APPENDIX 2

FIELD STUDY AND FIELD TESTING OF RESIDENTIAL KITCHEN RANGE HOOD AND BATHROOM EXHAUST SYSTEMS

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Ref. No. 001Z
August 9, 1988

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1.0 INTRODUCTION

Exhaust fans are installed in Canadian houses to remove pollutants and moisture, usually at their source, and to function as part of the system designed to meet the ventilation requirements of the 1985 National Building Code or a Provincial Building Code. Due to reasons such as noisy operation, poor performance and perceived ineffectiveness, these exhaust systems generally under-perform and are often under-utilized by the householders.

In this segment of the project, a study of field installation practices for residential exhaust fans in 4 major centers across Canada was conducted as Phase I. In Phase II, measurements of airflows and sound levels for kitchen range hoods and bathroom exhaust fans were made in houses in the same locales. A comparison was then made of manufacturers catalogue and/or certified performance data with that obtained in Phase II.

2.0 OBJECTIVE

The main objectives of this segment of the project were:

* to determine the make and model of residential exhaust fans currently being installed in Canadian homes;

* to determine the details of exhaust duct systems being installed in Canadian homes;

* to determine the installation practices used to install residential exhaust systems across Canada

* to measure the volume of air removed by the exhaust systems in a sample number of Canadian homes.

* to measure the sound level of exhaust fans installed in a sample of Canadian homes.

* to compare the actual results as measured in the field with manufacturers' catalogue data.

3.0 PROCEDURES

3.1 PHASE I FIELD SURVEY

Houses under construction in Vancouver (5), Calgary (5), Quebec City (7) and Halifax (3) were surveyed to obtain the following information on the kitchen range hood and bathroom exhaust systems being used:

* normal exhaust system duct sizes;

* number of fittings and type of outside termination used;

* the approximate equivalent length of the installed system;

* the kind of ducts used;

* installation procedure for the fan, the ducting and/or the termination device;

* the type of bathroom fan control system used;

* details of insulation of the ducting and taping of the joints.

This information was obtained through site visits while the homes were under construction, to enable the surveyor to see the complete exhaust duct system before construction of the interior. Data on Toronto area homes was obtained

from a similar study completed in November 1987[3], and are included in the summary table (Table I) in this report. Photographs were provided, in some instances by the field surveyors.

3.2 PHASE II FIELD MEASUREMENT

The kitchen and bathroom exhaust systems in twenty houses, in the same locations (although not necessarily in the same houses) as in Phase I, were tested to determine the exhaust airflows and sound levels.

The airflow measurement utilized flow hoods which were designed, fabricated and calibrated by the Ontario Research Foundation (ORF), specifically for this application. A balancing fan and airflow measuring device were a part of this equipment. The flow hoods were shipped to the field surveyors for use in taking measurements. (See Appendix II for detailed information on the airflow test equipment and procedure).

A sound level meter, provided by ORF, was shipped to the surveyors to measure both the ambient sound levels in the room where each fan was located, and the operating sound levels, measured when the fan was operated at its highest speed. Measurements were taken at the same defined point in each of the bathrooms and kitchens. Standardized instructions on the method of conducting the sound tests were provided by ORF. (See Appendix II for detailed information on the procedure).

3.3 FIELD SURVEYORS

The individuals selected to undertake the field survey and measurement work were all experienced in the construction of houses, and the installation and testing of residential mechanical ventilation equipment. All are qualified instructors in the Heat Recovery Ventilator Installer training courses delivered by HRAI-TSDI across Canada, and they are also qualified R2000 instructors and inspectors within that program.

3.4 INSTRUMENTATION

Instrumentation used in the field measurement program included the following:

Airflow

Airflows were measured using VanE flow sensors, 100 mm. and 150 mm. dia. Differential pressure was measured by an electronic manometer, Air Instrument Resources Ltd. model no. MP6KD.

Sound

Sound levels were measured by a Bruel and Kejer model 2409 sound meter.

4.0 OBSERVATIONS

4.1 PHASE I: FIELD SURVEY

The observations made during this phase are summarized in Table I. As the houses were viewed at the rough-in stage, the make and model of the exhaust fan and range hood could not always be determined.

Make And Model Of Exhaust Fans And Range Hoods

For the bathroom exhaust fans, one model of one manufacturer dominated the survey and the test phase, particularly in western Canada. Kitchen range hoods were found to be more diversified. In general, almost all the units were observed to be the low end or 'builder' models.

Duct Size

The most commonly used duct sizes were 75 mm. for bathroom fans and 100 mm. for range hoods. Occasionally in Vancouver, and usually in Quebec, 85 mm. by 255 mm.

was used for range hoods, which is the size of the connection on most models.

Equivalent Length

The equivalent length of the duct systems varied widely within each locale. Kitchen range hoods were usually located on an outside wall, resulting in a short duct run. Bathroom exhaust fans varied widely, but were usually longer than range hoods. In two areas, the surveyors noted that terminations are not usually put on the front wall of the house, the preference being for a longer duct run rather than defacing the front of the house.

Duct Material

The surveyors suggested that electricians and general contractors tended to use vinyl flex duct for bathroom fans and vinyl or aluminum flex duct for range hoods, while sheet metal contractors used galvanized duct and fittings for all applications.

Duct Insulation

Installation practice regarding use of insulation varied widely in the areas surveyed. In Vancouver, insulation was not seen on the exhaust ducts. In Calgary, some bathroom exhaust ducts were insulated for the full length, some for a part of their length, and some only where they ran through the attic. In Toronto, all exhaust ducts were wrapped with nominal 25 mm. thick insulation within 1 m. of a wall cap, or for the entire exposed length in the attic. In Quebec, only ducts exposed in the attic were insulated, and if they were between the ceiling joists, the contractor relied on the ceiling insulation, otherwise they were wrapped with nominal 25 mm. thick insulation. In Halifax, the surveyor stated that "Usually the insulation of the duct in cold spaces or near walls is entirely accidental."

TABLE 1: SUMMARY OF FIELD SURVEY FINDINGS

CITY	DUCT SIZE, mm.	NUMBER OF ELBOWS	TOTAL EFFEC. LENGTH, m. (1)	GALVANIZED DUCTS USED (2)	FLEX DUCTS USED (3)	DUCT INSULATION	FAN INSTALLER	DUCT INSTALLER	DUCT JOINTS TAPED	WALL/ROOF CAP MATERIAL	CAP INSTALLED BY
BATHROOM EXHAUST SYSTEMS											
VANCOUVER	75 & 100	1 TO 5	2 TO 35	YES	YES	NO	ELECT OR SHT MTL	ELECT OR SHT MTL	NO	SHEET METAL OR PLASTIC(4)	NR
CALGARY	75	2 TO 3	1 TO 13	YES	YES	NR	ELECTRICIAN	SHT MTL CONT.	NR	SHEET METAL OR PLASTIC	RFR OR BRCKLYR
TORONTO	75 & 100	0 TO 4	2 TO 15	YES	NO	YES	ELECTRICIAN	SHT MTL CONT.	NO	SHEET METAL OR PLASTIC	RFR OR BRKLYR
QUEBEC	75 TO 125	1 TO 4	4 TO 26	YES	YES	YES	ELECTRICIAN	SHT MTL CONT.	YES	SHEET METAL OR PLASTIC(4)	RFR OR SDR
HALIFAX	75 & 100	0 TO 2	1 TO 26	NO	YES	YES	ELECTRICIAN	ELECT OR SHT MTL	YES	SHEET METAL OR PLASTIC(4)	SIDER
KITCHEN RANGE HOODS											
VANCOUVER	100 to 150	0 TO 3	0.3 TO 16	YES	NO	NR	ELECT OR SHT MTL	ELECT OR SHT MTL	NR	SHEET METAL OR PLASTIC	NR
CALGARY	100	0	0.5	YES	NO	NR	ELECTRICIAN	SHT MTL CONT	NR	NR	RFR OR BRKLYR
TORONTO	100	1 TO 3	4 TO 12	YES	NO	YES	ELECTRICIAN	SHT MTL CONT	YES IN CUPBOARD	SHEET METAL OR PLASTIC	RFR OR SDR
QUEBEC	85x255 150	0 TO 4	0.3 TO 25	YES	NO	YES	ELECTRICIAN	SHT MTL CONT	YES EXCEPT IN CUPBOARD	SHEET METAL	RFR OR SDR
HALIFAX	NR	NR	NR	NO	YES	YES	ELECTRICIAN	ELECTRICIAN	YES	SHEET METAL OR PLASTIC	RFR OR SDR

Notes:

NA- Information not available.
NR- Information not reported.

1. Total effective lengths shown do not include the termination device.
2. Sheet Metal Contractors usually installed galvanized ducts.

Fan And Duct Installer

The electrician was the usual supplier and installer of the exhaust fans and range hoods. The exhaust duct mighty be installed by the electrician, general contractor, or the sheet metal contractor.

Taping of Exhaust Duct Joints

Taping of joints was found to be common only in Quebec, except where it was used to connect vinyl flexible ducts to the exhaust fan or outside termination.

Outside Terminations

The outside termination devices were usually of the dryer vent style for round ducts, made of either metal or plastic. Those made by the exhaust fan manufacturers were the exception rather than the rule. When installed on the wall, they always had a backdraft damper, but this was not always true for roof mounting. For soffit termination, in Vancouver, Calgary and Halifax, either the end of the pipe was left above a perforated section of the soffit, or a dryer vent or other termination was used.

Installation of the termination was usually done by the tradesman responsible for finishing the exterior of the house. Thus, a roofer installed roof vents, and a bricklayer or sider installed wall vents, whenever they encountered an exhaust duct, installed at the time of rough-in.

Control of Bathroom Fans

Control of bathroom exhaust fans was most commonly by a separate wall switch, or by connection to the light switch. In some rare cases, a manual timer or humidistat was found.

4.2 PHASE II: FIELD MEASUREMENT

The results of the field measurements are summarized in Table II.

Note that no measurements were undertaken in the Toronto area study referred to previously.

4.3 ANALYSIS

A comparison of manufacturers' published airflow and sound data, and certified and listed data where available, is presented in Table II.

Most North American manufacturers follow the procedures of the Home Ventilating Institute (HVI) in rating their exhaust fans and range hoods. Thus airflows are rated at a static pressure external to the exhaust fan of 25 Pa. Where available, HVI certified airflows are included in Table II, otherwise the manufacturers' catalogue airflows are provided for the analysis.

All certified sound ratings are provided in Sones, as measured under the HVI certification program in their approved testing laboratory. Again, for those products not listed by HVI, the manufacturer's catalogue information on sound level is included. Field measurements were made in decibels, using the A-scale weighting (dBA). As noted in the first report in the project, a comparison of sound levels in Sones and dBA is subject to some degree of interpretation[1], and therefore no conversion has been provided.

TABLE II: SUMMARY OF AIRFLOW AND SOUND FIELD TESTING

HOUSE NO.*	FAN MODEL	RATED AIRFLOW, L/S @ 25Pa	MEASURED AIRFLOW, L/S	% OF RATED AIRFLOW	RATED SOUND LEVEL, SONES	MEASURED SOUND LEVEL, dBA	SOUND LEVEL FAN - OFF dBA
BATHROOM EXHAUST FANS							
1B	A1	24	9	37	3.0	72	44
1B	A1	24	5	23	3.0	80	44
2B	A1	24	13	54	3.0	60	54
2B	A1	24	14	59	3.0	62	54
3B	A1	24	14	57	3.0	62	23
3B	A1	24	9	37	3.0	62	23
10A	A1	24	14	59	3.0	50	46
10A	A1	24	14	59	3.0	50	48
11A	NR	NA	11	NA	NA	50	43
11A	NR	NA	12	NA	NA	52	45
12A	A1	24	12	53	3.0	44	38
12A	A1	24	NR	NA	3.0	52	39
13A	A1	24	15	64	3.0	52	44
13A	A1	24	NR	NA	3.0	48	42
14A	A1	24	12	53	3.0	53	38
14A	A1	24	NR	NA	3.0	44	37
15Q	A1	24	5	23	3.0	46	20
16Q	B1	24	6	26	4.0	61	20
17Q	B2	38	13	34	3.5	54	26
18Q	A2	28	6	22	3.0	57	20
19Q	B1	24	11	46	4.0	58	24
20Q	B1	24	10	42	4.0	57	27
21Q	NR	NA	4	NA	NA	50	22
22N	E1	24	4	19	NR	58	35
23N	A1	24	16	70	3.0	49	32
24N	NR	NA	7	NA	NA	51	34
AVERAGE VALUES		24	11	47	3.0	60	42

NOTES:

NA - Information Not Available
NL - Product Information Not Listed
NR - Information Not Recorded

1. Airflow and sound ratings are converted from information published in manufacturers' catalogues.

* B = Vancouver, B.C; A = Calgary, Alberta; Q = Quebec, P.Q; N = Halifax, Nova Scotia.

TABLE II: SUMMARY OF AIRFLOW AND SOUND FIELD TESTING

HOUSE NO.*	FAN MODEL	RATED AIRFLOW, L/S @ 25Pa	MEASURED AIRFLOW, L/S	% OF RATED AIRFLOW	RATED SOUND LEVEL, SONES	MEASURED SOUND LEVEL, dBA	SOUND LEVEL FAN OFF dBA
KITCHEN RANGE HOODS							
1B	B10	85	12	14	7.0	71	23
2B	B10	85	50	59	7.0	66	54
3B	A11	85	78	92	5.5	71	24
11A	A10	75	52	69	6.5	62	42
12A	C10(RECIR)	75	23	31	NL	62	42
13A	C10	75	37	50	NL	65	43
14A	A10	75	34	45	6.5	66	35
15Q	A10	75	17	23	6.5	64	24
16Q	A10	75	16	21	6.5	68	20
17Q	A12	140	30	22	4.5	65	20
18Q	A12	140	32	23	4.5	65	34
19Q	D10	NA	17	NA	NA	63	31
20Q	B11	65	24	37	5.0	64	27
21Q	B10	85	23	27	7.0	65	22
22N	F10	75	24	32	NL	71	36
23N	A12	140	27	19	4.5	69	34
24N	A10	75	27	36	6.5	66	33
AVERAGE VALUES		89	31	35	6	66	32

NOTES:

NA - Information Not Available
NL - Product Information Not Listed
NR - Information Not Recorded

1. Airflow and sound ratings are converted from information published in manufacturers' catalogues.

* B = Vancouver, B.C; A = Calgary, Alberta; Q = Quebec, P.Q; N = Halifax, Nova Scotia.

5.0 CONCLUSIONS

1. Exhaust airflows for bathroom exhaust fans and kitchen range hoods, as installed in homes in Canada, are considerably below the nominal airflows described by the manufacturers' in their listed and/or published information.

2. Sound levels for bathroom exhaust fans and kitchen range hoods, as installed in homes in Canada, can be predicted with considerable accuracy by the manufacturers' listed and/or published information.

3. The most commonly selected exhaust fans and range hoods are the lower price, lower quality units.

4. The size of the ducts connected to the exhaust fans and range hoods are consistently below that specified by the manufacturers.

5. Little or no technology is applied to the design of the exhaust 'system', to ensure that an adequate quantity of air is removed from the house.

6. Installation standards should address the issues of taping of duct joints, insulating of ducts, use of flexible ducts, and types and location of duct terminations.

6.0 REFERENCES

1. 1985 ASHRAE FUNDAMENTALS, chapt. 7; Sound And Vibration Control Fundamentals.

2. HRAI RESIDENTIAL AIR SYSTEM DESIGN MANUAL, First Edition, December 5, 1986

3. Bach, H.R., "Selection and Application of Washroom Exhaust Fans and Kitchen Range Hoods in Single Family Tract Housing", prepared for Ontario Research Foundation, January 30, 1987.

APPENDIX 1

FIELD SURVEY PROCEDURE

DESCRIPTION OF WORK

PHASE I

1. Visit the sites of 5 different builders, building conventional (non-R2000) homes, at the rough-in stage.

2. Look at details of the installation of the washroom and kitchen exhaust fans in one typical house at each site.

3. Complete the enclosed survey form for each house, providing details of the make and model of the fans, where possible, and the duct installation. If further space is required, the back of the form can be used.

4. If practical, take photos of the installations, to simplify and clarify the installation details.

5. Comment on the installation procedure followed in your area. This does not need to be as extensive as the sample provided, and could be limited to citing the variations between your area and the description enclosed herein.

6. Forward the completed survey forms and photos, along with any other salient details, to HRAI-TSDI.

PHASE II

This phase will comprise the measurement of airflow and sound, using equipment being designed and produced by Ontario Research Foundation, at the same or similar building sites. Details on this procedure will be forwarded about mid-January. The test device will be shipped to each of you in turn, for your use.

APPENDIX II

FIELD TEST PROCEDURE

INSTRUCTIONS

AIRFLOW MEASUREMENT

The systems for measuring airflow will be set up as per Figures A and B. Airflow will be determined with the kitchen or bathroom fan set at high speed. Care must be taken that all duct work and connections are airtight. It is intended that the bathroom hood be pressed against the ceiling for an airtight seal. The range hood is to be sealed to the measuring duct with the 3" masking tape.

Once the system is set up and airtight, the signal in port on the electronic manometer is to be connected to the static port on the hood. The 1/8" tygon tubing will fit inside the 1/4" tygon tubing on the hoods and will fit over the manometer signal in port. With the manometer on the range with highest resolution (0 - 1999 Pa) zeroed, turn the exhaust fan on high speed. Then turn on the balancing fan and adjust the speed control to achieve zero static pressure at the exhaust fan (hood static).

With zero static at the hood, disconnect the static line from the manometer. Connect the airflow sensor to the manometer. The high pressure side of the sensor is connected to the signal in port of the manometer and the low pressure side of the sensor is connected to the reference in inches of water (differential pressure).

After recording the differential pressure, check the hood static pressure by disconnecting the flow sensor lines (1/8" tygon) and reconnecting the static line. Check the zero on the manometer at the 0 - 1999 Pa range and then take a static pressure reading. If the static pressure has drifted off zero by more than 5 Pa, adjust the balancing fan to achieve zero static pressure and repeat the airflow measurements.

The approx. airflow may be found from the chart on the 6 inch flow sensor if it is used or from the following equation:

$$\text{CFM} = 2378 \sqrt{\text{Diff. Pressure (Inch Water)}} \times \text{Cross Section Area of Sensor}$$

For 4" Ø Sensor

$$\text{CFM} = 208 \sqrt{\Delta P \ (\text{"}H_2O)}$$

In addition to recording the static and differential pressure, record the air temperature with the supplied digital thermometer. Make sure that the switch on the temperature probe is in the "dry" position. Also, obtain and record the local barometric pressure (indicate if it is corrected to sea level) and geographical elevation. This data will allow airflow correction factors to be determined at Ontario Research Foundation.

SOUND LEVEL MEASUREMENT

Read the instructions supplied with the sound meter and become familiar with the instrument's operation. Sound level readings are to be taken with the exhaust fans on high speed. All ducts used for airflow measurement should be removed.

Kitchen Fan: The location of the microphone is to be 5 feet from the floor and 12 inches in front of the range, centrally positioned. Record the meter reading at this position (dbA).

Bathroom Fan: The location of the microphone is to be 2 feet 6 inches above the toilet seat and 2 feet in front of the wall behind the toilet, centrally located. Record the meter reading at this position (dbA).

At each house the calibration of the sound meter should be verified using the supplied sound level calibrator. Readings should be taken with the meter set to the 'A' scale. If the indicated sound level with the calibrator deviates by more than 0.5 db from 94, adjust the meter gain to obtain 94 db.

All readings should be taken with the sound level meter set for normal response time.

If any questions or problems should arise, please contact one of the following people at Ontario Research Foundation.

Peter Edwards	(416) 822-4111 Ext. 463
Peter Grinbergs	(416) 822-4111 Ext. 272

NOTE: Hood static pressure and airflow measurements were performed alternately with micromanometer.

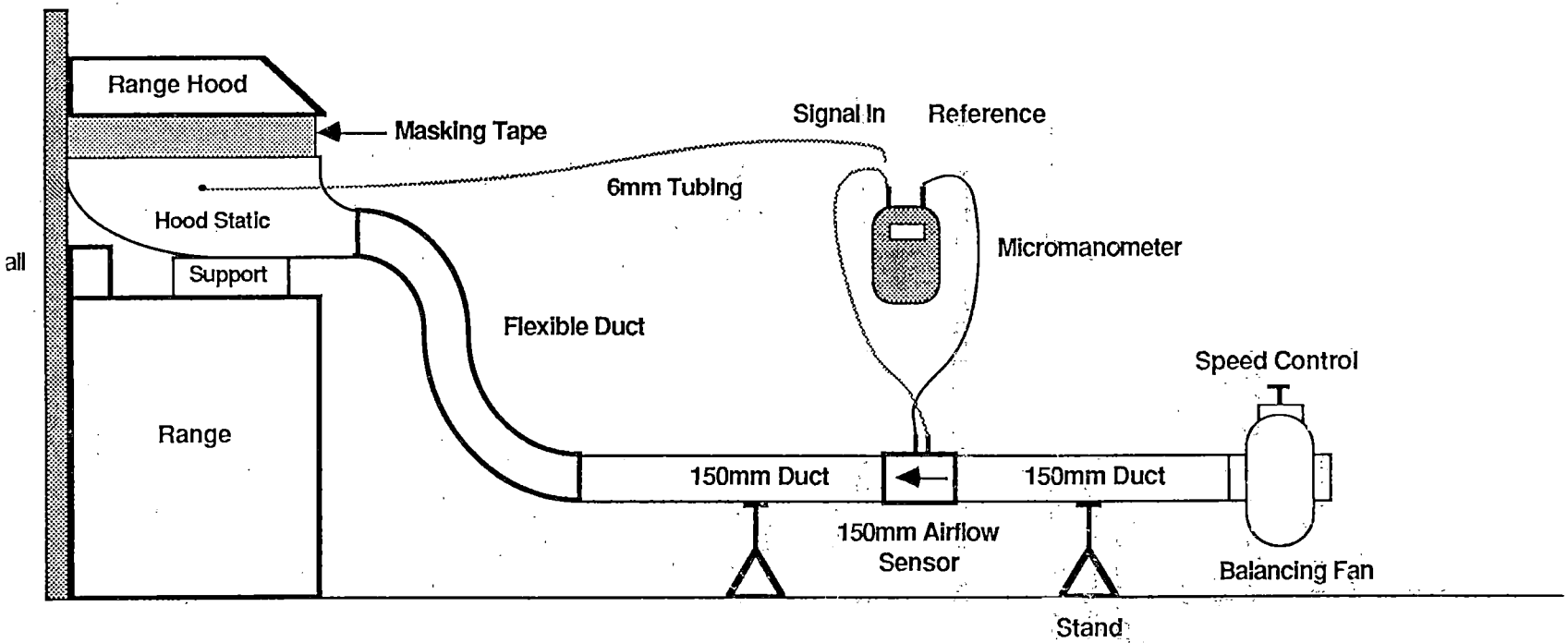

Figure A: Range Hood Airflow Test Set-up

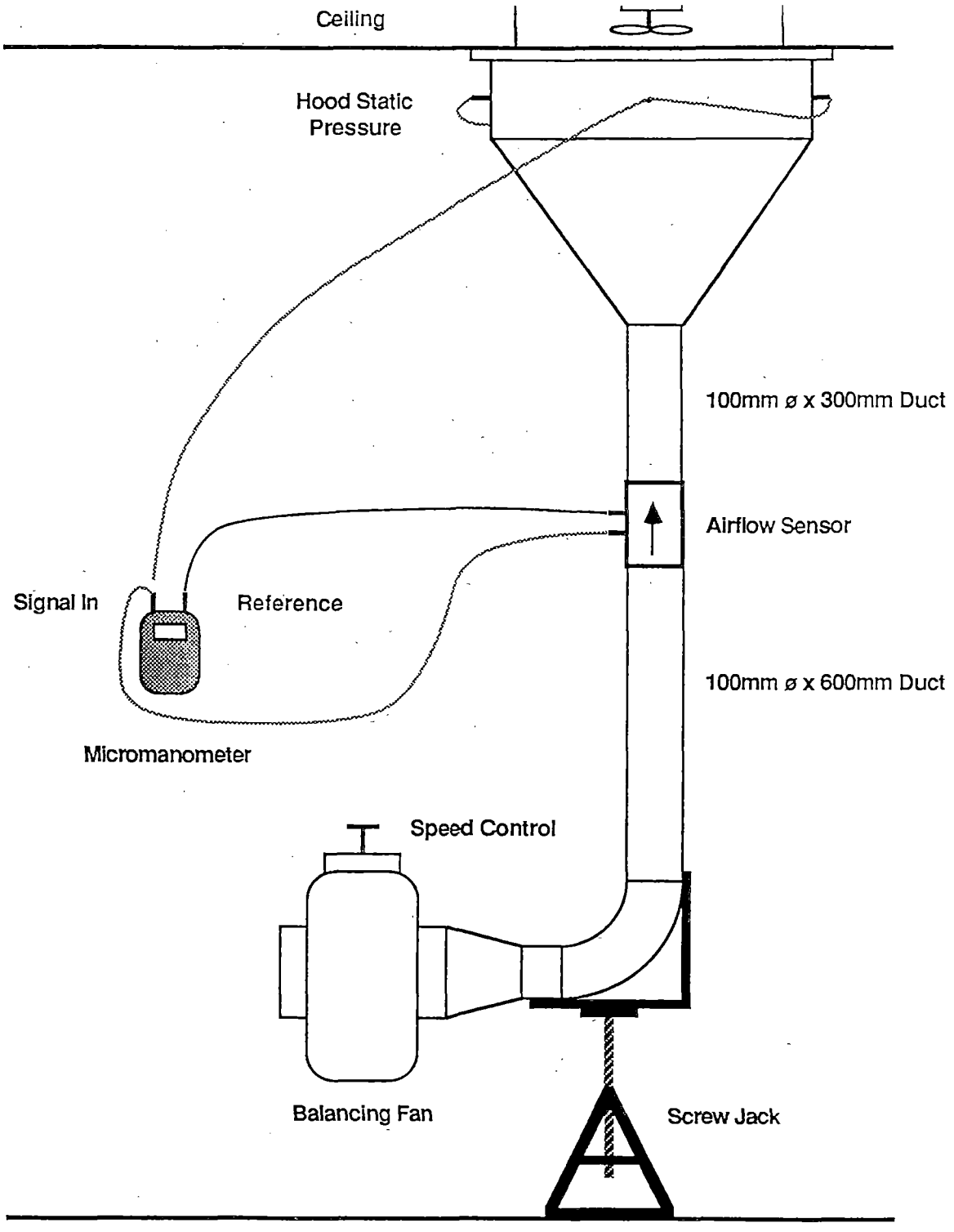

Figure B. Bathroom Exhaust Fan Airflow Test Set-up