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Instrumentation for the measurement of air infiltration - An annotated bibliography

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AIC

Air Infiltration Centre
Old Bracknell Lane, Bracknell,
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Annex 5 Air Infiltration Centre

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International Energy Agency

In order to strengthen cooperation in the vital area of energy policy, an Agreement on an International Energy Program was formulated among a number of industrialised countries in November 1974. The International Energy Agency (IEA) was established as an autonomous body within the Organisation for Economic Cooperation and Development (OECD) to administer that agreement. Twenty-one countries are currently members of the IEA, with the Commission of the European Communities participating under a special arrangement.

As one element of the International Energy Program, the Participants undertake cooperative activities in energy research, development, and demonstration. A number of new and improved energy technologies which have the potential of making significant contributions to our energy needs were identified for collaborative efforts. The IEA Committee on Energy Research and Development (CRD), assisted by a small Secretariat staff, coordinates the energy research, development, and demonstration programme.

Energy Conservation in Buildings and Community Systems

The International Energy Agency sponsors research and development in a number of areas related to energy. In one of these areas, energy conservation in buildings, the IEA is sponsoring various exercises to predict more accurately the energy use of buildings, including comparison of existing computer programmes, building monitoring, comparison of calculation methods, etc. The difference and similarities among these comparisons have told us much about the state of the art in building analysis and have led to further IEA sponsored research.

Annex V Air Infiltration Centre

The IEA Executive Committee (Buildings and Community Systems) has highlighted areas where the level of knowledge is unsatisfactory and there was unanimous agreement that infiltration was the area about which least was known. An infiltration group was formed drawing experts from most progressive countries, their long term aim to encourage joint international research and to increase the world pool of knowledge on infiltration and ventilation. Much valuable but sporadic and uncoordinated research was already taking place and after some initial ground-work the experts group recommended to their executive the formation of an Air Infiltration Centre. This recommendation was accepted and proposals for its establishment were invited internationally.

The aims of the Centre are the standardisation of techniques, the validation of models, the catalogue and transfer of information, and the encouragement of research. It is intended to be a review body for current world research, to ensure full dissemination of this research and based on a knowledge of work already done to give direction and a firm basis for future research, in the Participating Countries.

The Participants in this task are Canada, Denmark, Italy, Netherlands, Sweden, Switzerland, United Kingdom and the United States.

Introduction

Air infiltration is an increasingly important component of the heating and cooling load on a building. It is a complex phenomenon which is dependent not only on the air leakage qualities of the building structure, but also on the effects of wind and indoor-outdoor temperature differences, both of which vary significantly with time. Detailed knowledge of the air infiltration process is a pre-requisite of the ability to predict the energy losses arising from the leakage of outdoor air into particular buildings. In the search for this knowledge, one essential feature is the accurate measurement of rates of air infiltration.

There has been considerable development in the techniques and instrumentation used for infiltration rate measurement based on the use of a tracer gas. Three different methods are used of which the rate of decay technique is the most common. A quantity of tracer gas is mixed throughout a ventilated space and the concentration of tracer monitored over a period of time. The rate of decay of this concentration is directly related to the intake of fresh air. Alternatively, gas may be released at a steady rate—the constant emmission method. In this, the infiltration rate is calculated from the variations in concentration level. More complex equipment is needed for the third method—maintaining a constant concentration of gas. Tracer is automatically released when the concentration falls below a given level and the amount of tracer gas needed to maintain a given concentration is a direct function of the infiltration rate.

A number of different tracer gases have been used since measurements were first made in the 1930's when hydrogen and helium were commonly used. In particular there has been considerable interest in the last fifteen years in the use of sulphur hexafluoride. This halogenated gas can be detected in concentrations as low as parts per billion.

Tracer gas methods of measuring are generally complex and time-consuming so attention has been given to an easier approach which is more suited to site studies. One such approach involves the determination of the leakage characteristics or 'tightness' of a building from pressurization tests. An entire building is pressurized or depressurized to pressures up to 100 or even 150 Pascals, using a large fan or the mechanical ventilation system of the building. The flow rate through the fan and pressure difference across the building shell can then be used to calculate the air change rate of the building under pressure.

These pressure tests are simpler than tracer gas measurements but do not give the true air change rate of the building under natural, small, irregularly distributed and fluctuating pressure differences. However, pressure tests can be used to locate air leaks either by depressurizing a building and using thermography to detect leaks, or by testing individual components of a building for air tightness. These last tests may be carried out, either in the laboratory on isolated components, or on components installed in buildings.

This annotated bibliography contains a list of references selected from literature indexed in the AIC's library. The bibliography is intended to be selective rather than comprehensive and includes only papers entirely or substantially concerned with instrumentation or that contain significant information about a particular technique. The bibliography is divided into sections according to subject; and within each subject entries are arranged in chronological order of publication with the earliest first.

Photocopy Service

Photocopies of the papers listed in this bibliography are available free-of-charge to organisations in the countries which participate in the Air Infiltration Centre. This service is subject to the usual copyright practice.

To obtain photocopies, users should complete and sign the photocopy request form in the back of this bibliography and send it to the Air Infiltration Centre. Papers which are not available are marked with an asterisk*.

1.1 General

1 Coblentz, C.W., Achenbach, P.R.
Design and performance of a portable infiltration meter
ASHRAE trans. 1957, Vol. 63, p477-482

Describes the design and construction of a portable katharometer for detecting the rate of decay of hydrogen or helium as a tracer gas (in English).

2 Lidwell, D.M.
The evaluation of ventilation
J.Hyg. 1960, Vol. 58, No.3, p297-305

Describes apparatus and experimental procedure for measuring ventilation by the transfer index method using acetone as a tracer (in English).

3 Howland, A.H., Kimber, D.E., Littlejohn, R.F.
Measurements of air movements in a house using a radioactive tracer gas.
J.Inst. Heat. Vent. Eng. 1960, Vol.28, p57-71

Describes use of Krypton 85 as a tracer gas, detected by a Geiger-Müller counter (in English)

4 *Orr, H.W.
Studies and improvements to an air infiltration instrument.
M.Sc. Thesis, University of Saskatchewan, 1963, 63pps

Describes improvements made to a katharometer to enable it to be used for measurement of ventilation rate using helium as a tracer gas (in English).

5 Howard, J.S.
Ventilation measurements in houses and the influence of wall ventilators.
Build. Sci. 1966, Vol. 1, No. 3, p251-257

Includes discussion of apparatus and experimental techniques for measurement of ventilation rate using nitrous oxide as a tracer gas (in English).

6 Hitchen, E.R., Wilson, C.B.
A review of experimental techniques for the investigation of natural ventilation.
Build. Sci. 1967, Vol. 2, No. 1, p59-82

A major review of tracer gas techniques. Discusses measurement of rate of decay, constant emission of gas and transfer index method (in English).

Note: This was written before the widespread use of halogenated gases such as SF_6

7 Gerrard, M.
Measurement of ventilation rates with radioactive tracers.
ASHRAE Jnl. September 1968, Vol. 10, No. 9, p47-50

Describes use of krypton 85, xenon-133 and argon-41 as tracer gases (in English).

8 Evans, G.V., Webb, J.W.
An examination of radioisotope techniques for the measurement of ventilation rate.
U.K. Atomic Energy Establishment Report AERE-R6709 1971. 24pps

Discusses use of radioactive tracer gases. Describes test equipment and measurement procedure for determining ventilation rate using krypton 85 (in English).

9 Hunt, C.M.
Air infiltration: A review of some existing measurement techniques and data.
in "Building Air Change Rate and Infiltration Measurements" Proceedings, ASTM Conference, Gaithersburg, 13th March 1978. C.M. Hunt, J.C. King, H.R. Trechsel eds., ASTM 1980, p3-23

A state-of-the-art review of techniques for the measurement of air infiltration. Discusses different tracer gases and sources of error (in English).

10 Lagus, P.L.
Air infiltration measurements by the tracer gas dilution method - a review.
In "Building Air Change Rate and Infiltration Measurements" Proceedings ASTM Conference, Gaithersburg, 13th March 1978. C.M. Hunt, J.C. King, H.R. Trechsel eds., ASTM 1980, p36-49

The tracer dilution method for measuring air change rates is to release a quantity of tracer gas and measure the rate of decay of the concentration of tracer. Discusses the method and compares different tracer gases (in English).

11 Abel, A., Sundstrom, T.
The development of tracer gas methods of measuring air changes.
(Utveckling av spårgasmetoden för mätning av luftväxling)
V.V.S. Tidskrift September 1979, Vol. 50, No. 9, p37-40

Discusses measurement of ventilation rate using rate of decay of a tracer gas. Outlines problems in accurate determination and describes gas analysis equipment for nitrous oxide and the use of a microprocessor for evaluation (in Swedish).

12 Grimsrud, D.T. et al
An intercomparison of tracer gases used for air infiltration measurements.
ASHRAE Trans. 1980, Vol. 86, Part 1, p258-267

Compares methane (C_2H_6), sulphur hexafluoride (SF_6) and nitrous oxide (N_2O) as tracer gases for measuring ventilation rates (in English).

13 Kronvall, J.
Airtightness - measurements and measurement methods.
(Mätningar och mätmetoder för lufttäthet)
Swedish Council for Building Research, Stockholm
Report No. D8:1980 in English and T6:1979 in Swedish, 64pps

Describes measurement of ventilation rate using decreasing gas concentration, constant gas concentration and constant emission. Discusses different tracer gases (in English or Swedish).

14 Sherman, M.H.
Air infiltration measurement techniques.
Proceedings 1st AIC Conference "Instrumentation and measuring techniques", Windsor, UK, 6th-8th October 1980, 34pps

Surveys tracer gas techniques for measuring air infiltration. Includes theoretical derivation of the equations and description of each method and of the experimental procedures (in English).

1.2 Sulphur hexafluoride

15 Gregory, N.L.
Detection of nanogram quantities of sulphur hexafluoride by electron capture methods.
Nature, October 13th 1962, Vol. 196, p162

16 Lovelock, J.E.
Electron absorption detectors and technique for use in quantitative and qualitative analysis by gas chromatography.
Anal. Chem., 1963, Vol. 35, p474-481

17. Saltzman, B.E., Coleman, A.I., Clemons, C.A.
Halogenated compounds as meteorological tracers.
Anal. Chem., 1966, Vol. 48, No. 6, p753-758

Suggests use of SF_6 or other halogenated compounds to demonstrate the transfer of pollutants from one local area or city to another (in English).

18 Turk, A. et al
Sulphur hexafluoride as a gas tracer.
Env. Sci. & Tech., 1968, Vol. 2, p44-48

Discusses method for collecting and analysing SF_6 used as a tracer gas (in English).

19 Rubin, L.I., Gittens, R.
Use of a portable SF_6 detector and tracer gas for rapid determination of air change rates.
Analytical Instruments Ltd., unpublished report 1976, 7pps

20 *Harrje, D.T., Cooper, J.B.
Instumenting energy audits.
Princeton University, CEES Report 91, July 1979, 99pps

Describes tracer gas method using SF_6 collected in sample bottles (in English).

21 Kristensson, J.
Ventilation measurement using gas chromatographic analysis of sulphur hexafluoride.
(Ventilationsmätning med gaskromatografisk analys av svavelhexafluorid)
V.V.S. (Tidskrift), November 1979, Vol. 50, No. 11, p551-53

Describes use of SF_6 as a tracer gas both indoors and outdoors and discusses practical problems (in Swedish).

1.3 Automatic systems

(a) LAWRENCE BERKELEY LABORATORY

This system was designed to use nitrous oxide but is intended to use a non-flammable mixture of ethane in nitrogen in occupied spaces. Flow of tracer gas is controlled by a microprocessor.

22 Condon, P.E. et al
An automated controlled-flow air infiltration measurement system.
In "Building Air Change Rate and Infiltration Measurements" Proceedings ASTM Conference, Gaithersburg, 13th March 1978. C.M. Hunt, J.C. King, H.R. Techsel eds., ASTM 1980, p60-72

(b) PRINCETON UNIVERSITY/NATIONAL BUREAU OF STANDARDS

Developed jointly by Princeton and NBS, this system uses sulphur hexafluoride, automatically injected periodically or when the concentration falls below a chosen level.

23 Harrje, D.T. et al
Automated instrumentation for air infiltration measurements in buildings.
Princeton University, CEES Report No. 13, April 1975, 51pps

24 Hunt, C.M., Treado, J.
A prototype system for measuring air infiltration in buildings using sulphur hexafluoride as a tracer.
NBS Technical Note No. 898, 1976, 20pps

25 Harrje, D.T., Grot, R.A.
Automated air infiltration measurements and implications for energy conservation.
International Conference on Energy Use Management, Tucson, Arizona, USA, October 1977 Pergamon, p457-464

26 Harrje, D.T.
Instrumentation for monitoring energy usage in buildings at Twin Rivers.
Energy & Buildings, Spring 1978, Vol. 1, No. 3, p293-299

27 *Harrje, D.T., Cooper, J.B.
Instrumenting energy audits.
Princeton University, CEES Report No. 91, July 1979, 99pps

28 Grot, R.A., Hunt, C.M., Harrje, D.T.
Automated air infiltration measurements in large buildings.
Proceedings 1st AIC Conference "Instrumentation and measuring techniques", Windsor, UK, 6th-8th October, 1980, 23pps

Describes a development of the system to make tracer gas measurements in large multi-zone buildings (in English).

(c) NATIONAL RESEARCH COUNCIL OF CANADA, SASKATCHEWAN

A system using sulphur hexafluoride which can be used either to maintain constant concentration or to measure the rate of decay of concentration.

29 Kumar, R., Ireson, A.D., Orr, H.W.
An automated air infiltration measuring system using SF_6 tracer gas in constant concentration and decay methods.
ASHRAE Trans. 1979, Vol. 85, Part 2, p385-395

(d) E.M.P.A., SWITZERLAND

This system uses nitrous oxide and a relatively simple system with a purpose-designed controller.

30 Hartmann, P., Muehlebach, H.
Automatic measurements of air change rates (decay method) in a small residential building without any forced air heating system.
Proceedings 1st AIC Conference "Instrumentation and measuring techniques", Windsor, UK, 6th-8th October 1980, 13pps

2.1 Pressure tests of building components in the laboratory

31 Houghton, F.C., Schrader, C.C.
Air leakage through the openings in buildings.
ASHVE Trans. 1924, Vol. 30, p105-120

Describes apparatus used to measure air leakage through a window, built into a test wall, by using a blower to produce a pressure drop across the window (in English).

32 Larson, G.L., Nelson, D.W., Braatz, C.
Air infiltration through various types of brick wall construction.
ASHVE Trans. 1930, Vol. 36, p99-122

Describes apparatus for measuring air leakage through walls. The walls are built into steel frames which are moved into a machine for pressure testing (in English).

33 Larson, G.L., Nelson, D.W., Kubasta, R.W.
Air infiltration through double-hung wood windows.
ASHVE Trans. 1931, Vol. 37, p571-604

Describes apparatus for testing air leakage of a window, enclosed in a test box in the laboratory (in English).

34 Rusk, D.O., Cherry, V.H., Boelter, L.
Air infiltration through steel framed windows.
ASHVE Trans. 1933, Vol. 39, p169-178

Describes apparatus for testing windows. The window is enclosed in a steel hood and air can be blown directly onto the window or through a calcium chloride container to adjust the humidity of the air (in English).

35 Esdorn, H.
Air leakage of windows and pressure distributions in buildings.
(Luftdurchlässigkeit der Fenster und Druckverteilung in Gebäude)
in "Das Hochhaus der BASF", Hoffman Verlag. Stuttgart 1958, p161-170

Includes brief description of apparatus for pressure testing windows (in German)

36 Svendsen, S.D., Wigen, R.
Norwegian test methods for wind and rain penetration through windows.
Norwegian Building Research Institute Publication, No. 39, 1958, 19pps

Describes apparatus and experimental procedure for measurement of air leakage and rain penetration through windows (in English).

37 Mantle, K.G.
The measurement of air infiltration through metal-framed windows.
Heat. & Vent. Eng. and Jnl. of Air Cond., May 1958, Vol. 31, p529-531

Describes apparatus for laboratory measurement of air leakage and rain penetration through metal windows (in English).

38 Thomas, D.A., Dick, J.B.
Air infiltration through gaps around windows.
Jnl. Inst. Heat. Vent. Eng., June 1953, Vol. 21, No. 214, p85-97

Includes description of experimental set-up for measuring leakage through the gaps around windows (in English).

39 *Koontz, R.L. et al
Conventional buildings for reactor containment.
Atomics International, California, USA, NAA-SR-10100 1965, 418 pps

Includes description of test cell used to measure the air leakage of various structural components which may be used in buildings to house nuclear reactors. Components tested include doors and louvres (in English).

40 Shoda, T., Terasawa, T., Katayama, T.
Experimental study on air and water tightness of metal window sashes.
Proc. 5th Int. Congress for Heating, Ventilation and Air Conditioning, Copenhagen, Denmark, 17th-19th May 1971, p27-35

Describes apparatus used to measure air flow through a window under a range of pressure differences. At flow rates of 85 to 450 m^3/h and 3.0 to 120 m^3/h, pitot tube and hot wire anemometer are used respectively. For flow rates of less than 3.0 m^3/h the air flow is measured using carbon dioxide as a tracer gas (in English).

41 Fleury, G., Thomas, M.
Variation in the airtightness of windows as a function of the outside temperature: measurement apparatus and examples of application.
(Variation de la perméabilité à l'air des fenêtres en fonction de la température extérieure: Dispositif de mesure et exemples d'application)
Cahiers CSTB, September 1972, Vol. 132, No. 1129, 8pps

Describes study and operating principle of device allowing a window (or lightweight cladding unit) to be placed in variable temperature conditions simulating actual summer and winter, in order to determine the airtightness of the window under these conditions (in French).

42 *Sabine, H. et al
Acoustical and thermal performance of exterior residential walls, doors and windows.
NBS Building Science Series 77, 1975, 158pps

Includes description of method of testing the air leakage of windows and walls, which is based on ASTM E-283-73 "Standard method of test for rate of air leakage through exterior windows, curtain walls and doors" (in English).

43 Carruthers, J.F.S., Newman, C.J.
The repeatability and reproduceability of test results on windows and wall span elements and the expected results.
Building Research Establishment current paper CP 49/77, September 1977, 8pps

Discusses variations in the test results which occur with the laboratory procedures for assessing the air and water penetration attributes of windows (in English).

44 Carruthers, J.F.S., Newman, C.J.
The variability of test results when assessing the resistance of windows to water and air penetration using BS 4315.
In "Performance Test Methods and the Interpretation of Results", CIB W60, December 1979, p18-24

45 D'Havé, R., Spehl, P.
Comparison between some existing performance requirements for air permeability and water tightness in buildings.
In "Performance test methods and the interpretation of results", CIB W60, December 1979, p7-12

Compares standards for air and water tightness of windows. Gives table of main European standards (in English).

2.2 Standards

BRITAIN

46 Methods for testing for resistance to air and water penetration - Windows and gasket glazing systems.
British Standard BS 4315, Part 1, 1968, 16pps

47 Methods of testing windows Part 1. Air permeability test.
British Standard BS 5368, Part 1, 1976
= European Standard EN42, 5pps

GERMANY

48 Windows; air permeability of joints and driving rain (water tightness) protection.
(Fenster; Fugendurchlassigkeit und Schlagregensicherheit Anforderungen und Prüfung)
DIN 18055 T2, August 1973, 4 pps

SWEDEN

49 *Windows. Air tightness test.
(Fonster. Bestämning av luftäthet)
SIS 818126, April 1977

UNITED STATES

50 *Standard test method for rate of air leakage through exterior windows, curtain walls and doors.
ANSI/ASTM E-282-73

INTERNATIONAL STANDARDS

51 International Standards Organisation
Joints in building - method of test for the resistance of joints to air penetration.
Draft International Standard ISO/DIS 6589, February 1979, 5pps

52 International Standards Organisation
Windows and door-height windows - Air permeability test.
International Standard ISO 6613-1980(E), 3pps

2.3 Pressure tests on components in situ

53 Houghton, F.C., O'Connell, M.F.
Air leakage studies on metal windows in a modern office building.
ASHRAE Trans. 1928, Vol. 34, p321-336

Describes apparatus and experimental procedure for measuring air infiltration through windows installed on the 11th floor of a high-rise office building (in English).

54 Tamura, G.T., Shaw, C.Y.
Air leakage data for the design of elevator and stair shaft pressurization systems.
ASHRAE Trans. 1976, Vol. 82, No. 2, p179-190

Describes method for the pressurization of elevator and stair shafts in multi-storey buildings to determine their air tightness (in English).

55 Olsson, A.
Ventilation and the draught-proofing of windows in old blocks of flats.
Lund Institute of Technology, Dept of Building Science Report, 1977, 27pps

Describes method for measuring the air leakage of windows installed in flats. A plastic tent is sealed round the window and a pressure difference maintained across the window (in English).

56 Harrje, D.T., Blomsterberg, A.K., Persily, A.K.
Reduction of air infiltration due to window and door retrofits in an older house.
Princeton University, Center for Environmental Studies, Report No. 85, May 1979, 25pps

Includes description of tests on individual windows in a house. A plastic cover was taped tightly to the window frame and the space between cover and window depressurized. To minimise the chance of other leakage, the entire house was simultaneously depressurized (in English).

57 Shaw, C.Y.
Methods for conducting small-scale pressurization tests and air leakage data of multi-storey apartment buildings.
ASHRAE Trans. 1980, Vol. 86, Part 1, p241-250

Describes direct method of measuring leakage through a window or portion of a wall by sealing a test chamber to the wall. The test chamber is either pressurized or depressurized and the pressure in the adjacent room is balanced with that in the test chamber using fans (in English).

2.4 Pressure tests of whole buildings

58 Shaw, C.Y., Sander, D.M., Tamura, G.T.
Air leakage measurements of the exterior walls of tall buildings.
ASHRAE Trans. 1973, Vol. 79, Part 2, p40-48

Describes method for measuring the air leakage of a multi-storey building by using the central supply air system to pressurize the building (in English).

59 Stricker, S.
Measurement of air leakage of houses.
Ontario Hydro Research Quarterly 1974, Vol. 26, No. 4, p11-18

Describes a method, developed by Ontario Hydro Ltd., Canada, for pressurizing a house by installing a fan, mounted through a flexible plastic film, in a window (in English).

60 Stricker, S.
Measurement of air tightness of houses.
ASHRAE Trans. 1975, Vol. 81, Part 1, p148-167

61 McIntyre, I.S., Newman, C.J.
The testing of whole houses for air leakage.
Building Research Establishment Note 21/75, 1975, 11pps

Describes the BRE portable air leakage apparatus consisting of a fan unit and flow measurement duct. The fan is mounted in a wooden leaf which is placed in an exterior doorway of the test house. The system is used both to pressurize and to depressurize the house (in English).

62 Tamura, G.
Measurement of air leakage characteristics.
ASHRAE Trans. 1975, Vol. 81, Part 1, p202-208

Describes apparatus, developed at the National Research Council of Canada, in Ottawa, for depressurizing a house by installing a fan in a basement window (in English).

63 *Collet, P.F.
The natural ventilation of dwellings.
(Boligers luftskifte)
Teknoligisk Institut Denmark, 1976, 99pps

Includes brief description of apparatus for pressure testing (in Danish).

64 Kronvall, J.
Air tightness of whole buildings.
Lund Institute of Technology, 1976, 4pps

Gives simple explanation of a method of pressurizing or depressurizing a house by installing a fan in a special door leaf which replaces an ordinary outer door (in English).

65 Kronvall, J.
Testing of houses for air leakage using a pressure method.
ASHRAE Trans. 1978, Vol. 84, Part 1, p72-79

66 Caffey, G.E.
Residential air infiltration.
ASHRAE Trans. 1979, Vol. 85, Part 1, p41-57

Describes an air machine, the "Super Sucker", which is installed in a window opening and used to depressurize a building. The machine was developed by Texas Power and Light Company, Dallas, USA (in English).

67 Shaw, C.Y., Jones, L.
Air tightness and air infiltration of school buildings.
ASHRAE Trans. 1979, Vol. 85, Part 1, p85-95

Describes method for testing the air leakage of schools by pressurizing the school with a large fan. The method has been developed by the National Research Council of Canada (in English).

68 *Harrje, D.T., Cooper, J.B.
Instrumenting energy audits.
Princeton University, Center for Energy & Environmental Studies, Report 91, July 1979, 99pps

Pages 8 to 12 of this report describe the blower door used to both pressurize and depressurize a house. An appendix to the report gives a list of all the components of the system (in English).

69 Kronvall, J.
Air tightness - measurements and measurement methods.
(Mätninger och mätmetoder för lufttäthet)
Swedish Council for Building Research, Stockholm, 64pps
T6 : 1979 in Swedish
D8 : 1980 in English

Describes equipment for performing pressure tests on buildings and gives test procedure. Discusses accuracy of the method and calculates probable measurement errors (in English or Swedish).

70 Nylund, P-O
Tightness and its testing in single and terraced houses.
Proceedings 1st AIC Conference "Instrumentation and measuring techniques", Windsor, UK,
6th-8th October 1980, 11pps

Describes method for pressure testing a terraced house or flat which gives a correction for air leakage through party walls (in English).

71 Nylund, P-O
The application of reciprocity in tightness testing.
Proceedings 1st AIC Conference "Instrumentation and measuring techniques", Windsor, UK,
6th-8th October 1980, 10pps

Describes a method for measuring the leakage of large office blocks. Each room is pressurized in turn and the values for the leakage summed to give the true air leakage (in English).

72 Orr, H.W., Figley, D.A.
An exhaust fan apparatus for assessing the air leakage characteristics of houses.
Prairie Regional Station, Division of Building Research, National Research Council of Canada, March, 1980, 9pps

Describes apparatus developed at the Prairie Regional Station, Saskatoon, for air leakage testing of small buildings. The apparatus is fitted into a doorway and used to depressurize the building (in English).

2.5 Alternating pressure tests of buildings

A method for pressure testing a building using an alternating pressure source has been developed at Syracuse University and extended by the Lawrence Berkeley Laboratory, University of California, USA. The intention is to model the small pressure differences across a building shell which are the driving forces for air infiltration.

73 *Graham, R.W.
Infrasonic impedance measurements of buildings for air leakage determination.
MSc. Thesis, Syracuse University, 1977, 54pps

74 *Card, W.H. et al
Air leakage measurement of buildings by an infrasonic method.
Syracuse University, Technical Report TR-78-1, 110pps

75 Card, W.H. et al
Infrasonic measurement of building air leaks : A progress report
In "Building air change rate and infiltration measurements", Proceedings ASTM Conference, Gaithersburg, 13th March 1978. C.M. Hunt, J.C. King, H.R. Trechsel eds., ASTM 1980, p73-88

76 Sherman, M.H., Grimsrud, D.T., Sonderegger, R.C.
The low pressure leakage function of a building.
Proceedings ASHRAE/DOE Conference "Thermal performance of the exterior envelopes of buildings", December 3rd-5th 1979, Florida, USA.

77 Grimsrud, D.T., Sherman, M.H., Sonderegger, R.C.
Air leakage in a building at low pressure using an alternating pressure source.
XXI International Congress for Building Services Engineering, Berlin, W. Germany, April 1980, 15pps

3.1 Thermography

78 Paljak, I.
Infrared thermography applied on testing of buildings.
5th International Congress for Heating, Ventilating and Air Conditioning, Copenhagen, Denmark, 17th-19th May 1971, 13pps

Gives physical principles of thermography and describes techniques for photographing walls (in English).

79 *Paljak, I., Pettersson, P.
Thermography of buildings.
(Termografering av byggnader)
National Institute for Building Research, Stockholm, 1972, 45pps

A comprehensive manual describing theory and techniques of thermography as used to determine insulation defects in buildings. Includes 700 typical thermograms (in Swedish and English).

80 *Harrje, D.T., Cooper, J.B.
Instrumenting energy audits.
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Bibliography: Instrumentation for the Measurement of Air Infiltration.
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