plan will include a thorough specification and implementation strategy for thermal insulation and air sealing. Assess the amounts, location, and integrity of any existing insulation to determine the appropriate strategy for the climate region. Any existing fiberglass batt insulation in the floor system and draped over the foundation walls is likely to be damp and should be removed and discarded. During any air sealing process, follow safe work practices to minimize effects from sealant or adhesive fumes on workers' health. Temporary ventilation could be necessary during the installations.

Crawlspaces and basements must have a drying mechanism. Vents to the exterior are intended to provide this function in a vented crawlspace (although in climates with humid summers, they can introduce more humidity than they remove if the outside air is more humid than the crawlspace air; see "**New Light in Crawlspaces** [7]" by Lstiburek 2010). When converting to a conditioned, non-vented crawlspace, all operable and fixed foundation vents will need to be blocked off and sealed.

To provide drying in a conditioned crawlspace, a small amount of conditioned air from the mechanical system is directed into the space to temper it as if it were part of the home. A supply and return air strategy must be included to semi-condition the crawlspace. Verify the acceptability of this practice with local code officials. It may be necessary to install a permanent dehumidification system in the crawlspace or basement to maintain 30%–50% humidity levels within the space.

See the Ensure Thermal Comfort and Ensure Draft Free sections of the Existing Home Tool for more information on insulation and air sealing.

Code Considerations

It is imperative to check with local code authorities prior to insulating or adding conditioned air delivery to any crawlspaces, basements, or band joist areas to ensure that all local code requirements are met, such as the R-value of the insulation, fire and combustion safety requirements, pest inspection requirements, and radon mitigation requirements.

Local codes in flood-prone areas of the United States may require the installation of flood vents that allow water to pass freely

into and out of a foundation to equalize pressure on the foundation walls. Flood vents should be designed to reduce standby air leakage.

Safety

During any air sealing process, follow safe work practices to minimize any effects from sealants or adhesive fumes on workers' health. Temporary ventilation could be necessary during the installations. See the U.S. Department of Energy's **Standard Work Specifications** [26] for more information about worker safety in basements and crawlspaces, and related to radon.

More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

References and Resources*

1. **Asbestos**
   Author(s): U.S. Environmental Protection Agency
   Organization(s): EPA
   Publication Date: July, 2017
   EPA's website about asbestos.

2. **Closed Crawl Spaces: An Introduction to Design, Construction and Performance**
   Author(s): Advanced Energy
   Organization(s): Advanced Energy
   Publication Date: July, 2005
   This guide is an introduction to the design components, field implementation, code requirements, and measured performance of crawl space construction in central and eastern North Carolina.

3. **Designing Closed Crawlspaces**
   Author(s): Dastur, Davis, Warren
   Organization(s): Advanced Energy
   Publication Date: February, 2012
   Guide about designing and installing closed crawlspaces.

4. **Guide to Closing and Conditioning Ventilated Crawlspaces**
   Author(s): Dickson
   Organization(s): IBACOS, National Renewable Energy Laboratory
   Publication Date: January, 2013
   Document designed to explain the issues and concerns with conventional ventilated crawlspaces and to outline prescriptive measures for improvements that will create healthier and more durable spaces.

5. **Healthy Indoor Environment Protocols for Home Energy Upgrades**
   Author(s): U.S. Environmental Protection Agency
   Organization(s): EPA
   Publication Date: December, 2014
   This publication provides a set of best practices for improving indoor air quality in conjunction with energy upgrade work in homes.

6. **New Light in Crawlspaces**
   Author(s): Lstiburek
   Organization(s): Building Science Corporation
   Publication Date: March, 2010
   Building science insight into crawlspaces.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

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