Taitem TechTip New York State Homes & Community Renewal

Weatherization Assistance Program

Room Air Conditioner Conduction Losses

Introduction

During hot summer days, air conditioners (ACs) can be extremely helpful in keeping a building cool. However, if left in place through the winter, both window and wall-mounted ACs can burn a hole through a wallet.

No matter the make or model, air conditioners and AC sleeves can be thought of as gaps in a building's insulating envelope that results in heat loss due to air leakage and conduction.

A recent study investigated infiltration losses (Steven Winter Associates, 2011) and found that significant energy is lost due to air leakage around and through air conditioners that are left in place during the winter. In this Tech Tip, we look at ***conduction losses*** to determine the magnitude of the heating loss due to the direct transfer of heat through the surfaces of the air conditioner and try to answer questions such as:

Are conduction losses significant? Can they be reduced? Should an empty AC sleeve be stuffed with insulation in the winter? Should through-the-wall ACs be removed from their sleeves for the winter?

Room Air Conditioners

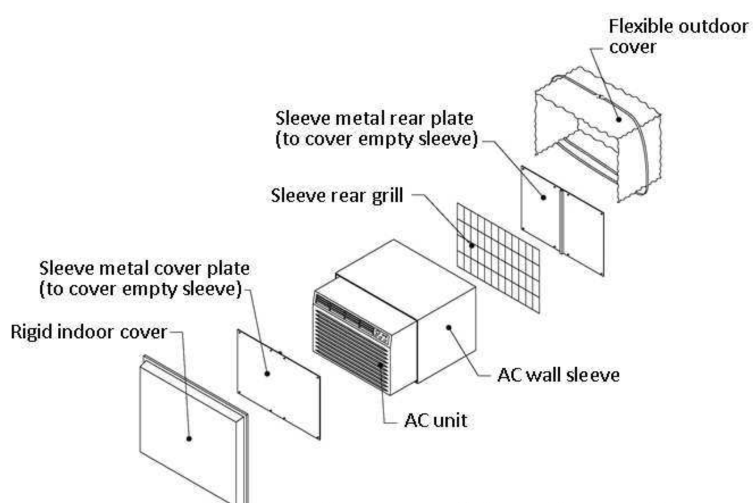
We looked at two common scenarios:

1. EMPTY AIR CONDITIONER SLEEVES

   These are often provided for owner-supplied units or future retrofits but in many cases remain empty.

2. AIR CONDITIONERS

   ◊ Installed in windows.
   ◊ Installed in through-the-wall sleeves.



Components of Sleeve-Mounted ACs

Recommendations

AC heat loss during the winter months is often not a high priority for most building owners, yet for large buildings these losses can quickly add up due to the size and number of window or wall openings involved. We found that the insulating value of a typical air conditioner is equivalent to about R-1, roughly the same resistance to heat flow as that of a poorly performing window of the same size. We confirmed that for air conditioners, the heat loss due to conduction alone is small compared to the reported heat loss associated with air leakage. However, there are effective methods to reduce total energy losses that can take a credit for reducing conduction heat loss as well.

What are the most cost effective measures to reduce conduction losses for each of these scenarios?

- EMPTY AIR CONDITIONER SLEEVE: For an empty AC sleeve, the most effective energy savings can be achieved by filling the sleeve with fiberglass insulation and placing a rigid, plastic cover over the indoor side of the sleeve.
- WINDOW AIR CONDITIONER: Ideally, if you want to eliminate heat loss due to the air conditioner, simply remove the unit and shut the window tight. When storage space is not available, an effective solution is to install a rigid cover on the indoor side of the air conditioner. The rigid cover that we tested had a glued-on layer of foam insulation and it provided coverage of the entire air conditioner tight against the wall. While they may protect the AC against the elements, we found that flexible outdoor covers (usually vinyl or plastic) are relatively ineffective against conduction losses.
- AIR CONDITIONERS IN SLEEVE: Removing these units for winter storage is <u>not</u> cost effective from the standpoint of reducing conduction losses alone. The most economical solution is to leave the unit in place and install a rigid indoor cover over the front of the AC unit.

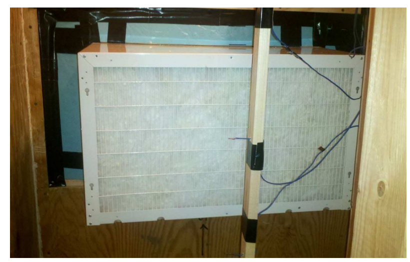


Figure 1: Wall sleeve in test lab with fiberglass fill. View from outside and cover not shown.

Figure 2: AC sleeve in test lab with rigid indoor cover.

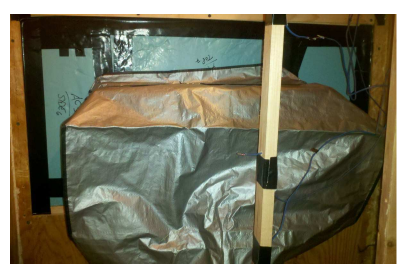
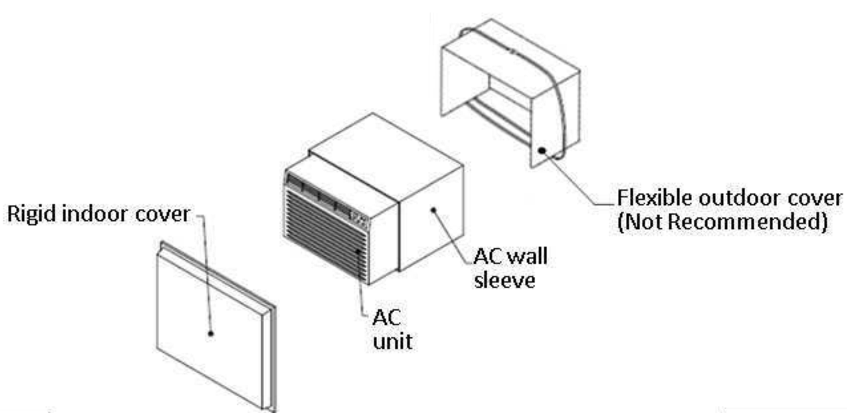


Figure 3: Air conditioner in test lab with flexible outdoor cover.
Not effective in reducing conduction losses.



Energy and Cost Savings for Through-the-Wall ACs and Empty Sleeves

ENERGY IMPACT:

For empty sleeves, our tests show that there are measurable energy losses due to conduction and simple steps can be taken to reduce these losses.

The equivalent R-value (resistance to heat flow) of an empty sleeve is about R-0.89, roughly the same as a single pane, aluminum frame window in the same opening. Compare this to a typical wall of the same area which might have a resistance of R-20 or more.

Table 1: Energy Savings for Sleeve Configurations

SLEEVE-ONLY CONFIGURATIONS	Net Heat Loss Through Sleeve BTU/Hr [4]	BTU/Hr Savings Compared to Baseline	Equivalent R-Value[5]	Equivalent U-Factor
Empty Sleeve (no AC or Insulation)	142	0	0.89	1.12
Empty with Flexible Outdoor Cover	128	14	0.99	1.01
Rigid Insulation Fill[1]	47	95	2.68	0.37
Rigid Insulation Fill with Flexible Outdoor Cover	44	98	2.90	0.34
Rigid Insulation Fill with Rigid Indoor Cover	20	122	6.21	0.16
Fiberglass Batt Insulation Fill [2]	52	90	2.44	0.41
Fiberglass Batt Insulation Fill w/ Rigid Indoor Cover[3]	21	121	5.97	0.17

[1] Test used extruded polystyrene (XPS), rigid foam insulation to fill the sleeve.
[2] Test used fiberglass batt insulation with kraft paper facing to fill the sleeve.
[3] This configuration was not tested but results are projected from other test results.
[4] Indoor Temperature = 70°F and Outdoor Temperature = 25°F, and a 2.8 square foot wall opening.
[5] Equivalent R-values were calculated from observed heat loss and therefore include surface thermal resistance.

Leaving the empty sleeve uninsulated and installing a flexible outdoor cover provided a minimal improvement by increasing the R-value from 0.89 to only 0.99. Installing fiberglass batt insulation in the sleeve, however, increased the R-value to 2.44 and the rigid insulation fill did slightly better at R-2.68. Adding a flexible outdoor cover to the rigid insulation fill did not increase the R-value very much (R-2.68 to R-2.90), but adding a rigid indoor cover to the insulation increased the R-value to 6.21, or **nearly tripling the R-value to that of rigid insulation alone.**

The analysis shows that for empty sleeves, installing rigid or batt insulation with a rigid indoor cover significantly decreases heat loss. A flexible outdoor cover may provide protection from the elements, but will not do much to reduce heat loss.

Table 2: Cost Savings for Sleeve Configurations

Improvement	Cost of Improvement	Annual Savings in Dollars	Payback in Years
Empty Sleeve with Flexible Outdoor Cover	$ 12.50	$0.89	14.0
Rigid Insulation Fill only	$ 49.90	$6.02	8.3
Rigid Insulation Fill with Rigid Indoor Cover	$118.90	$7.74	15.4
Fiberglass Batt Fill only	$ 16.80	$5.73	2.9
Fiberglass Batt Fill with Rigid Indoor Cover	$ 85.80	$7.66	11.2

Note: Labor costs based on $58 per hour.

COST SAVINGS:

The annual cost savings for these measures is relatively small, but keep in mind that these savings are for ***conduction losses only***. Additional savings, not addressed here, will be achieved by any improvement that reduces air leakage through the sleeves.

Note that the energy savings are modeled on a well-sealed sleeve. This includes an airtight, caulked seal at the sleeve-to-wall joint. Air infiltration is a major contributor to heat loss for air conditioners, and we recommend that the sleeve be inspected so that weather sealing can be done before insulation and/or cover improvements are made.

Fiberglass or Rigid Foam Insulation?

The advantage of fiberglass insulation is its ease of installation compared to rigid foam that has to be cut to fit. The disadvantage of the fiberglass insulation is that it can deteriorate quickly over time, especially when exposed to the elements. A vapor barrier is recommended where the outside air louver has a large free area exposed to the weather. Rigid, closed cell insulation, on the other hand, is more durable, especially when left in place, and does not lose its insulating properties when it gets wet. Unlike fiberglass batts, rigid insulation may not hold up to being repeatedly inserted and removed.

Energy Savings for Covers with AC Units in Place

Table 3: Energy Savings for AC Configurations

AIR CONDITIONER CONFIGURATIONS	Net Heat Loss Due to AC BTU/Hr[3]	BTU/Hr Savings Compared to Baseline	Equivalent R-Value[4]	Equivalent U-Factor
AC without Cover (Baseline)	88	0	1.09	0.93
AC with Flexible Outdoor Cover [1]	73	15	1.27	0.79
AC with Rigid Indoor Cover [2]	58	40	1.77	0.60

1 Outdoor cover tested: flexible, polyethylene.
2 Indoor cover tested: rigid, plastic with foam.
3 Indoor Temperatures = 70°F and Outdoor Temperature = 25°F.
4 Equivalent R-values were calculated from observed heat loss and therefore include surface thermal resistance. Results do not include effect of sleeves.

Figure 4: AC in test lab with no improvements.

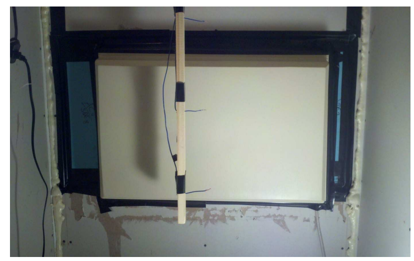


Figure 5: AC in test lab with rigid indoor cover.

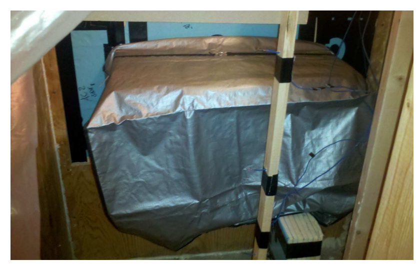


Figure 6: AC in test lab with flexible outdoor cover.

ENERGY IMPACT:

For air conditioners that remain in place during the winter, we calculated the average heat loss for each improvement and the equivalent R-value for each air conditioner scenario listed above. Our analysis shows a modest increase in equivalent R-value, from 1.09 to 1.77, for the rigid indoor cover. As with empty sleeves, **the rigid indoor cover saves nearly three times the energy of a flexible outdoor cover- from 40 to 15 Btu/hr.**

Table 4: Cost Savings for AC Covers

Improvement	First Year Cost	Annual Labor Cost ($/year)	Install Time (per year)	Annual Savings in Dollars
AC Remains and Install Flexible Outdoor Cover (1st floor, no ladder)	$5.00	$9.67	10 minutes	$1.45
AC Remains and Install Flexible Outdoor Cover (2nd floor, with ladder)	$5.00	$19.33	20 minutes	$1.45
AC Remains and Install Rigid Indoor Cover	$69.00	$9.67	10 minutes	$2.98
AC Removed and Fill Sleeve with Fiberglass Batt	$16.80	$58.00	60 minutes	$5.73
AC Removed and Fill Sleeve with Rigid Foam and Install Rigid Indoor Cover	$118.90	$72.50	75 minutes	$7.74

Note: Labor costs based on $58 per hour.

COST SAVINGS:

For annual energy dollars associated with conduction losses, none of these measures saves more than the cost of the improvement. It is clear that removing the air conditioner is particularly **not** cost effective. But like sleeve improvements, it is important to keep in mind that these savings are for conduction losses only and that savings associated with reducing air leakage should also be considered.

Appendix

Experimental Setup

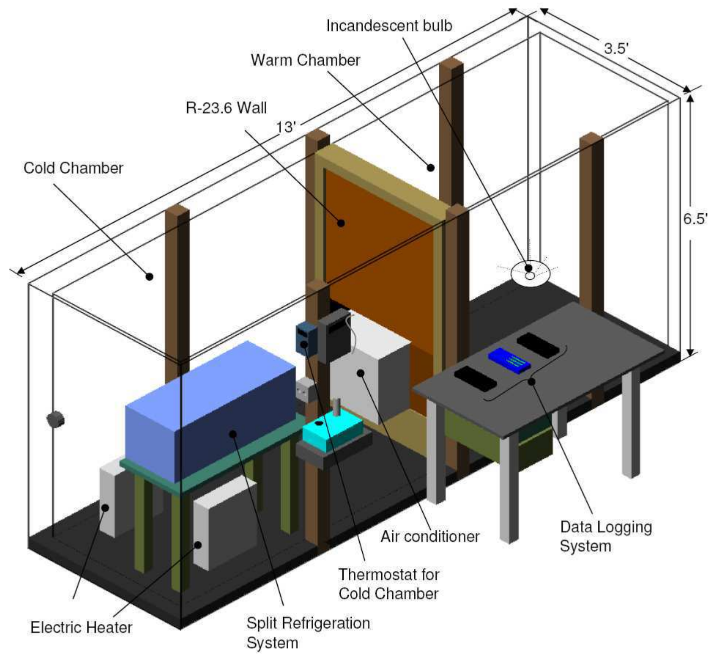
Each AC was tested in a temperature-controlled test chamber. The test chamber consisted of a small, well insulated room with R-17.5 walls, an R-5 floor and an R-25 ceiling. The test chamber was divided by an R-23.6 wall with an opening for the AC or sleeve being tested. Once in place, gaps around the AC unit were filled in with R-23.6 material.

On the cold side of the chamber, a refrigeration unit cooled the space to model the outside air temperature. Two space heaters cycled on and off to maintain the test temperature, generally set to 25°F.

On the warm side of the chamber, a 200-watt light bulb cycled on and off to keep the “indoor space” at precisely 70°F. The on-time of the light bulb represented the amount of energy required to balance the energy losses due to the air conditioner.

Various AC units were installed in the dividing wall, and the warm space heat loss was measured by calculating the energy used by the light bulb to maintain the warm side of the chamber at a constant 70°F. A correction was made to account for losses to the ambient temperature outside the chamber, using a baseline test in which no AC was installed.

Each AC was tested in a number of configurations and under a range of cold side, or “outdoor” temperatures.



Test Chamber