

Chasing Interior Ducts

In order for ducts within conditioned spaces to be effective, builders need to establish an effective air barrier around them.

by Janet McIlvaine
and David Beal

Energy efficiency experts agree that minimizing duct leakage is one of the most important energy conservation measures they can take. It provides rapid payback from energy savings and mitigates the health and durability issues associated with duct leakage to and from unconditioned spaces. Over the past 15 years, researchers and builders have developed three primary strategies to reduce the impact of duct leakage: sealing ducts, placing ducts in unvented attics or crawlspaces, and placing the ducts in conditioned space. This article focuses on placing the ducts within the conditioned space.

The design and construction guidelines given below are the results of our work with builders and an energy consultant who routinely build homes with ducts in the conditioned space. They are Bentwood Custom Homes of Waxahachie, Texas; Broward County Habitat for Humanity of Fort Lauderdale, Florida; Durham County Habitat for Humanity of Durham, North Carolina; and builders affiliated with Ken Fonorow of the Florida Home Energy and Resources Organization, Incorporated, of Gainesville, Florida.

Duct Leakage Basics

Forced-air heating and cooling systems distribute air by means of an air handler and a duct system. The air handler is designed to remove air from the house, condition it, and supply it back to each room.

Duct leakage can occur on either the supply side or the return side of the air handler, as well as in the air handler itself.



Both supply and return leaks cause air to move in unforeseen ways, usually through unconditioned spaces, often bypassing air, thermal, and moisture barriers.

Supply leakage. When supply ducts leak, it creates a negative pressure in the house because more air is being removed than is being supplied. The negative pressure draws air from outside and/or from unconditioned spaces (infiltration) through holes in the house's air barrier. This leads to

- backdrafting of atmospheric combustion devices (water heaters, space heaters, fireplaces);
- introduction of outside air pollution, pollen, and other allergens;
- introduction of airborne particles (such as dust, insulation, and VOCs) from floors, walls, and ceiling cavities;
- degraded comfort (damp or drafty rooms);
- greater conditioning load; and
- reduced system life.

Supply leaks also spill conditioned air into unconditioned spaces, wasting energy and creating the potential for mold growth, condensation, and rot.

Return leakage. When return ducts leak, part of the return air is drawn from unconditioned spaces, or outside, rather than from the house. This dirty air often

bypasses the system's filter. The leakage creates a positive pressure in the house because more air is being supplied than is being removed. The positive pressure forces air through holes in the house's air barrier (exfiltration). Return duct leakage leads to

- introduction of outside and/or unconditioned air, with its attendant moisture, dirt, and pollutants, into the air handler;
- degraded comfort (conditioned air is leaving the house);
- increased conditioning load; and
- reduced system life.

Reducing Duct Leakage

There are three primary ways to reduce duct leakage.

Sealing ducts. Researchers and builders have studied the duct leakage phenomenon for about 15 years and have found that sealing the duct system with a combination of fiberglass mesh and mastic is inexpensive and cost-effective. Several residential studies have shown that these simple repairs can reduce duct leakage to less than 3%–5% of the fan flow (at 25 Pa), saving 15%–20% of cooling and heating costs, respectively, or about \$60 annually. At an installed cost of about

\$200, this improvement generally pays for itself in less than four years. The basic premise of this concept is that the air barrier of the duct system needs to be continuous and directly connected to the air barrier of the house.

Placing ducts in unvented attics or crawlspaces. In recent years, researchers have begun to explore another way to reduce the duct leakage. Relocating the thermal and air barriers of the house to the outer edges of the structure creates either an insulated roof deck or insulated foundation walls. The space containing the ducts is not vented to the outside, nor is it conditioned. Research to evaluate the effectiveness of this method is in progress. Code issues and construction process logistics factor large in this approach.

Interior ducts. The third way to reduce duct leakage is to put the entire forced-air system, including the air handler, inside the conditioned space. Technically, this means inside the air boundary as well as the thermal boundary, and within the space that is served by the conditioning system. Field data evaluating the success of this strategy are scant. The primary challenges in this approach involve establishing an air barrier around the ducts, meeting code requirements, and integrating the new detail into the design and construction process. Theoretically, interior ducts will yield the savings of eliminating duct leakage plus the savings of reduced thermal gain/loss in the duct system.

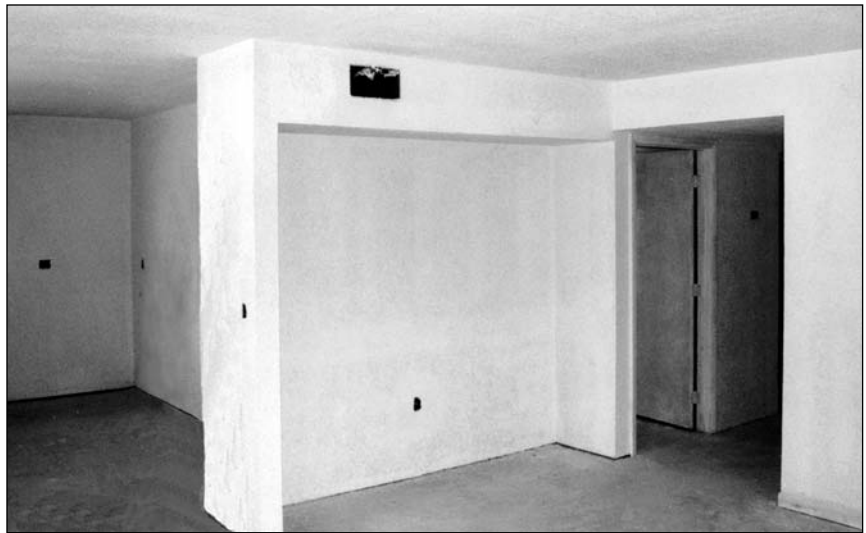
Developing a Standard

Usually an interior duct system is installed either in a fur-down chase below the ceiling insulation, or in a fur-up chase in the attic, insulated at the same time as the ceiling. Though ducts in floor cavities between upstairs and downstairs are often thought of as being in conditioned space, this is rarely the case. A definitive air barrier does not normally surround floor cavities. With careful attention to sealing the perimeter of the floor cavity, placing ducts in floor cavities may be a viable option.

Seen from the living area, fur-up chases are literally indistinguishable from the finished ceiling; seen from the attic, they look like a boxed-out area covered with insulation. All sealing should be

complete before insulation is installed, since access to the chase from below will be limited after the ducts and drywall are installed. All sides of the chase should be thoroughly covered with insulation. Since fur-ups are more obvious from the attic than fur-downs, they are more likely to be targeted for wiring and plumbing runs. The chase needs to

ings, that leaves 12 inches or less for the ducts and the structure of the chase. To minimize the space needed for the chase structure, detail the smallest available framing member that will support the weight of the drywall (for the bottom of the chase) and the ducts (if these are not supported by straps). This might be 2 x 2s or light-gauge metal framing.



This interior duct chase with supply register extends into a living room, creating an alcove that will be used as an entertainment center.

be carefully inspected before the builder releases the house. Upon completion of the house, all penetrations should be filled with a code-approved sealant, and any missing pieces of the air barrier should be replaced and sealed.

Fur-down chases built down into the conditioned space generally occupy the upper portion of hallways, run along walls, and/or cut across open living areas as architectural elements. The lowered ceiling height can be offset by widening the hallway and can be used to define living spaces in open floor plans. Most of the houses that we studied featured fur-down chases.

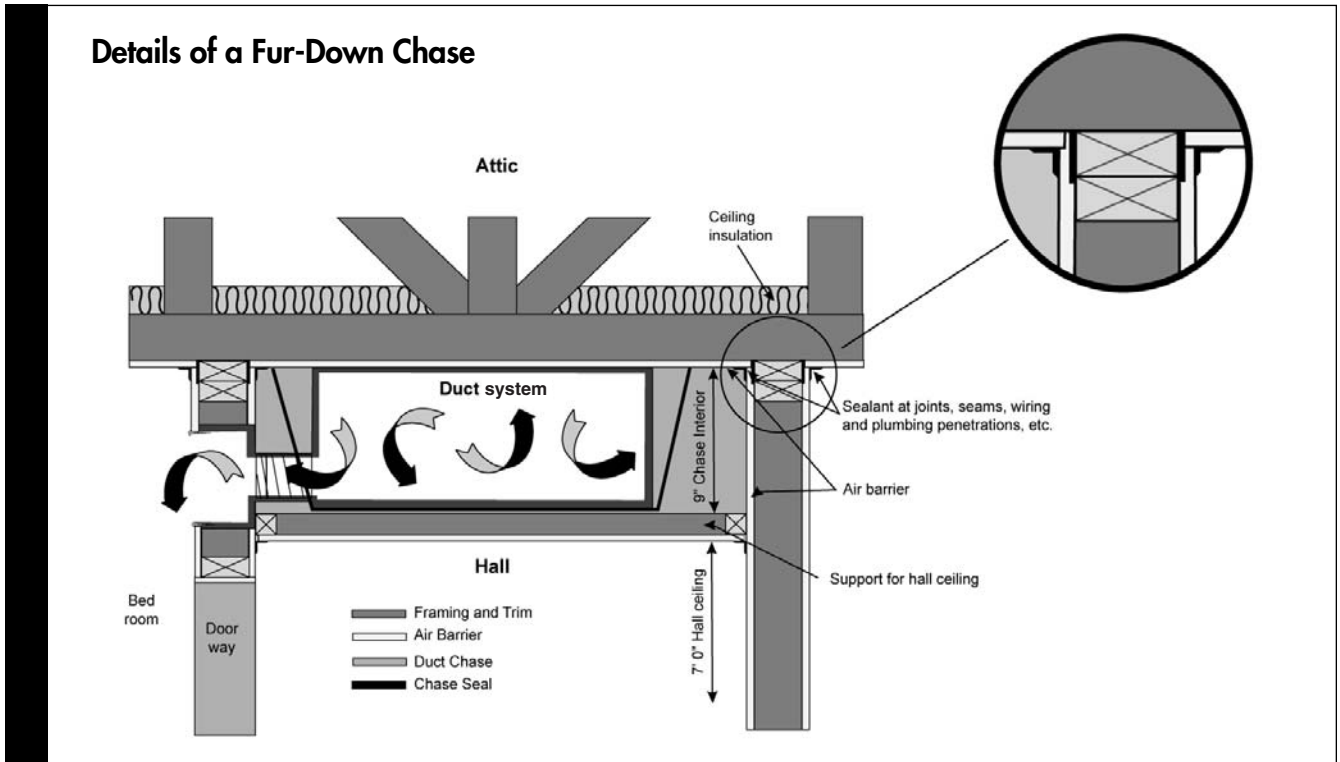
Interior ductwork in a fur-down system typically consists of metal or fiberglass duct board. Space limitations generally rule out the use of flex duct. (Note that the flex duct can be used in a fur-up system, or in an unvented attic or crawlspace.)

Usually, ceiling heights cannot be less than 7 ft, to meet code and allow for door framing. For homes with 8-ft ceil-

In ranch-style homes (homes with all the bedrooms grouped together at one end of the house, and a main hallway), the chase runs the length of the hallway (flanked by bedrooms) and extends out into the main living area. In split-plan homes (homes with bedrooms on either end of the house, separated by the main living area), the duct chase runs from the master bedroom area across the main living area and into the other bedrooms. Whereas the hallway fur-down makes use of the upper portion of the hall walls, chases in open areas are built out from one wall and down from the ceiling framing.

To locate the chase in a specific design, start by examining the plan for an obvious path. The air handler can be located either centrally or at one end of the chase, but as the heart of the duct system, it must be inside the conditioned space. To avoid long run-out ducts, the chase should trace a path down the center of the house and go to all spaces to

Details of a Fur-Down Chase



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Figure 1. This cross section of a hallway fur-down chase shows the air barrier and sealant that keep the chase within the air and thermal barrier of the house.

be served. Otherwise, small supply runs in unconditioned spaces or excessive chase construction will be required to reach distant rooms. Align the central chase with closets, cabinets, or transverse halls to achieve coverage of all rooms.

The top of the chase should be uninterrupted by framing. Miscellaneous bracing that interrupts the upper air barrier creates additional cutting, fitting, and sealing work. In most cases, the air barrier will be made of an airtight material (such as drywall or rigid insulation) sealed at the edges and seams; and the thermal barrier will be ceiling insulation installed over the top of the chase, and the sides of the chase for fur-ups.

Often it is tempting to use the chase as a ducted return to the air handler, as the chase goes to all rooms. This practice is not currently recommended because reliable sealing of the chase from surrounding unconditioned spaces has proven difficult to achieve. Any leakage in the chase air barrier can cause severe return leaks. This is similar to the pitfalls associated with using building cavities as ducts, as is sometimes done with panned floor joists.

Integrating the

New Strategy

Indicate the chase and air handler on both the mechanical drawings and the dimensional drawings. After laying out the chase on the plans, detail it in section for clarity, indicating materials, critical dimensions, and sealing details.

To clearly communicate both the intent and the specifications to all crews working with the chase, provide the plans and the detail to each one. These may include framing, drywall, insulation, and finishing crews as well as the mechanical contractor. Include the electrical and plumbing contractors, who need either to avoid putting holes in the chase or to fill any holes that they make.

Be sure the mechanical contractor takes the location of the ducts into consideration for system sizing calculations and the size of the chase for duct sizing calculations, bearing in mind that for 8-ft ceilings there will be less than 12 inches of clearance.

Before constructing the chase. Most of the chase is built after the rough framing and before the mechanical rough-in. A copy of the mechanical system plan showing the location of the

chase in hatch marks should be posted in the house for reference. After rough framing, Ken Fonorow of Gainesville, Florida, recommends marking the location of the chase for the crew building it. The construction supervisor responsible for the chase spray paints the floor along the bottom plate of all the walls where the chase is to be built. They start at the air handler and trace the path of the chase to its end. After the chase is installed, mark the location of the supply registers.

Make sure that materials for building the continuous air barrier (and later the thermal barrier) are available when needed. If any special materials are needed (light gauge metal framing for the chase support, for example), make sure they are on hand.

During construction. Let the guiding principal for building an interior duct system be the establishment and maintenance of an air barrier. After an air barrier is established, a thermal barrier in the same location is needed. The chase's ceiling air barrier should be placed first. Next, place the side or sides of the chase. Then all joints and seams should be sealed with code-approved sealant, including the gap between the



(left) This chase under construction in a ranch style home shows the sealing of the chase with drywall compound. (right) The completed chase.

air barrier and the top plates of adjacent walls (see Figure 1). At this point, the chase's principal air barrier is complete. The open sides facing conditioned space will be finished later when the rest of the house is drywalled.

Next, the mechanical system is roughed in and the rest of the chase is framed. Much of the duct system can be assembled on the floor and then lifted and strapped into place. The remaining chase framing is put into place within the chase's air barrier in such a way that it will not interrupt the house air barrier.

The joints and seams of the chase must be sealed. So must any penetrations in the chase that intersect an unconditioned space. Note that unconditioned spaces are any cavity or room that is not served by the mechanical system. These include obvious spaces, such as attics, garages, and storage rooms, as well as hidden areas, such as wall and floor cavities.

The penetration in the chase wall for the supply run-out intersects an unconditioned space—the interior wall cavity.

To prevent air from coming down from the attic between the drywall and the top plate, the joint between the chase wall and the interior wall framing must be sealed or the joint between the top plate and the drywall must be sealed. Without this continuous air barrier, any duct leakage will be in communication with an unconditioned space, either the attic directly or the interior wall cavity. This type of sealing is especially important in the air handler closet, since the return side of the air handler induces strong negative pressures, significantly increasing the leakage through any gaps.

Special attention must also be paid to the platform that the air handler sits on in the house. Preferably, central returns should be ducted from the air handler to the return grille instead of being open to the walls of the air handler closet.

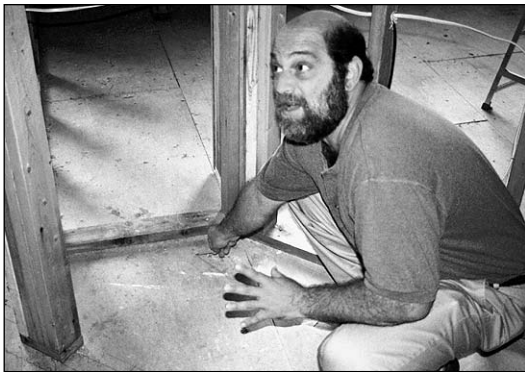
A supervisor who understands the purpose of the chase should regularly check progress and follow the chase construction through to completion—that is, until the ducts are all installed, holes have been sealed, and the chase is

ready for close-in. The chase is closed in as the house is drywalled.

After construction. Protect the finished chase from cable, phone, and other installers who may want to use it as a convenient place to run wires. The holes that typically result will compromise the air barrier. It is difficult at best to identify the chase as a space that must be kept separate from surrounding unconditioned spaces. We know of no consistently effective method of doing this. Communication is important. Advisory notices to cable, security, and phone installers should be posted in conspicuous locations, such as the panel box, attic access hatch, wiring service entrance, and so on. Since these notices cannot clearly identify the location of the air boundary in the attic, the notices should advise the installer to seal any penetrations to drywall made from unconditioned spaces. Though this should be standard practice and is often required by code, some services that are installed postoccupancy are never inspected.



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(above) The framer and drywall crew need to take special care in making sure that the chase is properly installed. The site supervisor has to make sure that the integrity of the chase is not compromised. (left) Ken Fonorow points out the spray paint marking the chase location during home construction.

Toward Better Design and Practices

The authors worked with four builders who adopted interior duct design for the health and energy benefits that it provides. We conducted a battery of airtightness tests at more than two dozen of these builders' homes. (For details and experimental results, see *Field Study of Interior Duct System Design, Construction, and Performance*.)

The experimental results show that chases were typically leaky, meaning that they were not isolated from unconditioned spaces. Despite the care taken to ensure that the ducts were in conditioned space, the integrity of the chase air barrier was often thwarted by a lack of communication among the many trades, and by the complexity of the chase construction.

We and our builder partners agree that it is easier to make an airtight duct system than it is to make an airtight chase, and that it would be a mistake to assume that

tight duct systems are not needed when the ducts are placed in an interior chase. Leaky ducts placed in leaky chases will not provide the desired energy or health benefits. On the other hand, an airtight duct system in a leaky chase may provide some of the thermal benefits of interior ductwork without causing the energy, building durability, and health problems associated with leaking ductwork.

Our conversations with the builders made it apparent that the builder and the site supervisor must be committed to performing the duties that are required to place the ducts in the conditioned space. The framers and the drywall crew must do additional work to build the chase, which often requires additional job site visits. There can be added costs for materials, such as custom trusses for a fur-up installation, or additional framing and drywall, or a more expensive duct system made necessary by space limitations. Our field observations consistently revealed chases that had been compromised because subcontractors, not understanding the purpose of the chase, used them for wiring or plumbing runs. The site supervisor or the builder must constantly monitor the progress of the

house to insure that the integrity of the chase is not compromised.

As builders continue experimenting with building interior duct systems, patterns of problems will develop and successful solutions will be found. Much like duct sealing a decade ago, this technique is still being perfected. Additional work is needed to refine a method of measuring duct leakage to the outside of interior duct systems.



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For more information:

For a copy of the report *Field Study of Interior Duct System Design, Construction, and Performance*, contact:

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