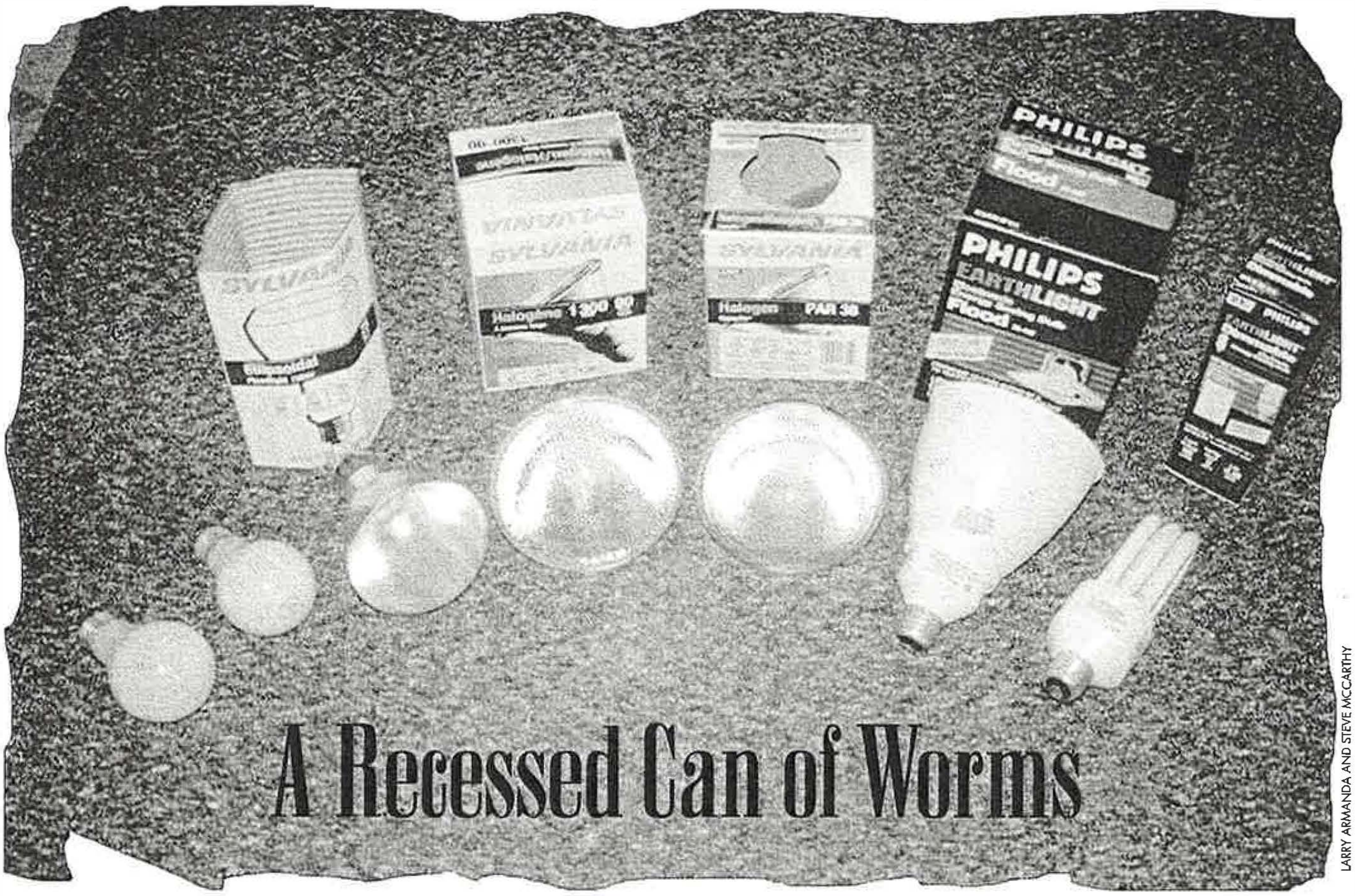


LARRY ARMANDA AND STEVE MCCARTHY

A Recessed Can of Worms

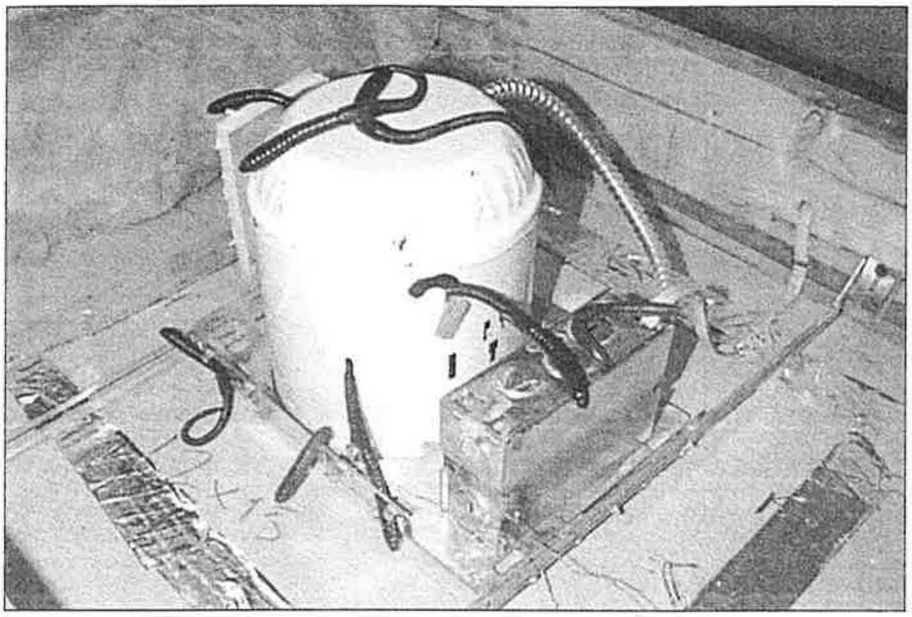
by Larry Armanda and Steve McCarthy

As weatherization consultants and trainers, we see many kinds of problems in different homes. A few years ago, we received a call to solve an unusually high bill complaint. The homeowner who called us had been referred to us by the local electric company. The house, a large new luxury home in Harrisburg, Pennsylvania, was heated with electric-resistance baseboards and cooled with two central air systems. The utility bills for the winter months ranged from $680 to $1,220. The homeowner told us that the house was uncomfortable and had other problems—the most dramatic one being the ice dam that formed on the back of the house. It broke loose, and crushed the two A/C units on the ground below! A contributing factor to both the high bill comlaint and the ice dam was the recessed-can lighting.

We proceeded to perform an air leakage test and an infrared scan of the home. We pressure-panned all of the registers and took notes on the size and physical characteristics of the house. We noted that the first and second floors were heavily lit using recessed-can lighting fixtures—134 in all. On the second floor, below the attic, we counted 56 recessed-can lights. A closer inspection of the fixtures revealed that they were all non-IC–rated fixtures (see "Recessed-Can Light Basics", p. 43). This is important, because thermal insulation may not be installed in contact with a recessed-can light if it is rated "non-IC" (see "Wiring and Safety" p. 44). During the air leakage test, we noted air leaking from most of the recessed fixtures, including all 56 fixtures on the second floor.

When we climbed up through the attic hatch, we were surprised by what we saw. The attic was partially floored with plywood and insulated with cellulose. Prior to insulating, the installer had carefully fitted 12-inch-tall sheet metal barriers around each light fixture. There were what looked like 56 short, open-topped, sheet-metal chimneys protruding into the attic through both the insulation and the plywood floor.

This treatment is the most commonly prescribed method for protecting non-IC recessed lights from insulation contact. Attic preparation, in this case, had been done by the book! However, the energy implication of this sort of by the book treatment is significant. It creates a huge section of the ceiling that is not insulated. In addition, since most recessed-can light fixtures are full of holes that allow for adjustments that may be necessary for different bulbs, the fixture is a serious air leakage site. An air leakage problem may also contribute to or cause a moisture problem. There was no doubt that, in this particular house, one of the factors that contributed to the glacier on the roof was the existence of so many leaky recessed-can lights leaking heated air into the attic.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A graphic description of our problem: a recessed can of worms.

Plugging the Leaks

What treatment can a contractor use that is a safe and effective method of recessed-can light repair?

Some contractors fabricate boxes made of sheetrock to enclose the fixture. This box method addresses the air loss issues as well as keeping the light a safe distance from the insulation, but is it a safe retrofit?

The 98 International Energy Conservation Code (IECC) requirements for non-IC rated fixtures include a mandate that they be "installed inside a sealed box constructed of a minimum of 1/2-inch gypsum wallboard or constructed from a preformed polymetric vapor barrier, or other material manufactured for this purpose, while maintaining required clearance of not less than 1/2-inch from combustible material and not less than 3 inches from insulating material."

So in order to plug the leaks in this home's ceiling in the way required by the building code, each recessed-can light would have to be enclosed within a sealed and airtight box. But how safe is this method? Several issues must be addressed to answer that question:

How much heat is generated inside the airtight box?

Does the heat get trapped within the fixture, creating a safety issue involving the wiring or the lamp holder?

What is the temperature rise inside the air sealed box during the summer, when attic ambient temperatures can reach +130°F?

What is the temperature rating of building wire, old and new?

Because the energy code specifies constructing this airtight box above the recessed-can lights, we decided to see what would happen in a variety of situations regarding safety issues. We knew the client's energy problem in this house could be fixed, but we wanted to make sure it was a *safe* fix.

In the Lab

With the goal of measuring the temperatures that would result within an airtight box such as the one required under varying ambient air temperatures using bulbs of var-

Recessed Can Light Basics

Recessed can lights are pretty simple—they consist of a lamp, the recessed can housing, and trim.

Lamps

The lamps (bulbs) come in a variety of types, styles, and wattages. Incandescent lamps are the most commonly used in recessed can lighting. The "A" lamps are non-directional, meaning that light is emitted from around the entire lamp. Most of the light is lost inside the fixture housing. Reflector spot lamps also known as PAR lamps, are directional, meaning that most of the light is projected out of the fixture (see Figure A).

Incandescent lamps use most of the energy they consume in the production of heat, not in the production of light. Compact fluorescent lamps (CFLs) are rated differently than incandescent lamps. A 20-watt rated CFL we tested has the equivalent light output of a 75-watt standard reflector flood lamp, and the 23-watt CFL tested was equivalent to a 90-watt incandescent lamp.

Trims

Trims come in a variety of styles. Black baffle trims are used to reduce glare by absorbing the lamp light by as much as 50%. White baffle trims also reduce glare and project about 70% of the lamp's available light. Highly reflective trims, sometimes called "specular", have almost a mirror interior coating which projects almost 100% of the available light out of the fixture. Trims are designed for specific lamp styles. Labels are installed inside each style of new trim to designate the type and wattage of lamps allowed by the trim manufacturer. Older fixtures and trims without thermal overload switches (see "Wiring and Safety, p. 44) usually do not have this label.

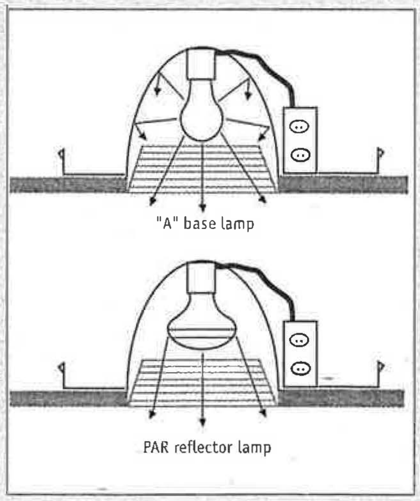

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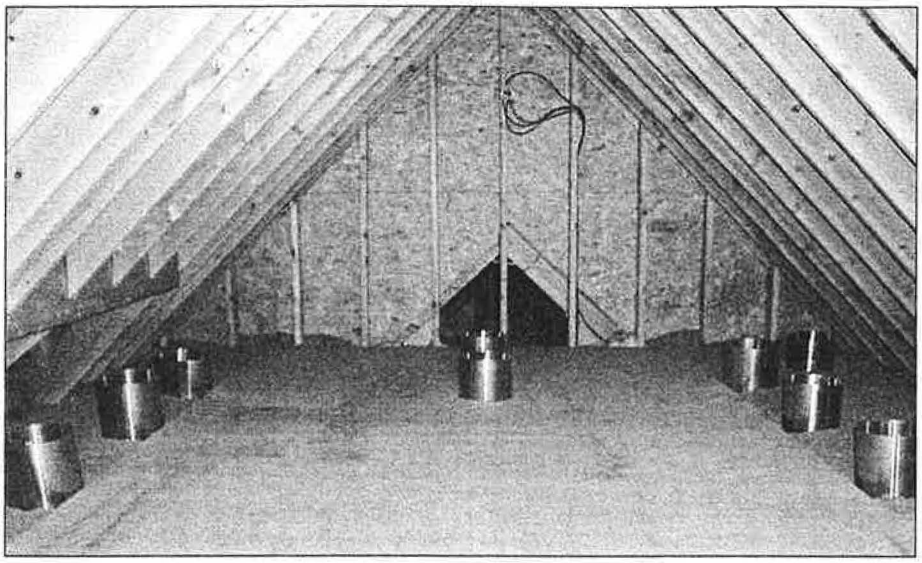
Figure A. PAR reflector lamps project both light and heat out of the recessed can.



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Open topped insulation shields around recessed-can light fixtures act just like chimneys.

ious wattages and styles, we took the problem with us into the laboratory. First, we installed a recessed-can light housing in a simulated ceiling section with a 1/2-inch Sheetrock surface on the bottom of the frame to simulate a drywall ceiling.

Then we suspended the frame 36 inches above the floor. The light housing was equipped with an open black baffle trim. We removed the thermal overload switch and jumpered it to prevent the temperatures generated by the lamps from shutting off the light. Then we fitted the frame with an airtight box made of 1/2-inch drywall, and measuring 13 inches x 16 inches x 10 1/4 inches. This box was built in accordance with the IECC 98 requirement to maintain 3 inches of air space around the fixture.

We installed 12-inch fiberglass batt insulation around, but not over the top of, the airtight box. Finally, we installed thermocouples in four different locations to allow us to monitor temperatures within, on and above the box. When the box was completed, we conducted three different tests to see how it would perform under different conditions and with different lamps. The results of these tests are shown in Table 1.

Test 1. Here we tested the temperatures above and around a variety of bulbs when the ambient temperature above the box was approximately 70°F.

Test 2. Here, all seven lamps were tested in a summer condition, representing a potentially dangerous situation if the lights were left on all day during a hot day. To simulate summer attic temperatures of 135°F, a polyisocyanurate foil-faced rigid-board insulated box (R-7.2) measuring 28 inches x 53 inches x 24 1/2 inches was built and placed over the entire 2 inch x 6 inch frame. We cut an inspection window into the top of the box directly above the light fixture and sealed it in place with silicon caulking. To obtain an average summer attic temperature of 135°F around the outside of the air sealed fixture box, we placed a 300W lamp inside the insulated outer box. This light was controlled by a Chromolox thermostat to maintain temperature.

The 60W standard lamp indicated a temperature of 147°F, and the 100W standard lamp a temperature of 164°F inside the air sealed fixture box. In summer conditions with 135°F attic ambient temperature, both lamps exceeded the legal limits of the wiring inside, considering that this was a box for an older style fixture with a 140°F rating. Likewise, the 100W standard lamp exceeded the temperature limit with an ambient temperature of 72°F. The 120W Capsylite flood lamp indicated a temperature of 140°F, which is at the limit of the temperature rating of the wiring. Because these older fixtures were not protected with thermal overload switches, this result clearly suggests the possibility of wire insulation damage, and may suggest the possibility of a fire hazard.

The 75W reflector flood and the 90W Capsylite flood lamp indicated temperatures of 122°F and 129°F respectively, well below

Wiring and Safety

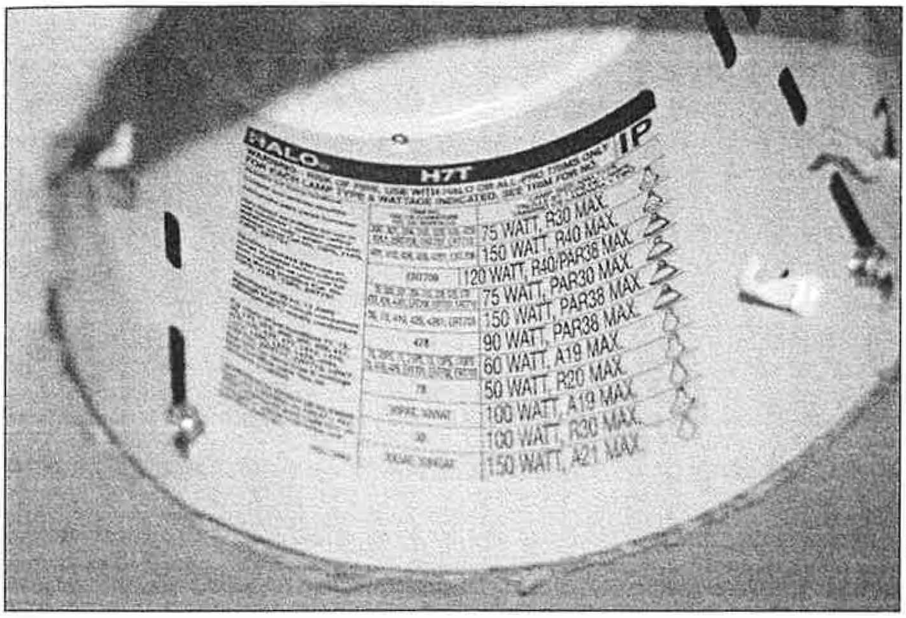
Many older homes have light fixtures that are non-IC–rated. These fixtures were designed for uninsulated ceilings and may have factory installed wiring rated at 140°F. When insulation is installed, it must be kept three inches from all sides of the fixture.

IC-rated fixtures are designed to be installed with insulation over them. IC-rated fixtures have a thermal overload, or "cutout", switch; these have been required since 1982 on all manufactured recessed can light fixtures. The thermal overload switches are usually installed inside the recessed can, adjacent to the lamp or inside the electrical terminal box. Most thermal overload switches are preset by the manufacturer to open when the temperature of 194°F is indicated, may have a variance of (+ or –) 15 degrees, and may vary from one manufacturer to another.

A 10°F drop in temperature is needed for the thermal overload switch to reset and re-energize the lamp. The thermal overload switch protects the fixture and fixture wiring. Such fixtures are usually manufactured with 194°F rated wire.

Branch circuit wires are the conductors that supply power to a number of outlets or lights. It is sometimes referred to by the commercial name for a type of nonmetallic-sheath cable, Romex.

A type NM-B (nonmetallic sheath cable) designation means that the wire has a nonmetallic sheath or outer overall jacket. The B suffix means that the cable's conductors are rated for a maximum operating temperature of 90°C 194°F. This requirement was added in the 1984 edition of the National Electrical Code (NEC), section 336-26. The B distinguishes the 194°F rated version from the older 140°F rated version. We can conclude that wiring manufactured prior to 1984, without the B suffix, is rated at 140°F. This is the type of wiring found in most older homes that were built before 1982.



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Manufacturers' trim and bulb recommendations are printed on the recessed-can housing.

the 140°F rating of the wiring.

The 20W and 23W compact fluorescent lamps (CFLs) indicated the lowest temperatures—110°F and 114°F, respectively. (Both fluorescent lamps tested had a manufacturer average rated life expectancy of 10,000 hours. According to some of the manufacturers, this life expectancy can be cut in half if the lamp is installed in a recessed-can light. This reduction in life expectancy could be due to the reduced air flow around the ballast of the lamp, which is located in the base of CFLs.)

Test 3. In this last test, a 60W A lamp with a gasketed glass shower trim was installed on the fixture. R-5 fiberglass batt insulation was loosely laid over the top of the air sealed box. The test was set for summer conditions of 130°F–135°F. This is absolutely the worst-case scenario, because the lens on the bottom of the light and insulation over the top of the enclosure really trap the heat.

These temperatures went well over the rating of the fixture wiring. The temperature inside the electrical terminal box—183°F—even came close to the temperature limit of 194°F for the newer thermally protected fixtures. If a 100W standard lamp had been installed, I suspect the temperature would have gone sky-high, possibly creating a serious overheating problem. The fire hazard in this case, depending on the combustibility of material around the lamp and lamp housing, could be very great.

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Temperature recording instument.

Table 1. Lamp Temperature Test Results

Temperature Sensor Location*	60-watt Standard	20-watt Compact Flood	75-watt Reflector Flood Lamp	100-watt Standard A Base Lamp	90-watt Capsylite Flood Lamp	23-watt Compact Flourescent	120-watt Capsylite Flood Lamp
T1 ambient (69 to 72/0°F)	69°F	69°F	70°F	72°F	70°F	70°F	70°F
T2	131°F	87°F	N/A	166°F	N/A	N/A	N/A
T3	131°F	88°F	N/A	167°F	N/A	N/A	N/A
T4	122°F	85°F	N/A	153°F	N/A	N/A	N/A
Summer Attic Simulation							
T1 ambient (134 to 138°F)	136°F	134°F	135°F	135°F	134°F	134°F	135°F
T2	162°F	121°F	136°F	180°F	142°F	127°F	154°F
T3	166°F	125°F	140°F	185°F	145°F	131°F	157°F
T4	147°F	110°F	122°F	164°F	129°F	114°F	140°F

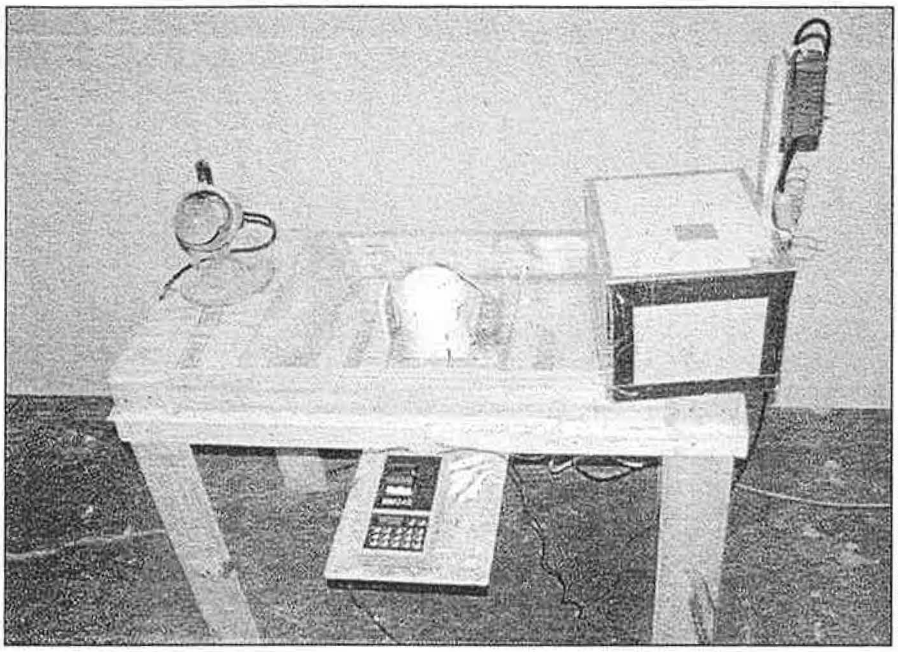
*T1 is a measure of the ambient air temperature above the enclosure. T2 is the air temperature inside the drywall enclosure. T3 is the temperature of the drywall inside the enclosure, directly above the can. T4 is the temperature inside the electric terminal box of the fixture, which is within the drywall enclosure.

Safety First

As our test results showed, before you follow the IECC requirement of building an airtight box constructed of at least ½-inch gypsum wall board, you need to address the following considerations:

Determine the age of the light fixture and the building wiring in order to determine if there is a thermal overload switch installed on the light fixture, the temperature rating of the fixture wire, and the temperature rating of the building wiring.

If there is a lamp label inside the trim, make sure the proper type of lamp is installed. If there is no label, check the lamp socket for the maximum lamp wattage allowable. To help prevent a homeowner from overlapping the fixture (putting in a higher-watt bulb than the manufacturer recommends), mark the inside of the fixture adjacent to the lamp with the style and wattage of the replacement lamp. A-lamps should never be used in any type of recessed-can fixture. CFLs or PAR lamps are a safer choice.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The recessed-can light test fixture with the box enclosure around the light housing removed to the side.

Recommendations

If you build an airtight box around a recessed-can light, as code requires, we suggest that you take the following precautions for safety reasons and to allow an energy efficiency retrofit:

- Use only PAR (reflector-type) bulbs or CFLs.
- Do not use any bulb that exceeds 75 watts.
- Make sure the airtight drywall boxes maintain a minimum of 3 inches of clearance to all parts of the fixture, including the terminal or junction box.
- Do not place insulation over the top of the drywall enclosure.

The builder of the house we inspected should have installed IC-rated, airtight recessed-can lights. Given the situation we found, we felt that the best alternative to replacing all of the lights was to build the airtight drywall enclosures. This was indeed an important energy-efficient fix. We did, in fact, make this recommendation to the homeowner.

Only by understanding recessed-can light fixtures, building airtight boxes, and addressing the temperature and safety issues associated with them can contractors *safely* keep heat and moisture from entering the attic space, as well as keep glaciers from forming on our roofs.

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