Taitem TechTip New York State Homes & Community Renewal

Weatherization Assistance Program

V-Strip Window Weatherstripping

Introduction:

Windows are a major source of air leakage in buildings and replacement is expensive. Installing plastic self-adhering V-strip weatherstripping provides an opportunity for increasing the energy efficiency of older double-hung windows. In order to evaluate the effectiveness of plastic V-strip as an energy conservation measure, we asked the following questions:

- How well does plastic V-strip work?
- How well does it hold up over time?
- How can you tell ahead of time if a particular window will benefit from V-stripping, for example during an energy audit?
- How long does it take to properly install, and how much does it cost to install?
- How does it compare to metal V-strip, for savings, installation, cost, and reliability?

Results:

We installed plastic V-strip weatherstripping on wood-frame double-hung windows in six houses. In these houses, plastic V-strips reduced air infiltration by 5% - 13%, with an average of 9.2% reduction. Average air infiltration reduction per house was 314 CFM50. Dividing whole-house infiltration reduction over the number of windows per house, each individual window benefited with an average air infiltration reduction of 20 CFM50. Average air infiltration reduction per foot of V-strip installed was 1.6 CFM50.

The installed cost of plastic V-strip was estimated at $2.75 per linear foot, about $35 per window on average, and $550 per house on average. These figures include material costs and labor costs at a rate of $58 per hour (Building Laborer, RS Means Repair & Remodeling Cost Data, 2010).

Despite variations in window age and tightness, the installation of plastic V-strip was cost-effective in all six houses, saving an average of 54.7 therms of natural gas annually, or about $82 per year. This translates to a Savings-to-Investment Ratio (SIR) ranging from 1.2 to 2.3 for the six houses tested.

A comparison test of metal and plastic V-strip showed that metal performed better. The metal V-strip reduced infiltration by 8.5%, while the plastic reduced infiltration by 4.6%, when compared apples-to-apples for the same house. Metal V-strip, however, is more costly to install, and it does not fit on all windows; for example, it is often too thick to be installed between the sash and jamb of a typical window.

Figure 1: Metal vs. Plastic V-strips

Other Results:

1. Installing V-strips generally makes windows more difficult to open and close. However, there were some instances where plastic V-strips acted as lubrication and made windows easier to operate.
2. When installed carefully, plastic and metal V-strips hold up well over time.
3. Surface preparation is very important. If surfaces are not prepared properly, plastic V-strips will not stick. Failures typically happen soon after installation if surfaces are not prepared.
4. Both plastic and metal V-strips are vulnerable to “catching” at the window latch, unless they are installed in a way to prevent such a failure.

Methods:

We experimented with two kinds of V-strip weatherstripping. The first was a thin, flexible plastic V-strip with an adhesive backing. The second was a significantly thicker, stiffer metal V-strip (see Figure 1) that required nailing. Figure 2 shows plastic V-strips installed on bottom rail of lower sash and left window jamb. V-strips were placed along the bottom rail of lower sashes and top rail of upper sashes, as well as the top rail of the lower sash where the lower rail of the upper sash makes contact. V-strips were also placed along the parting beads or jambs depending on where there was a wide enough gap for V-strips to be installed. The parting bead is typically a piece of wood which sticks out from the jamb and which guides the sash. In other words, the sash sits between the stop and the parting bead. See Figure 3 for window terminology.

Blower-door tests were run four times in each house, each test with a different window configuration.

Test 1 – Storm windows closed
Test 2 – Storm windows open
Test 3 – Windows V-stripped, storm windows closed
Test 4 – Windows V-stripped, storm windows open

The width, height, gaps (between sashes and stops, and between sashes and side jambs), and total length of weatherstripping installed were recorded for each window.

In addition to the blower door tests, four windows in each house were arbitrarily chosen to undergo a secondary set of tests.

- The force required to open and close each window was measured with a force gauge before and after V-strips were installed.
- Windows were opened and closed 20 times to test for premature failure of installed V-strips.

Figure 2: Plastic V-strips Installed

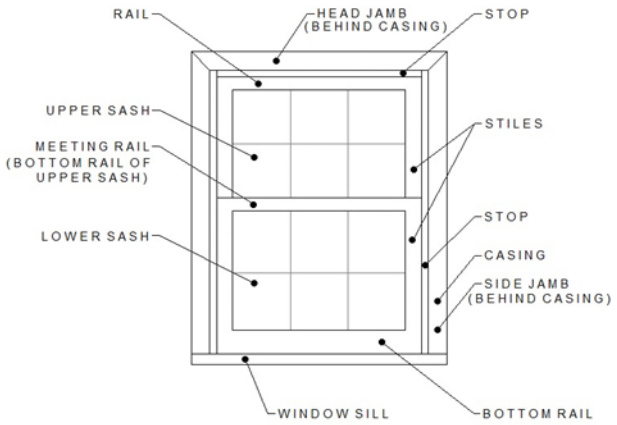

Figure 3: Window Terminology

Reliability/Durability:

Surface preparation is important. If surfaces are not properly prepared, plastic V-strips will not adhere and will fail prematurely. Our surface preparation included sanding (both with sandpaper and an abrasive pad), vacuuming and wiping with a damp paper towel.

The only failure we experienced occurred to V-strips located along the back side of the top rail of the lower sash, where the two sashes meet. When sliding the lower sash up, the V-strip would get caught on the window latch on the bottom rail of the upper sash. This problem was not limited to plastic self-adhesive V-strips, it also occurred for nailed metal V-strips. When operating windows normally, this snag was enough to rip metal V-strips from their nails, as well as completely detach or destroy plastic V-strips adhered to the rail's surface (see Figure 4). To prevent this problem, we recommend that V-strips be installed on the front side of the lower rail of the upper sash. This was the only problem which occurred during the test where windows were opened and closed 20 times after initial installation of the V-strips.

To test the longevity of V-strips, we built a test rig with a double-hung wood-frame window and an automatic actuator which repeatedly opened and closed the window (see Figure 5). For this test rig we placed four V-strips on the left and right jambs (one on the stop, two on the jamb, and one on the parting bead). There was one strip on the lower rail of the lower sash, and two strips between the upper and lower sashes. Each V-strip location was tested with both metal and plastic V-strips. The window rig was opened and closed 15,375 times, with no separation of V-strips from the surface, and minimal signs of wear and tear. This number of cycles represents the equivalent of about 40 years of operation, assuming one open/close cycle per day.

Traditionally, both plastic and metal V-strips have been presumed to have fairly short lifetimes. The accelerated life testing showed that, if properly installed, both plastic and metal V-strips will mechanically last for over 40 years. We did not test for the impact of temperature, humidity, and UV exposure variations. Until such data is available, we recommend that the life expectancy be treated as 15 years for plastic and 20 years for metal.

Figure 4: V-strip Failure

Figure 5: Test Rig in Window Open Position

Avoiding Premature Failures

The key to avoiding premature failures is to properly prepare the surfaces, fasten the strips securely, install them in a manner in which they will not be caught or snagged by the latch, and avoid applying them at low temperatures. After installation of V-strips, windows should be open and closed 10 times to test for premature failures.

Other considerations: Although metal V-strips may be more durable, they are also much more difficult to replace when damaged. Plastic V-strips can be replaced without disassembling the window, and removing plastic V-strip is easier.

Installation Time:

The average time to install plastic V-strip was 8.8 hours per house, or 22.4 linear feet per hour, or 34 minutes per window. See Figure 6.

By way of comparison, metal V-strips (for the one house where it was installed) took 11.3 hours, with 9.0 linear feet per hour, and 52 minutes per window. It should be noted that in this house, the metal V-strip was only installed on the lower sash, so the important comparison is on the basis of linear feet per hour: The metal V-strips take more than twice as long to install, per linear foot, partially due to the fact that window sashes have to be removed for proper installation.

Cost Per Foot:

The cost per foot for v-strips (material only) was:

Frost King V-strips (plastic) $0.22 per foot of material
Niagara V-strips (plastic) $0.13 per foot of material
Kilian Hardware V-strips (metal) $1.08 per foot of material

Installation Cost:

Average installed costs for the plastic V-strip, including both material and labor, and assuming a labor cost of $58/hour: $550/house, $35/window, and $2.75/foot.

By comparison, the metal V-strip was $7.49/foot to install. See Figure 7.

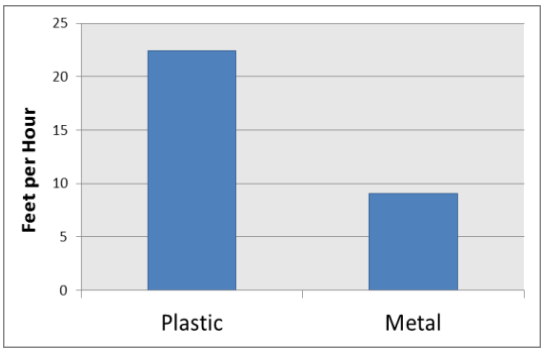

Figure 6: Installation Time (Feet per Hour)

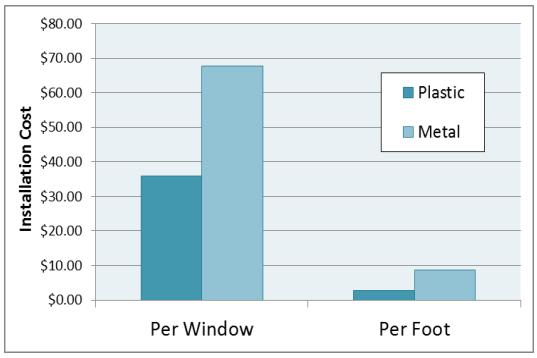

Figure 7: Installation Costs for Plastic vs. Metal V-strips

Installation Notes:

Installing plastic V-strips required sanding, wiping, and vacuuming all surfaces planned for adhesion of V-strips. Often V-strips needed to be slid forcibly into place in the gap between the sash and the jamb, which was more difficult on tighter windows. Metal V-strips, on the other hand, required no surface preparation, though we had to take the sashes completely out of the frame for installation. Metal V-strip weatherstripping required more labor and the use of tools such as a nail gun, hammer, screwdrivers (for removing stops) and putty knives (for fitting sashes back into window frames).

Cost Effectiveness:

In all six houses, with widely varying window tightness, adding plastic V-strips had a Savings-to-Investment Ratio (SIR) greater than 1.0, which means installation is cost-effective, even while assuming the following:

- $58/hour conservative labor cost
- 7400 Heating Degree Days
- Natural Gas at $1.50/therm
- Life expectancy of 15 years for plastic V-strips, 20 years for metal V-strips

In fact, the SIR was greater than 2.0 in some cases, indicating that it is very cost-effective to install V-strip weatherstripping. The SIR averaged 1.7 for the six houses. In one house, an apples-to-apples comparison of plastic versus metal V-strips showed that metal V-strips saved 60 therms annually which translates to $90 per year in savings. The SIR of metal V-strips was 1.5 (See Figure 8). The results for metal V-strips are based on tests in only one house, where the windows were very leaky, making results a little harder to generalize.

	House 1	House 2	House 3	House 4	House 5	House 6 with Plastic	House 6 with Metal
Costs	$660.43	$515.40	$421.02	$635.35	$579.22	$487.08	$762.15
Annual Gas Savings (Therms)	70.82	65.83	37.01	71.17	45.37	32.62	60.35
Annual Dollar Savings	$106.22	$98.75	$55.51	$106.76	$68.06	$48.93	$90.52
SIR	1.92	2.29	1.57	2.01	1.40	1.20	1.49

Figure 8: Cost Effectiveness Table for Windows with Open Storm Windows.

Do Storm Windows Reduce the Benefits of V-strip?

The results presented above are for windows with storm windows open. Most of the houses we tested did in fact have storm windows. With the storm windows closed, blower door test results found that average air leakage was approximately 60 CFM50 lower per house, which means houses were 3.2% less leaky (see Figure 9).

On average, the infiltration reduction achieved from the installation of V-strips when the storm windows are closed was 213 CFM50 or 6.0% per house. This translates to a 2.0 CFM50 reduction per window and an average SIR of 1.15. Only two of the six houses had SIR's of less than 1.0 when storm windows were closed.

When storm windows are closed, savings from V-strip weatherstripping are reduced. However for our "closed storm" tests, we made sure to properly close each and every storm window. Often storm windows are not present or are not closed. In these instances, V-stripping windows will provide additional savings.

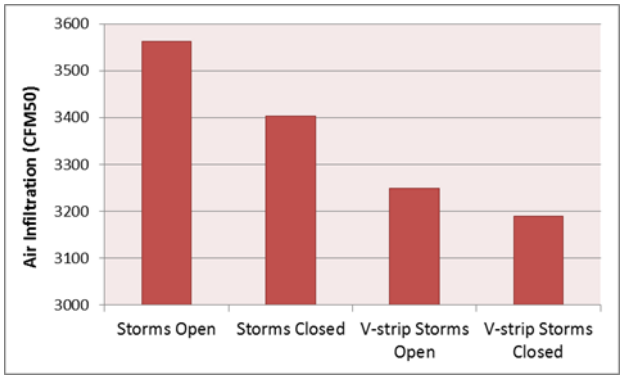

Figure 9: Air Infiltration with Varying Window Configurations

How Much Harder Is It To Open and Close the Windows?

Figure 10: Force Gauge

We measured the force required to open and close the windows, before and after weatherstripping, with a force gauge (see Figure 10).

V-strip weatherstripping does make windows harder to open and close. For metal V-strips, average measured force to open windows was 1.5 lbs before V-stripping and over 44 lbs (the limit of the force gauge) after. The force to close windows with metal V-strips went from 10 lbs to over 44 lbs. This increase in required force made windows with metal V-strips difficult to operate. Average measured force to open windows with plastic V-strips was 21 lbs before V-strippping and 28 lbs after. Measured force to close plastic V-stripped windows changed from 8 lbs to 14 lbs. Overall, plastic V-strips did not become significantly more difficult to operate.

Tests to Determine Need for Weatherstripping:

How can we tell if windows need weatherstripping, for example during an energy audit? There are a number of widely-used methods for testing whether or not a given window could benefit from the installation of V-strip weatherstripping. These include:

- An operable window moves and rattles when it is in a closed position.
- A length of thread or bathroom tissue held near a window or door indicates air movement through a crack.
- Outdoor light can be seen through a crack from inside the house.
- A piece of paper slides easily through a closed opening.
- Turning on exhaust fans in the house and seeing if smoke at the windows indicates infiltration.

5 of 19 windows tested across the six houses did not rattle, 12 of 19 windows did not show air movement with a thread or tissue, 8 of 19 windows did not indicate any light, 5 of 19 would not allow paper to be pulled through, and 4 of 15 did not show smoke movement when exhaust fans were turned on.

Though these tests are easy and convenient, each of the above tests were found to be not conclusive. For example, when examining the two windows in our study with the smallest gaps and the two windows with the largest gaps (as measured using a feeler gauge or calipers and a wooden shim shown in Figure 11), we found that there was no recognizable correlation to be made between the outcome of the tests to determine the need for weatherstripping, and the window gap sizes. Windows on both ends of the gap spectrum rattled, allowed paper to be pulled through, allowed light to pass through cracks, and indicated air movement using either a length of thread or smoke.

Figure 11: Calipers and Wooden Shim

Tests to Determine Need for Weatherstripping (continued):

We examined one further test, by measuring the gap with a feeler gauge. Figure 12 shows the average infiltration reduction (per foot of V-strip installed) graphed against the average gap, for each house.

This shows that as the average window gap increases, the infiltration reduction decreases. In other words, as the window gap gets bigger, the savings go down. We added an extra known point to the graph at 0 gap and 0 savings, and ran a curve fit through the points. This would indicate that if the gap is over 0.15 inches, there may be little savings, likely because the gap is too big for the V-strip to reduce infiltration. Also, as the gap gets very small, we expect savings to go down as well. It's hard to tell where the gap is too small, the below graph might point to a gap of 0.05 inches, although at this point the window will likely start to get too difficult to open and close. Though this analysis requires a number of presumptions, based on our tests, we can confidently recommend V-strips for gaps between 0.07" and 0.12". Extrapolating from our results, plastic V-strips will likely provide good savings down to gaps of 0.02" and up to gaps of 0.13", but caution should be taken at the smaller gap sizes, to make sure the windows open and close easily, and at the higher gap sizes, to ensure that infiltration is in fact being reduced. For larger gaps we recommend using metal V-strips, keeping an eye on making sure windows are not made too difficult to open or close.

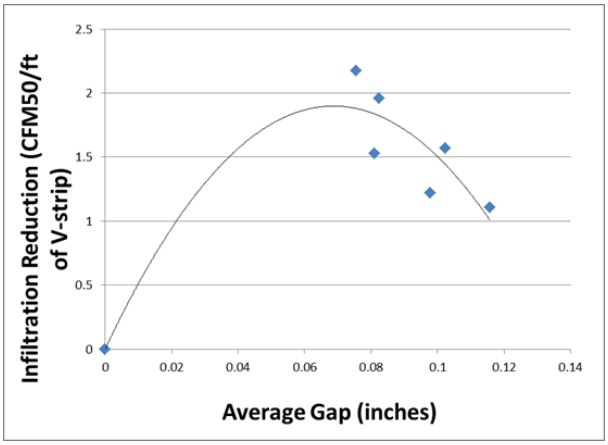

Figure 12: Gap Size and Infiltration Reduction

Conclusions:

Installing plastic V-strips on double-hung wooden windows is a cost effective improvement, which can be reliable and last for many years, as long as the initial installation is done well. Though metal V-strips are better at reducing air infiltration, they can cause windows to become difficult to operate and require that window sashes be removed in order to properly install them. Plastic V-strips are overall cheaper, easier to install, and more versatile than metal V-strips and are therefore a good choice for reducing air infiltration in windows.

Lead Safe Work Practices:

Please note that all work should be done in a lead-safe manner. Consult the Weatherization Assistance Program policies for further information.