Do modern storm windows reduce prime window air leakage?

W. J. GRUBBS
Member ASHRAE

Leaky prime windows

Almost everything you buy today is sold on some performance standard. This is not true in the window and door industry. The Federal Housing Administration and the Architectural Aluminum Manufacturers Assn have established a maximum permissible air infiltration standard of 0.750 cfm/ft of crack at an outside wind velocity of 25 mph for prime units. However, there are no meaningful standards available for storm products. A paper by A. C. Wilson and J. R. Sasaki,[1] of the Building Services Section of The Canadian National Research Council, Ottawa, Canada, on Air Leakage Values for Residential Windows,[1] disclosed that, of the 26 different brands of double hung and slider type windows tested, only nine met the recommended value.

INFILTRATION TESTING PROGRAM; APPARATUS AND PROCEDURE

As the first step of the testing program,* the air infiltration characteristics of windows and doors, both prime and storm, alone and in tandem, were studied* A set of specifications was prepared by Professor Seichi Konzo (Member ASHRAE), of the University of Illinois, for the construction of an air infiltration testing apparatus, Fig. 1. After calibration and preliminary trial runs with the apparatus, the first official test on a product was completed in December of 1963. Since then, approximately 2500 hr of testing on many types of windows and doors, both prime and storm, wood and aluminum, including patio doors, has been completed.

Most heat loss calculations are made at 15 mph wind velocity. However, the ASHRAE Guide And Data Book specifies air leakage up to 30 mph. For this reason, the maximum design condition in the test chamber was chosen to simulate a 30 mph wind velocity.

The test chamber static pressure for a corresponding wind velocity can be computed by the formula:—

$$P = 0.000481\,V^2$$

where P = Test Chamber Pressure—in. of water
and V = Wind Velocity—mph

Four years ago The Weather-Seal Research Dept developed a testing program to study infiltration and transmission through windows and doors.

W. J. Grubbs is Chief Engineer of Weather-Seal, Inc, Barberton, Ohio.

By this formula test pressures have been set up as follows:

Wind Velocity mph	10	15	20	25	30
Test Chamber Pressure in. H_2O	0.048	0.108	0.192	0.301	0.434

All of the tests are run at each of these wind velocities or corresponding pressures. A curve is then plotted on log log paper, and this curve then becomes the air infiltration characteristic of the product or products tested.

PRODUCTS TESTED

All types of windows and doors have been tested. In this paper, only the double hung and slider wood prime windows tested alone and in combination will be discussed. This is the most common combination found in the average American home.

First, representative samples of prime windows were obtained. Products produced by the better window manufacturers of this type of window were selected wherever possible. Some were purchased, some were furnished by contractors building higher priced, quality homes having very low heat loss resulting from infiltration; others were sent in by company representatives. The curves covering prime windows represent the results of 26 tests on different windows produced by nine prime window manufacturers.

Second, representative samples of storm windows were obtained. This was done in the same manner as the prime windows. The curves covering storm windows represent the results of 19 tests on different storm windows, produced by 16 storm window manufacturers.

OBJECT

The three objectives of the study were: to determine the upper and lower range of the prime windows and compare them with the ranges found by the Wilson and Sasaki,[1] to find the range of the storm windows to be used in this study and to determine the characteristics of prime and storm windows tested in tandem.

CHARACTERISTICS OF PRIME WINDOWS TESTED ALONE

Weather-stripped prime wood windows, Figs. 2 and 3, were tested alone, in 24 tests on different windows pro-

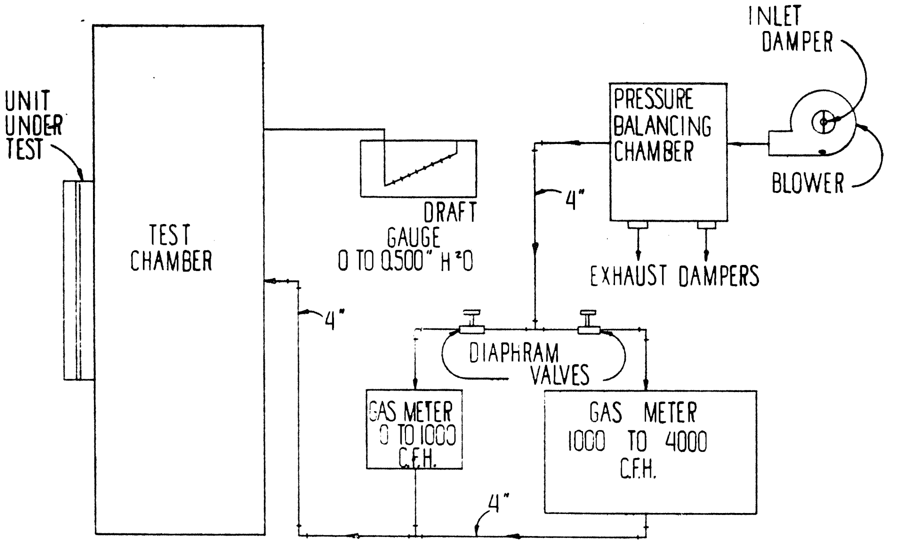


Fig. 1 Infiltration test unit

duced by seven window manufacturers. Shown in Table I is the range of leakage found by Wilson and Sasaki.[1] The values shown in the ASHRAE Guide And Data Book are indicated for reference. In reviewing the construction of these prime windows, it was noted that the ones having the lowest leakage were weather-stripped at the head rail, meeting rail and sill. The distinctive feature of these windows was their pressurized tracks, Fig. 3. The higher range windows were weather-stripped but did not have pressurized tracks, Fig. 2.

Table I indicates the infiltration for each range in cfh at 15 mph wind velocity.

Non-weather-stripped prime wood windows, Fig. 4, were covered in two tests on different windows produced by seven prime window manufacturers. In Table II, the range found by Wilson and Sasaki,[1] and the Guide And Data Book values are indicated along with results of the author's tests. This group has a higher average rate than the group shown in Table I, which was expected. Table II indicates the ranges found in cfh at 15 mph wind velocity.

Three representative prime windows for tandem tests with storm windows: a weather-stripped window having pressurized tracks, Fig 3; a weather-stripped window without pressurized tracks, Fig. 2; and a non-weather-stripped window, Fig. 4; were selected as about the middle of their range by type of construction, and are far enough apart to give a good indication of the effect on the infiltration characteristics when tested in tandem with the three selected storm windows.

Table III lists the leakage of each window in cfh at 15 mph wind velocity.

CHARACTERISTICS OF STORM WINDOWS TESTED ALONE

All-aluminum storm windows, Figs. 6, 7 and 8, were tested alone in 22 tests on different storm windows produced by 17 storm window manufacturers. Wilson and Sasaki[1] did not cover this phase of testing. Professor C. E. Lund and W. T. Peterson[2] of the University of Minnesota made a study of wood hang on storm windows in 1952. In their findings, the fit required to satisfy that of a "well fitted" and a "poorly fitted" wood hang on storm window is described. Since their testing only included the prime alone, and in tandem with the hang on type storm, these fits were duplicated in the laboratory and the characteristic for this type of storm tested alone were determined. Both of these fall in the higher bracket of the modern day aluminum storm windows.

In a study of the construction of these storms it was noted again that the windows having the lowest leakage had pressurized tracks, Fig. 8. The storms in the middle range were double tracks of aluminum or vinyl, and these tracks were not pressurized, Fig. 7. The storms having the higher leakage were all triple track, Fig 6. This is characteristic of the triple track since in most construction the sash is held into position by pins and the sash is not backed up by a track. This per-

Table I. Range of Test Data for Weather-Stripped Windows CFH at 15 MPH

Limit	Crack Length (In.)	Cfm/Ft	Cfh
Upper Range—Author's Test No. 73	17.5	2.10	1880
Upper Range—Wilson and Sasaki Test No. H-15[1]	16.1	1.48	1433
1965 ASHRAE Guide and Data Book Values	17.0	0.38	387
Lower Range—Wilson and Sasaki Test No. H-16[1]	10.6	0.28	180
Lower Range—Author's Test No. 81	13.9	0.15	125

Table II. Range of Test Data for—Non-Weather-Stripped Windows CFH at 15 MPH

Range Limit	Crack Length (In.)	Cfm/Ft	Cfh
Upper Range—Wilson and Sasaki Test No. H-7[1]	16.2	3.48	3385
Upper Range—Author's Test No. 28	17.1	1.31	1349
Lower Range—Author's Test No. 48	17.6	0.84	880
Lower Range—Wilson and Sasaki Test No. H-3[1]	16.2	0.83	810
1966 ASHRAE Guide and Data Book Values P-459	Assume 17	0.60	612

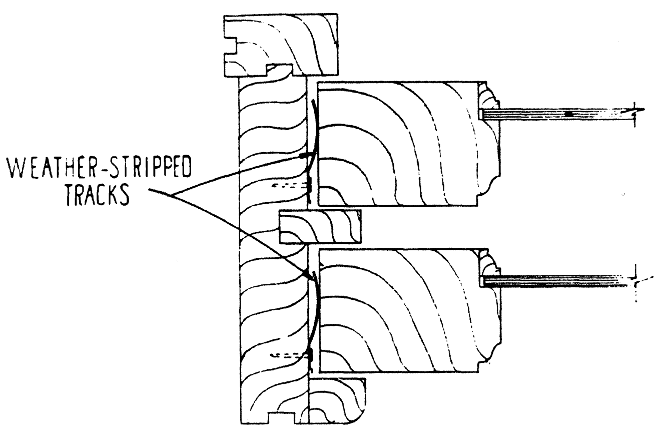


Fig. 2 Double-hung wood prime window, weather-stripped at head, sill and meeting rail

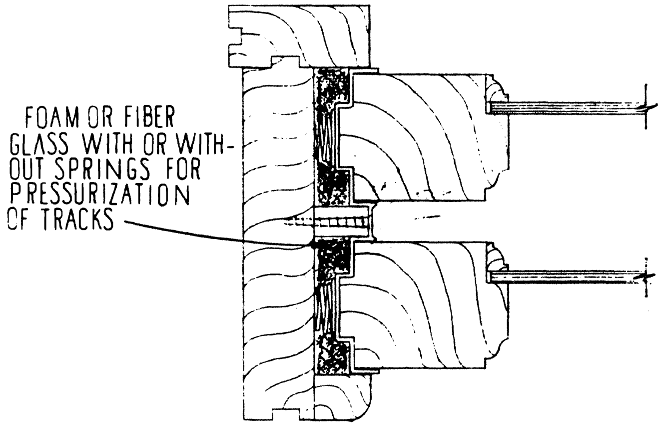


Fig. 3 Double-hung wood prime window with pressurized track weather-stripped at head, sill and meeting rail

mits the vertical members of the sash to deflect, resulting in a higher rate of infiltration.

Table IV indicates the range of all storm windows tested in cfh at 15 mph wind velocity.

The three representative storm windows for tandem testing with the three selected prime windows: a storm having pressurized tracks; a double track of aluminum or vinyl with tracks which are not pressurized; and a triple track; were selected as about the middle average of their range and far enough apart to give a good indication of the effect they will have on the infiltration characteristics when tested in tandem with the three selected prime windows.

Table V indicates leakage for each selected storm window tested alone in cfh at 15 mph wind velocity.

CHARACTERISTICS OF PRIME AND STORM WINDOWS TESTED IN TANDEM

Three prime windows which had been tested alone were selected as representative to be tested in tandem. The characteristics of these three prime windows are now known and plotted. Three storm windows tested alone were also selected as representative to be tested in tandem. The characteristics of these three storm windows are now known and plotted. The windows were then tested in tandem in various combinations.

The infiltration through a non-weather-stripped prime window when tested in tandem with the three selected storm windows disclosed that the loose prime window allowed the greatest tandem leakage. The double track storm window without pressurization performed a little better. However, the very tight storm with pressurized tracks allowed the lowest tandem leakage. This then becomes the combination to consider when buying storms for the older house.

Results of the tests on a good average weather-stripped prime window tested in tandem with the three selected storm windows showed that again, the very tight storm with pressurized tracks allowed the lowest tandem leakage. This combination should be considered when selecting storms for the newer house built shortly after World War II.

When an excellent prime window having pressurized

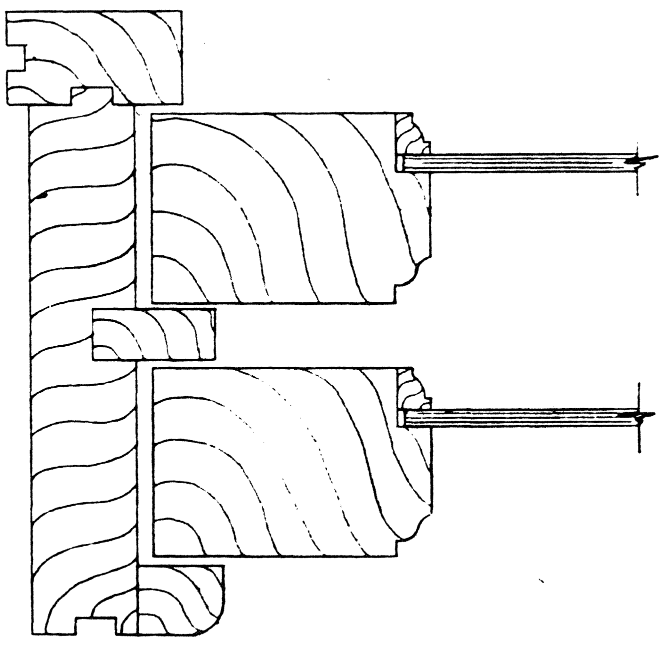
Table III. Representative Values—Prime Windows—Selected for Comparison CFH at 15 MPH

Description by Type	Crack Length (In.)	Cfm/Ft	Cfh
Non-weather-stripped	17.0	1.450	1479
Weather-stripped	17.0	0.720	734
Weather-stripped—with Pressurized Tracks	17.0	0.350	357

Table IV. Range of Test Data—All Storm Windows Tested CFH at 15 MPH

Limit	Crack Length (In.)	Cfm/Ft	Cfh
Poorly Fitted — Wood Hang on Storm Test No. 110	15.1	2.88	2611
Upper Range—Author's Test No. 11	16.75	1.69	1699
Well Fitted — Wood Hang on Storm Test No. 111	15.1	1.43	1291
Lower Range—Authors Test No. 5	16.63	0.247	247

Fig. 4 Double-hung wood prime window, not weather-stripped



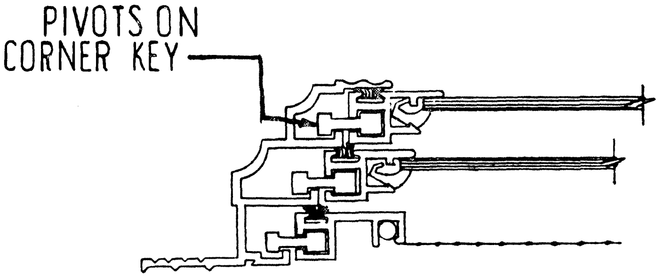
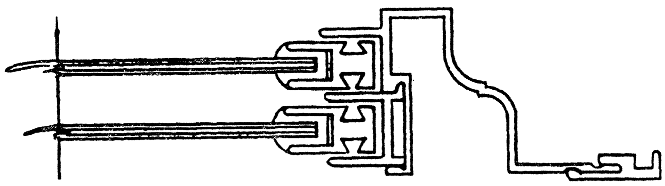


Fig. 5 Double-hung triple track tilt aluminum storm window

Fig. 6 Double-hung double track, not pressurized, aluminum storm window



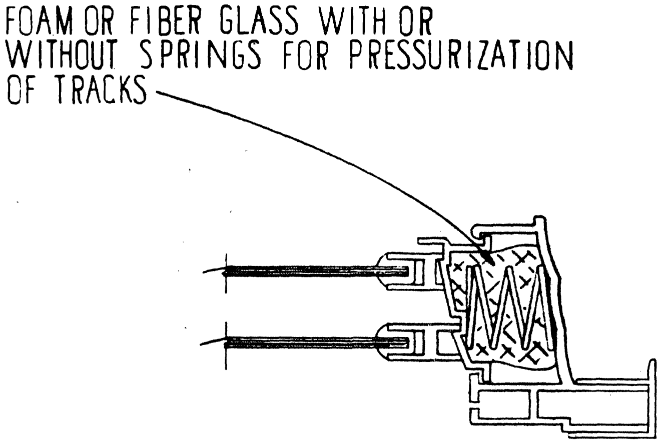


Fig. 7 Double-hung double track, pressurized, aluminum storm window, weather-stripped at head, meeting rail and sill

tracks was tested in tandem with the three selected storms, all three tandem curves were very low. This combination indicates the type or characteristics desired for the construction of a home which would have a very low heat loss due to infiltration. This combination gave the lowest infiltration leakage of any of the combinations studied.

Table VI is a tabulated summary of all tandem tests investigated in this study. The infiltration of each type of prime and storm window and the various combination tests are compared. The table indicates the cu ft per min per ft or crack and the cfh these combinations will leak at 15 mph.

CONCLUSIONS

Window characteristics will change with the design and construction from window to window. The range of values for both primes and storms tested alone and in tandem proves that one set of values cannot possibly be adequate to cover all types of design and construction found on the market today.

There is a need for more definitive and comparative information of the performance of windows and doors. From this will evolve a new set of more meaningful standards, which when published, will serve as a guide to the buying public. Performance standards and producers certification or compliance with these standards will better enable the buyer to know what he hopes to accomplish by installing prime and storm windows and doors of various standards on his home.

ACKNOWLEDGEMENT

The author wishes to acknowledge the aid of H. T. Gilkey, E. R. Ambrose, L. F. Schutrum, Carl Coblentz, G. W. McElhaney and T. F. Faison.

REFERENCES

1. Sasaki, J. R., and A. G. Wilson, Air Leakage Values for Residential Windows, ASHRAE Transactions, Vol. 71, Part II, 1965, p. 81.
2. Lund, C. E. and W. T. Peterson, University of Minnesota Bulletin No. 35, p. 40, May 15, 1952, Engineer Experiment Station, University of Minnesota.

Table V. Representative Values—Storm Windows—Selected for Comparison CFH at 15 MPH

Description by Type	Crack Length (In.)	Cfm/Ft	Cfh
Triple Tracks	17.0	1.4	1428
Double Tracks	17.0	0.7	714
Pressurized Tracks	17.0	0.3	306

Table VI. Prime Window—in Tandem with—Storm Window Air Infiltration CFH at 15 MPH Wind Velocity

Combination: Prime	Combination: Storm	Crack Length (in.)	Cfm/Ft Crack	Cfh
Non-weather-stripped	Triple Track	17	0.970	989
Non-weather-stripped	Double Track	17	0.550	561
Non-weather-stripped	Pressurized Track	17	0.270	275
Weather-stripped	Triple Track	17	0.590	601
Weather-stripped	Double Track	17	0.430	438
Weather-stripped	Pressurized Track	17	0.250	255
Pressurized Track	Triple Track	17	0.320	326
Pressurized Track	Double Track	17	0.270	275
Pressurized Track	Pressurized Track	17	0.220	224