BUILDING RESEARCH NOTE

AN EXHAUST FAN APPARATUS FOR ASSESSING THE AIR LEAKAGE CHARACTERISTICS OF HOUSES

by

H.W. Orr and D.A. Figley

Prairie Regional Station, Division of Building Research,

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INTRODUCTION

Air leakage through the exterior envelope of a residence can constitute a significant energy loss, and can contribute to discomfort and to concealed condensation problems. Air tightness is thus a desirable characteristic and is in fact necessary for control of ventilation and heat recovery systems. The air tightness of a building enclosure can be assessed by exhausting air from the structure and measuring the air flow rate and corresponding pressure difference across the enclosure (1-5). Although it is not a measurement of the natural air leakage rate, the method characterizes the building in regard to its over-all air leakage properties and provides a relatively simple and direct means to assess its conformance to desired standards.

The exhaust fan apparatus was developed by researchers at the Prairie Regional Station of the Division of Building Research in Saskatoon for air leakage testing of small buildings. It was designed to be easily portable and simple to operate, allowing a two-man crew to pressure test a house in about 45 minutes.

DESCRIPTION OF THE APPARATUS

The prototype apparatus consists of a replacement plywood door section with a fan located in the centre. A bell mouth nozzle is used to measure the air flow rate and the door has an outdoor pressure sensor connected to it for measuring the net pressure difference exerted across the building envelope.

Figures 1 and 2 show drawings of the door section. The vertical piano hinge allows it to be placed in either 800 or 900 mm wide doorways. The horizontal hinges allow the apparatus to be folded to a size that can be handled by one person and placed in the trunk of a car.

The fan chosen for the pressurization apparatus is a Joy Manufacturing Company Axivane fan, Model AV-9-6.5-65D, rated at 543 L/s free air and 1625 Pa static pressure. It is capable of producing a 50 Pa differential pressure across all but the most leaky single-family house enclosures. It is very compact and light, weighing less than 9 kg. The fan operates from a 27 volt power supply and draws a maximum current of 50 amperes. A variable transformer (Variac) and rectifier circuit convert standard 110 volt AC power to the voltage required by the motor. This system allows the fan speed to be varied to obtain different pressure levels across the building envelope.

a quick and easy method of securing the panel in place. The door section is then taped to the door frame to ensure an air tight seal.

The outdoor pressure sensor is connected via a flexible tube to the connection in the door panel. Care must be taken to locate the outdoor pressure sensor in a clear area, away from the house so air turbulence due to wind will be minimized. A second tube connects the digital manometer to the inside connection on the door panel. The second pressure tap of the manometer is left open to the house pressure.

Two tests are conducted on each house. The first is done with the chimney and other vents open, giving a test that may represent the house in actual operation. The second is performed with the chimney and other vents blocked, allowing the air leakage component through the ceiling, walls, windows and doors to be evaluated. During the tests, all outside doors and windows are closed and all inside doors are open to allow free air flow within the building enclosure.

The test involves depressurizing the house to different levels by varying the fan speed with the Variac. At each pressure level, the air flow rate is measured. House pressures were varied between 0 and 100 Pa in ten equal increments whenever possible. This range of pressures is sufficient to establish an air flow versus envelope pressure difference curve for the structure.

Several additional measurements are required in order to evaluate the test data. It is necessary to know the total house volume and the exposed surface area above ground to determine the relative air tightness of the building. These measurements are taken at the air barrier boundary.

PRESENTATION OF RESULTS

During the summer of 1979, the fan pressurization apparatus was installed in a number of wood frame, single-family residences in Saskatoon. The wide variation in the air flow rates, shown in Figures 4 and 5, indicates the extremes in air tightness that have been found in residential construction to date.

In order to relate the fan pressurization results for different sized structures, the air flow parameter is expressed as a specific air flow:

Specific air flow = air flow rate/exposed surface area

where the exposed envelope area is taken as the air barrier surface area above the ground level.

A few examples of the house characteristic curves plotted from pressurization data are given in Figure 4. It is also possible to plot the pressurization results on a logarithmic scale, as shown in Figure 5. Presenting the data in this form yields straight-line relationships between

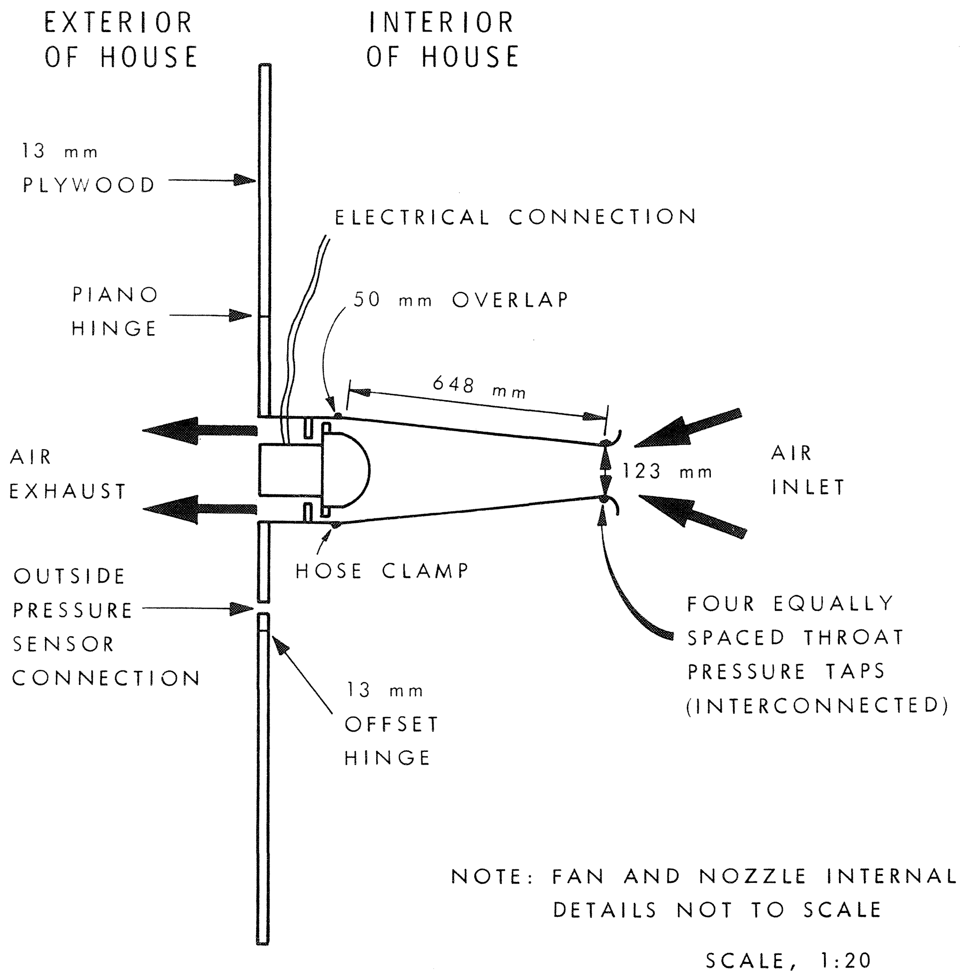

FIGURE 1

EXHAUST FAN APPARATUS

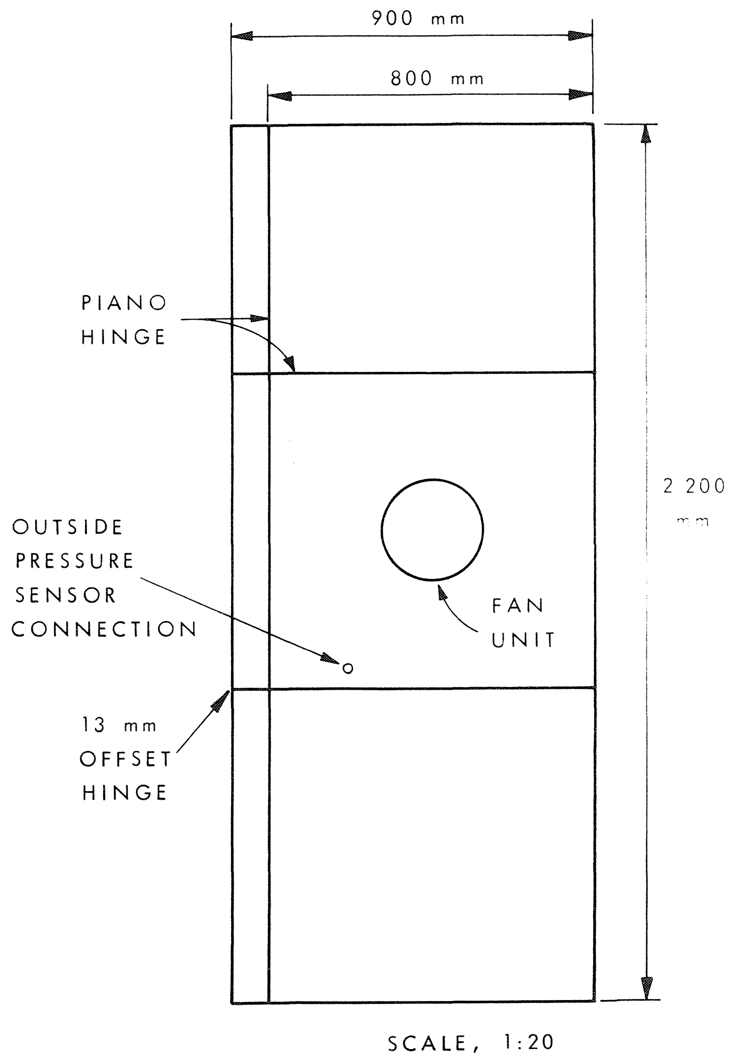

FIGURE 2

EXHAUST FAN APPARATUS - DOOR PANEL DETAILS

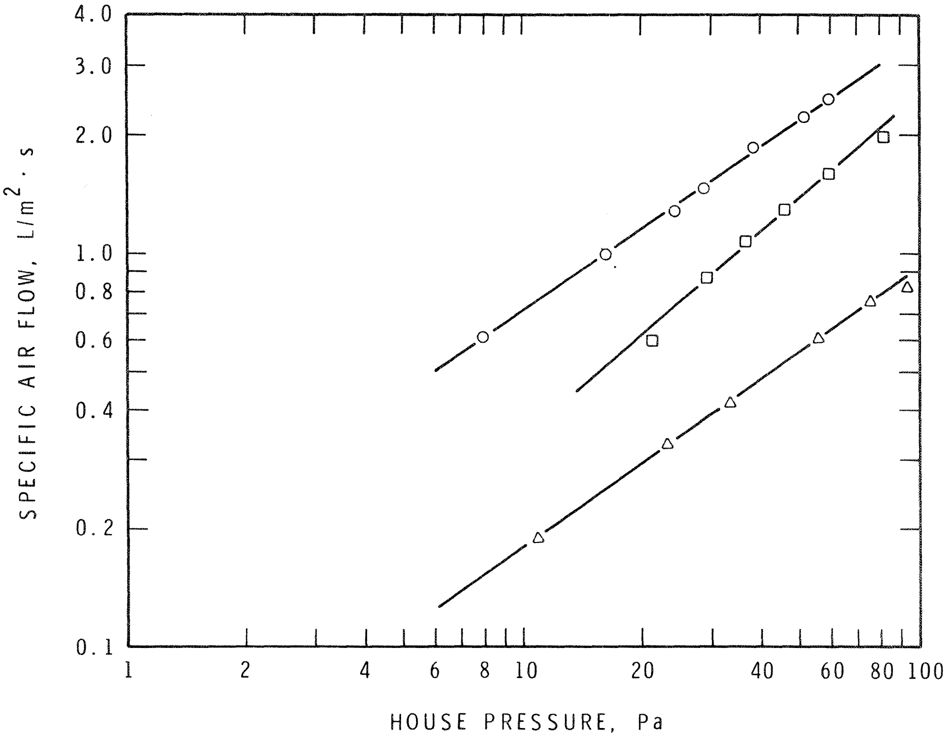

FIGURE 5

SPECIFIC AIR FLOW VS HOUSE PRESSURE FOR THREE SASKATCHEWAN RESIDENCES WITH CHIMNEY AND VENTS BLOCKED

APPENDIX I

CALIBRATION CORRELATION FOR LONG RADIUS FLOW NOZZLE

The air volume flow rate as measured, using a 10 point pitot tube traverse, and the corresponding nozzle pressure difference for each flow rate (Figure 3) were analyzed using a log-log linear regression. The resulting expression is of the form

$$\log Q = a + b \log \Delta P \tag{A.1}$$

where

Q = air flow rate (m^3/s)
ΔP = nozzle pressure (Pa)
a = abscissa intercept
b = slope of the line

Taking the anti-log of equation A.1 results in

$$Q = a\Delta P^b \tag{A.2}$$

The values of the constants a and b were determined from the linear regression as $a = 0.01473$ and $b = 0.5092$. For this expression, the correlation coefficient is 0.9999.

The air flow through a nozzle is given by Bernoulli's theorem as

$$Q = AC\sqrt{\frac{2\Delta P}{\rho}} \tag{A.3}$$

where

A = nozzle cross sectional area at the pressure taps (m^2)
C = nozzle discharge coefficient
ρ = density of fluid (kg/m^3)

Substituting the physical parameters for this nozzle results in the following equation,

$$Q = 0.01588 \quad C\sqrt{\Delta P} \tag{A.4}$$